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Forgotten Time Capsule Tells of Women Chemists

BULLETIN FOR THE HISTORY OF CHEMISTRY

VOLUME 43 CONTENTS

The Cover … Portraits of professors Rachel Lloyd and Mary Louise Fossler from a time capsule held by Mark Griep, page 27

ALEXANDER MARCET, CHEMIST, PHYSICIAN AND GEOLOGIST, A NEGLECTED FIGURE IN BRITISH SCIENCE FROM 1797 TO 1822

G. J. Leigh, University of Sussex; jeffery.leigh@sky.com

Alexander Marcet, born in Geneva in 1770, was exiled from there in 1794 to Edinburgh where he studied medicine and chemistry. He then moved to London in 1797, and married Jane Haldimand in 1800. Apart from supporting her in writing her noted series of books of scientific conversations, especially *Conversations on Chemistry*, he established himself in society as a fever doctor, taught chemistry at Guy's Hospital, and assisted in several national emergencies including the treatment of Walcheren fever, vaccination against smallpox, and the threat of invasion by Napoleon. He tried to establish the chemical nature of medical stones, isolated xanthine and collaborated with Berzelius on carbon disulphide, and was acquainted with scientists such as Wollaston, Smithson Tennant, Davy, Roget, Yelloly and Faraday. He tried to use analysis to identify biological materials, encouraging the widespread application of medicine to protect the health of the public at large. He was influential in establishing The Geological Society and also the predecessor of the Royal Society of Medicine. Alexander died in 1822.

Introduction

Alexander Marcet is remembered today, if at all, as the husband of Jane Marcet, who wrote several influential instructional books on science in the nineteenth century, particularly *Conversations on Chemistry* (1). Her *Conversations on Political Economy* was perhaps even more important, but it is unlikely that Alexander contributed as much to this and her many other related volumes. However, his assistance to his wife was only a minor part of his own scientific activities, which were wide and influential. As well as researching in chemistry and medicine, he contributed to the development of medical and scientific societies in London around the turn of the eighteenth and nineteenth centuries. His contribution to the writing of Jane's *Conversations on Chemistry* has been well documented (2, 3). The current paper is a unique account of Alexander's scientific and public activities from about 1800 until his death in 1822.

Early Life and Education

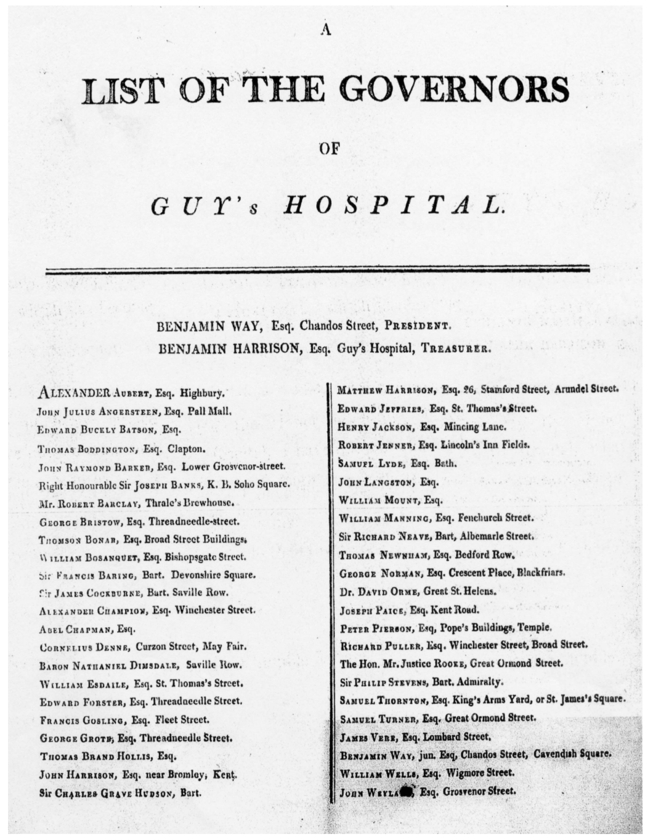
Alexander was born Alexandre in 1770 in Geneva, to a family which was part of the ruling elite. Genevan society at that time had an unusually liberal attitude, to universal education in particular. When the French Revolution reached Geneva in 1794, Alexander was exiled from the city as a consequence of his earlier activities in the Geneva voluntary militia. He moved to Edinburgh University to study medicine at what was then the leading medical school in Europe. He graduated in 1797, and still unable to return to Geneva, he moved to London. The contacts he made in Edinburgh, and the people there who had become his friends, exercised an important influence on his later life. He brought with him to London from Edinburgh fresh insights into medicine and particularly chemistry. He had been taught by Joseph Black who pioneered the teaching of the "French chemistry" before it was widely established in Britain. In addition, his family and francophone connections gave him a direct link to scientific and political developments on the Continent. His background was more cosmopolitan than that of most of the circle with which he associated in London. From 1797 he worked in London in several areas of professional and public importance, at a time when science as a profession and a discipline was still becoming established. Several accounts of his life are available (4-6) but the current paper is more detailed than these, describing Alexander's significant contribution to the scientific and social development of his adopted country.

Life in London

Alexander took up an appointment at the Carey Street Dispensary in 1797, moving to the City Dispensary in 1798. Fevers of various kinds were common at all social levels of the population, though the majority of sufferers were poor and forced to depend upon charities such as the dispensaries for any treatment. Alexander's appointments must have required a considerable amount of work for low reward. It seems to be a coincidence that Carey Street is close by St Mary Axe where his future wife, Jane Haldimand, lived with her father. The exiled Alexander needed to restore his financial and social position by acquiring wealthy private patients, and these he set out to find.

By 1802 Alexander was building a reputation as a fever doctor but was clearly dissatisfied with his work at the City Dispensary. A letter in the Alexandre Marcet archive in the Bibliothèque de Genève (designated BGE in this text) shows that in 1802 Alexander was mounting a campaign to support his election to the post of Assistant Physician at Guy's Hospital. Many of the individuals he enlisted for support, as well as their families, were already amongst his patients. Figure 1 lists the Governors of Guy's Hospital (7), and a hand-written accompanying note with further names lists people who were going to approach which Hospital Governor on Alexander's behalf (8). The breadth of his support is notable. His active supporters included Sir William Wickham, Sir Samuel Romilly, and Charles Abbott, later first Baron Colchester, one-time Speaker of the House of Commons. Abbott wrote from Eastbourne directly to Alexander at St Mary Axe about the election (9)

> 1. Sept. 1802
>
> I fear I can serve you little upon your present canvas – but I have written to Sir Joseph Banks - M^{r} [name illegible] Thornton – Mr Manning – & Sir Francis Baring – & heartily wish you success.
>
> Mrs Wickham [who was of Genevan extraction and wife of William Wickham, the politician, civil servant and spy master] by all accounts rides on horseback & may be considered as nearly re-established
>
> I am
>
> Dear Sir
>
> Yr Most obed Servt
>
> Chas Abbot



A

LIST OF THE GOVERNORS

OF

GUY'S HOSPITAL.

BENJAMIN WAY, Esq. Chandos Street, PRESIDENT.
BENJAMIN HARRISON, Esq. Guy's Hospital, TREASURER.

Alexander Aubert, Esq. Highbury.
John Julius Angersteen, Esq. Pall Mall.
Edward Buckly Batson, Esq.
Thomas Boddington, Esq. Clapton.
John Raymond Barker, Esq. Lower Grosvenor-street.
Right Honourable Sir Joseph Banks, K. B. Soho Square.
Mr. Robert Barclay, Thrale's Brewhouse.
George Bristow, Esq. Threadneedle-street.
Thomson Bonar, Esq. Broad Street Buildings.
William Bosanquet, Esq. Bishopsgate Street.
Sir Francis Baring, Bart. Devonshire Square.
Sir James Cockburne, Bart. Saville Row.
Alexander Champion, Esq. Winchester Street.
Abel Chapman, Esq.
Cornelius Denne, Curzon Street, May Fair.
Baron Nathaniel Dimsdale, Saville Row.
William Esdaile, Esq. St. Thomas's Street.
Edward Forster, Esq. Threadneedle Street.
Francis Gosling, Esq. Fleet Street.
George Grote, Esq. Threadneedle Street.
Thomas Brand Hollis, Esq.
John Harrison, Esq. near Bromley, Kent.
Sir Charles Grave Hudson, Bart.
Matthew Harrison, Esq. 26, Stamford Street, Arundel Street.
Edward Jeffries, Esq. St. Thomas's Street.
Henry Jackson, Esq. Mincing Lane.
Robert Jenner, Esq. Lincoln's Inn Fields.
Samuel Lyde, Esq. Bath.
John Langston, Esq.
William Mount, Esq.
William Manning, Esq. Fenchurch Street.
Sir Richard Neave, Bart, Albemarle Street.
Thomas Newnham, Esq. Bedford Row.
George Norman, Esq. Crescent Place, Blackfriars.
Dr. David Orme, Great St. Helens.
Joseph Paice, Esq. Kent Road.
Peter Pierson, Esq, Pope's Buildings, Temple.
Richard Puller, Esq. Winchester Street, Broad Street.
The Hon. Mr. Justice Rooke, Great Ormond Street.
Sir Philip Stevens, Bart. Admiralty.
Samuel Thornton, Esq. King's Arms Yard, or St. James's Square.
Samuel Turner, Esq. Great Ormond Street.
James Vere, Esq. Lombard Street.
Benjamin Way, jun. Esq, Chandos Street, Cavendish Square.
William Wells, Esq. Wigmore Street.
John Weyla[illegible], Esq. Grosvenor Street.

***Figure 1**. List of the Governors of Guy's Hospital who were eligible to vote in 1802 when Alexander Marcet was elected Assistant Physician. The list is in the Alexander Marcet Archive at the Bibliothèque de Genève (7).*

Several of the Governors promised to vote for Alexander. Another Governor, a judge, Justice Rooke, wrote to William Wickham (10) saying that though he supported Alexander's election, he wouldn't bother to go to vote because the result was a foregone conclusion.

> Dear Sir
>
> Your Favor of the 6th Instant has been duly forwarded to me; I have delayed answering it in the Hope to be able to write decidedly to you on I [word illegible] of y^{r} application: & I think myself peculiarly fortunate

in acquainting you that, tho' if it were necessary I wo[d] [word illegible] at Guy's Hospital to vote for Dr Marcet yet, I learn from a Letter from the Treasurer [Benjamin Harrison] that he is generally approved of by the Governors therefore my attendance is unnecessary there being no doubt of his success. I shall at all Times be ready to pay attention to your application & am with great esteem and respect, Dear Sir

Y[r] Obed[t] Serv[t]

G. Rooke

Not everyone Alexander approached responded to his entreaties for support, notably Sir Joseph Banks on 21 August 1802 (11). Banks was an eminent member of the Royal Society and long-time President.

Sir Jos: Banks presents his Comp[ts] to Dr Marcet & begs the Dr to be assured that far from having forgotten him he Remembers with pleasure some good offices he Receivd from the Dr Several years ago Sir Jos: will be happy if he Can be of Service to the Dr in this or any other occasion however he can not promise anything as the governors always Settle the affairs of Election in Private to prevent the unpleasant consequences of contested Elections.

What the good offices he had received from Alexander are not evident, but evidently Banks, a Governor of the Hospital at the time, did not wish to promise anything. His preference that matters should be settled between gentlemen in private was in character. Many years later, in a letter to Alexander now in the Banks Archive Project (12), dated 27 July 1816, Banks was regretfully again unable to help, though the context is again not evident.

My Dear Dr

I have received an answer from Clermont not very advantageous for the Present but which holds out some hope for futurity when Ever you Call here you Shall See it

Faithfully yours

Jos: Banks

A letter from this period to Alexander from John Yelloly, also a physician and a chemist, is held with many others exchanged between them in an archive at the History of Medicine Collections of Duke University, here designated HMLDU (13). Like Alexander, Yelloly was a graduate in medicine of Edinburgh University, and like him had moved to London. Unless otherwise stated, Yelloly's letters cited here are copied with permission from the Duke University archive. By 13 August 1802 Yelloly knew that Alexander was trying to obtain a position at Guy's, and he was attempting to help him to do so. He wrote to Alexander:

My Dear Sir

I think I may venture to assure you from pretty good authority of your success at Guy's, and tho' congratulations would be as yet premature, I hope to be able to present them in a month [word illegible] of this when we meet, and in the mean time I remain

Yours very truly

J.Yelloly

Wednesday morning

The election took place on 25 August 1802 and Alexander was successful. In 1804 when Dr Relph, a Physician to Guy's, died, Alexander applied to be appointed Physician in his stead. He mounted a similar campaign and was again elected.

Early Chemical Work

Once established at Guy's Hospital, Alexander was required to teach chemistry to medical students. Chemists were reporting many new compounds and there was a desire amongst doctors to test them as drugs, though some evidently did more harm than good. Alexander's colleagues at Guy's included Allen and Babington who had published a syllabus for teaching chemistry to medical students as early as 1802. Similar syllabuses were published until at least 1822 and Alexander combined with Babington and Allen to update the syllabus in 1816 (14, 15). By 1822 some of the authors of the syllabus and Guy's Hospital staff had changed (16) but the teaching of chemistry to medical students continued. Two illustrations from these syllabuses, Figures 2 and 3, are shown below. The chemical laboratory of 1816 (Figure 2) contains some pieces of glassware that would be found in a chemistry laboratory today. Figure 3 dates from 1822 and the beginning of the quantitative study of chemistry, when the practical and compositional implications of the atomic theory were still being evaluated. Several of the numbers quoted in this table are clearly in error, even allowing that the weights are all standardized to O = 1 rather than to C = 12, as today. Another of Alexander's acquaintances, William Wollaston, was a principal researcher in establishing a quantitative approach to chemical composition (17, 18).

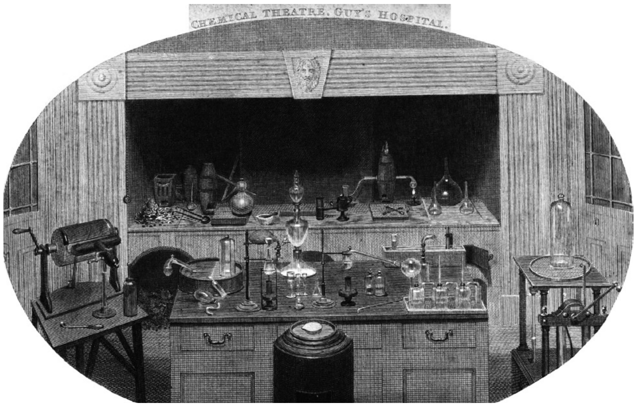
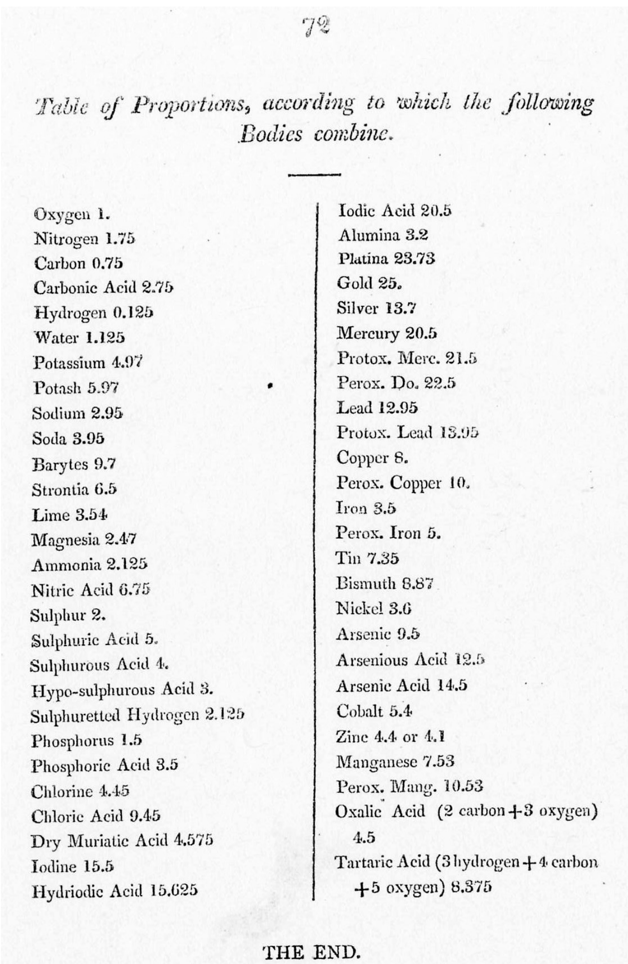


Figure 2. *A well-found chemical laboratory in 1816 (15).*



72

Table of Proportions, according to which the following Bodies combine.

Oxygen 1.
Nitrogen 1.75
Carbon 0.75
Carbonic Acid 2.75
Hydrogen 0.125
Water 1.125
Potassium 4.97
Potash 5.97
Sodium 2.95
Soda 3.95
Barytes 9.7
Strontia 6.5
Lime 3.54
Magnesia 2.47
Ammonia 2.125
Nitric Acid 6.75
Sulphur 2.
Sulphuric Acid 5.
Sulphurous Acid 4.
Hypo-sulphurous Acid 3.
Sulphuretted Hydrogen 2.125
Phosphorus 1.5
Phosphoric Acid 3.5
Chlorine 4.45
Chloric Acid 9.45
Dry Muriatic Acid 4.575
Iodine 15.5
Hydriodic Acid 15.625

Iodic Acid 20.5
Alumina 3.2
Platina 23.73
Gold 25.
Silver 13.7
Mercury 20.5
Protox. Merc. 21.5
Perox. Do. 22.5
Lead 12.95
Protox. Lead 13.95
Copper 8.
Perox. Copper 10.
Iron 3.5
Perox. Iron 5.
Tin 7.35
Bismuth 8.87
Nickel 3.6
Arsenic 9.5
Arsenious Acid 12.5
Arsenic Acid 14.5
Cobalt 5.4
Zinc 4.4 or 4.1
Manganese 7.53
Perox. Mang. 10.53
Oxalic Acid (2 carbon+3 oxygen) 4.5
Tartaric Acid (3 hydrogen+4 carbon +5 oxygen) 8.375

THE END.

Figure 3. *The last page of the 1822 Guy's Hospital chemistry syllabus (16).*

Service for the British Army

After the French Revolution of 1789 the British establishment was very suspicious of political and philosophic ideas emanating from France, but the treaties of London (1801) and Amiens (1802), which attempted to establish a world-wide settlement between Britain and the newly established French Republic were greeted by the Marcets in London with enthusiasm, as their correspondence shows. The treaties did not hold for more than about a year, when Britain and France renewed their war. By mid-1803 Britain was again threatened by invasion, and Alexander clearly felt he should do something to protect his adopted country against the French threat. Alexander joined the Light Horse Volunteers. He seems to have had some social contact with its Colonel, Charles Herries, and three letters from the colonel concern an accident suffered by Alexander, apparently a fall from his horse, during a journey to an inn called The George (19). The Volunteers seem to have been a rather stuffy upper-class English (rather than British) organization. Parading and playing military games seem to have been a major occupation, although the Volunteers elected to place themselves under national command if there were an invasion. Alexander was informed of his election by a letter from the Secretary dated 30 June 1803 (20).

> Sir
>
> I am directed by the Committee of the Light Horse Volunteers to acquaint you that you are elected as Honorary Member of the Corps and that you may enjoy the following privileges
>
> Wearing the undress Uniform of the Corps, and being present if you chuse it at all general meetings but not entitled to vote,
>
> Learning Chasing[?] Fencing, & the use of the Broad Sword, gratis,
>
> Keeping a Horse at the Corps Stables provided they are not filled by those of effective Members—
>
> Having the option of joining the Corps, provided there is a Vacancy, upon giving Notice to the Commanding Officer that he may apply for His Majesty's approbation.—
>
> And lastly you are subject to no other Expence until you join than the Annual Subscription of Eight Guineas towards the General Charges of the Establishment.
>
> I have the honor to be
>
> Sir
>
> Your most Obedt Servt
>
> Ed. Hughes, Sec.
>
> N. B. The Exemptions enjoyed by the Light Horse Volunteers, such as from serving in the Militia Tax for one House, Powder Tax &c cannot be availed of by any one till he is enrolled, approved by his Majesty and has joined the Corps.

On 23 July 1803 Alexander received another letter asking him to make himself [physically?] fit, and with a request for £43/18/9 (about £43.93) to pay for his "Arms and Accoutrements" and his annual subscription of eight guineas (£8/8/0 or £8.40). Service in the Light Horse Volunteers was not a poor man's pastime. Alexander was provided with a list of tradesmen who would supply him with the necessary equipment, and he was assigned to First Troop, provided he had a horse of the proper color. Presumably this was so that they would not offend the artistic sensibilities of the opposing French, should they invade. When he resigned in 1806, Alexander offered his services as Physician to the Light Horse Volunteers, who seem already to have had an official Surgeon. His generous offer was gracefully refused by Colonel Herries, since it was not deemed appropriate for a regiment of cavalry to have an official physician (21).

> Orderly Office 24 Oct 1806
>
> Dear Sir
>
> I have the pleasure of informing you that the Light Horse Volunteers in accepting of your Resignation as an honorary effective have been elected as an honorary Member, and resolved by joining your name to that of Dr Saunders, to avail themselves of your handsome offer to give your advice in a medical capacity when necessary to any of the dependants of the Corps; but as we already had the honor of informing you, they cannot regularly propose the appointment of a Physician to a Reg^t^ of Cavalry
>
> I am with great regard
>
> Dear Sir
>
> Your faithful humb. ser^t^
>
> Charles Herries
>
> Col L. H. V.
>
> Dr Marcet &. &. &.

The Dr. Saunders mentioned in this letter was a Scottish physician, William Saunders, who had studied medicine at Edinburgh University and was a colleague of Alexander (22). He was elected Physician at Guy's in 1770, and retired in 1802, and had been a Fellow of the Royal College of Physicians since 1790. One of his patients was the Prince Regent. Although William Saunders was considerably older than Alexander, the Saunders and the Marcet families were friends. Saunders, like Alexander, was distressed by the rigid boundaries that seem to have existed in England between Surgeons, Physicians, and Apothecaries, and he tried to overcome them. In 1805 Alexander chaired the inaugural meeting of the Medical and Chirurgical Society, later a founding partner of the Royal Society of Medicine (23).

The Medical and Chirurgical Society

The Medical Society of London had been founded in 1773, in part with the aim of enhancing cooperation between the medical professions. Many members had become dissatisfied with the way it was run, and they met together at The Freemasons' Tavern on 22 May 1805 to form the Medical and Chirurgical Society. Its purpose was "conversation on professional subjects, for the reception of communications and the formation of a library" in the service of various branches of the medical profession. William Saunders was the first President, John Yelloly an Honorary Secretary, Astley Cooper the Treasurer, and Alexander Marcet the Foreign Secretary. Peter Mark Roget eventually ran the Library, and he became President in 1829. There was a considerable struggle, aided by such as Sir Samuel Romilly, to obtain a Royal Charter, because of resistance from the medical establishment and Royal Colleges, but this was finally achieved in 1834. In 1907 the Society was united with various other specialist societies to form the Royal Society of Medicine.

Yelloly and Alexander were principal actors in all these early developments, and Alexander also introduced eminent foreigners to the Society. Banks and Davy were members, and Berzelius, de Carro, Corvisart (Napoleon's personal physician), Odier, and Sabatier became Honorary or Honorary Foreign members. Peter Mark Roget also appreciated his activities greatly, exemplified by an obituary he wrote for Alexander and discussed below.

John Yelloly was also keen to retain Alexander's support for the new society and he wrote to him on 13 June 1805 as follows (24):

> It is really quite impossible that you can think of the possibility of being absent tomorrow from the meeting; and indeed considering the many little arrangements it may be proper to think of, it would be much more convenient if you were at home in the forenoon, that we may confer together.…Nothing I assure you would be as mortifying to me as not to have you sitting next to me at the meeting, and I should not even like to be there before you, as you may readily conceive that to be there unsupported (for all our committee felt less interest than we do) must be particularly disagreeable – I request you will give me your assurance before you leave Town that you will be at the meeting at two o'clock. I would if I could for an instant have imagined the possibility of you being absent from the 1^st^ general meeting I should certainly for my part have taken no stake in the interprise [*sic*] in which we are engaged at all.

Smallpox Inoculation

As well as his work with the Medical and Chirurgical Society, Alexander was active in matters related to public health, and his wife Jane supported him in this work. One of the diseases which Alexander met in his work in the public dispensaries was smallpox, a cure for which was not known. However, prevention of smallpox by inoculation was gradually being practiced in some circles, including many of the royals and upper classes, and it was becoming more common.

The idea of inoculation was considered bizarre in some circles, and the eccentric behavior of the English upper classes in this context had earlier been recorded by Voltaire (25) but many people and organizations were beginning to accept that this surprising method of smallpox prevention, which had originated in the Middle East, was better than suffering from the disease. For example, the members of the British fleet which isolated Napoleon's army in Egypt in 1798 by cutting its supply lines at the battle of Abukir, and also the men of Napoleon's army in Egypt, were inoculated against smallpox (26). However, it was only with the wider recognition of the possibilities of vaccination that doctors began to think that it might be possible to eradicate smallpox entirely.

The person most often identified with smallpox vaccination is Edward Jenner (1749-1823), whose work had been recognized by his neighbors in Gloucestershire by the award of a testimonial (27, 28). He vaccinated many people for free, especially around his Gloucestershire home. Though a country doctor, he had worked for Sir Joseph Banks on the material brought back from Cook's first voyage of discovery, and his background was in natural history and geology. He graduated at St Andrew's in Scotland as doctor of medicine in 1792, so he came to medicine in his forties, rather later in his life than Alexander and his colleagues. However, he clearly influenced them, and also people such as de Carro and Odier, who spread the vaccination gospel across Europe. Alexander had also recommended inoculation to some of his patients, including Sir William Wickham and his wife, Eléanore, who was also of Swiss origin.

In 1801 Jenner spent a year to try to establish himself as a physician in London, but he was not successful, and returned to Gloucestershire in 1802. Jenner had been in favor of setting up an Institution for Gratuitous Vaccination, and in 1802 the Jennerian Society (soon to be the Royal Jennerian Society) was formed in London. A meeting of three hundred people chaired by the Lord Mayor of London was held at the London Tavern in Bishopsgate on 19 January 1802. The intent was to abolish smallpox and the meeting appointed an organizing committee of 54 members, supported by the Dukes of Bedford and of Clarence. Royal Patronage was rapidly achieved, and the first meeting of the Royal Jennerian Society was held early in February 1802. The campaign to eradicate smallpox from the world which started in 1802 took nearly two hundred years to complete (29).

Alexander's important part in supporting Jenner and encouraging universal inoculation against smallpox has not been generally recognized. It is exemplified by an entry in the *London Times* of 12 January 1803 which announced a public meeting to consider the best means to exterminate smallpox using Dr. Jenner's techniques. The Chair was to be taken by the Lord Mayor of London, and amongst those listed as supporters of the project were William Wilberforce, William Babington, Astley Cooper, C. R. Aikin, and Alexander Marcet M.D.

An early job of the organizing committee of the Jennerian Society was to appoint a "resident vaccinator." Alexander was deeply involved in all this, and the Geneva archive contains many papers, generally formally printed, recommending two particular candidates, a Dr. Domeier and a Dr. Walker. Each candidate was running a campaign, pulling as many strings as he could, exactly as Alexander had done when he applied for positions at Guy's in 1802 and 1804. A letter of 4 April 1803 from Anne Romilly, the wife of Sir Samuel Romilly, to Jane Marcet (30) reveals that Alexander was one of a large number of people involved in selecting the vaccinator. The Romillys then lived in Gower Street whereas Jane and Alexander still lived at St Mary Axe. Later the two families were neighbors and friends in Russell Square.

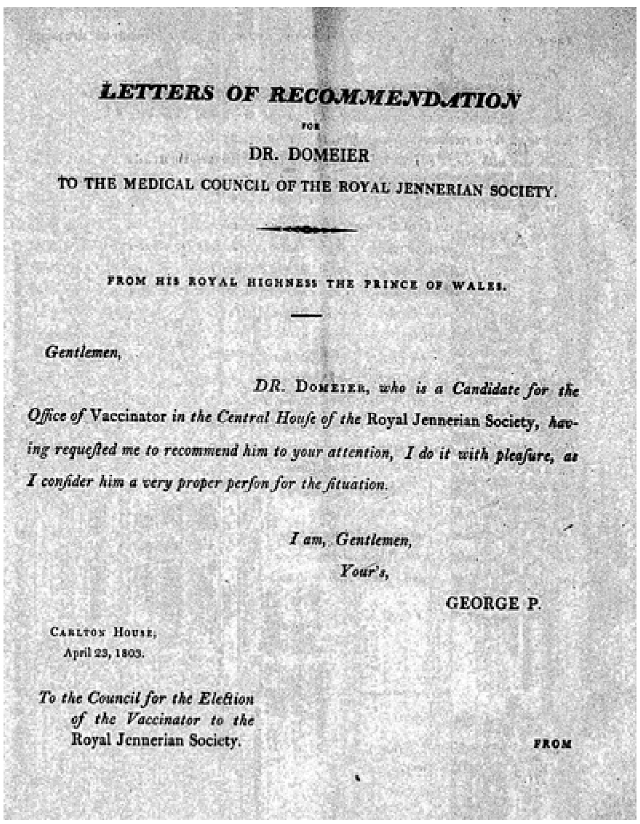
> My dear Mrs Marcet
>
> Understanding that Dr Marcet is one of the Council of fifty appointed to nominate a Resident Physician to the Jennerian Society Mr Romilly and I wish to mention a gentleman whom we believe to be extremely well qualified for the situation Dr Domeier has been ten years Physician to the Duke of Sussex and is an uncommonly clever man, at Lisbon he introduced the vaccine with the greatest success and had the children of the first families under his care,…… he is remarkably well informed and clever in his profession to which he is devoted; His merits as a Physician are well known to all the Royal family ……we cannot presume to do more than mention Dr Domeier's name as a candidate of very great talents I hope you and

Dr Marcet will excuse the Liberty I have taken and believe me to be

Very sincerely yours

A. Romilly

One of several further recommendations on behalf of Dr. Domeier, who had been the royal physician in Hanover, are in the Marcet archive (31). One of these, from the Prince Regent, is shown in Figure 4. The Royal Family were evidently not too worried about publicly exerting influence in favor of Domeier, though the nautical Duke of Cumberland and another writer expressed a surprising anti-foreign feeling (27, 32). The other candidate was a Dr. Walker, who had distinguished himself as a vaccinator in several different places, and he submitted several references, including some from the commanders of the British Fleet referring to his work with the Fleet in Egypt (33). Dr. Walker was elected, and during about three years performed thousands of vaccinations annually (33) .



LETTERS OF RECOMMENDATION

FOR

DR. DOMEIER

TO THE MEDICAL COUNCIL OF THE ROYAL JENNERIAN SOCIETY.

FROM HIS ROYAL HIGHNESS THE PRINCE OF WALES.

Gentlemen,

DR. DOMEIER, *who is a Candidate for the Office of* Vaccinator *in the Central House of the* Royal Jennerian Society, *having requested me to recommend him to your attention, I do it with pleasure, as I consider him a very proper person for the situation.*

I am, Gentlemen,

Your's,

GEORGE P.

CARLTON HOUSE,
April 23, 1803.

To the Council for the Election of the Vaccinator to the Royal Jennerian Society.

FROM

Figure 4*. Letter of recommendation for Dr. Domeier from the Prince Regent. This printed letter is in the Alexandre Marcet Archive of the Biblithiothèque de Genève (31).*

Some of the letters in the Alexandre Marcet archive of the BGE and concerned with inoculation and inoculators were addressed directly to The Board of Directors of the Society, so it would appear that Alexander was also a member of the Board. The direction of the Society was weak, and Dr. Walker was too opinionated for Jenner's taste. Walker had, after all, carried out some fifty thousand vaccinations in all, and he thought himself well qualified to advise and recommend. After a series of unseemly public discussions, Walker was dismissed. There was the usual public exchange of letters, some of these dating to 1806, and they again found their way to Alexander. Dr. Walker set up his own Institution for vaccinating the populace, and the Jennerian Society gradually dissolved, finally expiring in 1808, to be replaced by a publicly funded National Vaccine Institution.

Jenner and Alexander were good friends. Between 1801 and 1814 Jenner wrote Alexander nineteen letters, which are now in the possession of the Royal Society of Medicine. A further letter from Jenner to Alexander dated 2 July 1814 bears witness to their friendship (34).

My dear Doctor

Never shall I forget the jewel of a day when we journeyed together into Essex. I feel as if I am now united to the highest pitch of saturation, bidding defiance to the powers of all decomposition save one which we must all submit to.

This letter continues with an invitation to Dr. and Mrs. Marcet to visit him at his home in Cheltenham, and with a discussion of problems with papers for publication. Apparently the Marcets did not take up Jenner's invitation before 1822 when Alexander died. Jenner himself died in 1823.

Alexander continued his association with de Carro in the context of vaccination. An unsigned letter in the HM-DLU archive (35) to Alexander from Vienna and dated 14 January 1804 was almost certainly written by de Carro. This letter asks whether Alexander has received his work on oriental vaccination and also a packet he wished to send to a Dr. Waterhouse of New Cambridge in America. The work was almost certainly a book, *Histoire de la vaccination en Turquie etc.* De Carro refers to his new son in jocular fashion: "Mme De Carro vient de mettre au monde un candidat pour la vaccination." Alexander had arranged for diplomas of the London Societies to be sent to de Carro but at that time they had not yet arrived.

Walcheren Fever

Alexander was involved with the Royal Jennerian Society throughout its existence from 1802 until 1808, when he was also establishing himself professionally and socially, and whilst *Conversations in Chemistry* was being written and Jane was starting the family. His activity as a fever doctor, as well as his increasing connections with the higher ranks of society, doubtless contributed to him being asked to take over the running of the fever hospital at Gosport, which received thousands of sufferers of Walcheren fever.

In July 1809 a large British army expedition had been sent to the island of Walcheren in the Scheldt estuary to prevent the French fleet using the port of Antwerp as a base to support an invasion of England. As a later Government enquiry confirmed, the British force was inadequately supported and though it lost only 106 men in combat it lost over 4000 men to disease, probably typhoid, but termed Walcheren fever. The ill-fated expedition has been described by Howard (36). The survivors withdrew on December 9, 1809, and returned to England for treatment. Howard mentions the various places to which the survivors were sent for treatment.

Although omitted by Howard, a fever hospital established at Gosport with Alexander in charge also received survivors for treatment. This is evident from the correspondence exchanged between Jane and Alexander in 1809, and now held in Geneva. Treatment was rudimentary, though it seems to have involved the use of Peruvian bark, now known to contain quinine, so this may have helped some victims.

In 1809, whilst Alexander was deeply involved in the Walcheren medical emergency, he was also helping Jane who was revising *Conversations* in 1809 (37), and also advising private patients, such as the daughter of Baron C. P. de Arabet, Susan de Arabet, who wrote twenty four letters to him in 1809 (38) all concerning her own health. Few of his replies are to hand.

Alexander and Berzelius

Alexander was also a friend of the eminent Swedish chemist Berzelius. He stayed with the Marcets in London in 1812 and collaborated with Alexander in chemistry research, principally on the "sulphuret of carbon," nowadays named carbon disulfide (39). The extensive correspondence (34, 40) between Alexander and Berzelius throws light on their social and scientific interests, as well as giving us a first clue as to the identities of the models for the two pupils used by Jane as students in the *Conversations* volumes (18). On 7 December 1812 Berzelius wrote to Alexander (as always, in French), "Many compliments to all our friends and especially to the chemists of the fair sex." These chemists were not named. Less than a year later, in a letter of 14 September 1813 to Alexander, Berzelius discussed Davy and the controversy as to whether the substance we now recognize as elemental fluorine did, or did not, contain oxygen.

The Geological Society and Related Interests

Alexander was also concerned with the genesis of The Geological Society. Geology was another of the scientific interests that were originally stimulated by the researchers in Edinburgh, who effectively laid the scientific basis for the discipline. Alexander receives only a brief mention in the official history of The Geological Society (41), which was founded in 1807. He was not one of the thirteen founder members who started the society, though Humphrey Davy was. Alexander had joined by 1808, and he served as a member of the Council for two periods, 1810-13 and 1814-17. One of the people who counted Alexander as friend and who joined the Geological Society in the same year was the economist David Ricardo. One account (42) of Ricardo's life mentions Alexander as husband of the author of *Conversations on Political Economy*. At about that time Alexander also acted as the Foreign Secretary of the Geological Society, though this would have been before 1810 when the organization of Council and Officers were first formalized (43).

Alexander's interest in geology must have been related to his interest in the beneficial properties of mineral waters, which he collected from many places, both from Britain and abroad, and submitted to chemical analysis. For example, Captain Basil Hall, the sailor and explorer, made a practice of sampling waters during his travels and returning them to Britain for Alexander to analyze. The eminent Brighton Quaker, John Glaisyer, also provided him with samples of mineral waters for analysis, particularly from Brighton. The Glaisyer family name still appears over a pharmacy in Hove, Sussex. Alexander's especial interest in calculi such as kidney stones, which he must have imagined were inorganic in nature, allowed him to produce a book in 1817 (44), the agreement to publish it being drawn up in 1815, as a letter of 4 December from Longmans at Paternoster Row (45) makes clear.

> Agreement &c.
>
> Dear Sir
>
> We are favoured with your letter respecting your book on Calculi, which, we will undertake, with pleasure, on the Plan of dividing Profits similar to that of the

Conversations on Chemistry. It is understood that you are to have 36 copies for distribution. Pray refer M^{r} Thompson to us for payment of his Account.

Believe us

Dear Sir

Y^{rs} very truly

Longman & C^{o}

Table 1 details his classification of calculi, which shows a considerable advance upon a purely descriptive account, but which also emphasizes that Alexander considered them solely in an inorganic chemical fashion, which reflects the state of chemical understanding of the time. A contemporary review of this book was published in the *Edinburgh Review* (46). Study of correspondence reveals that MacCulloch and Leonard Horner apparently wrote this review, though it carries no authors' names.

Table 1. Alexander Marcet's characterization of urinary calculi, adapted from his *An Essay on the Chemical History and Medical Treatment of Calculous Disorders* of 1817, which was reviewed anonymously in the *Edinburgh Review* (46).

Name of calculus	**Appearance**	**Reaction with blowpipe**	**Acids**	**Alkalis**	**Chemical composition**
Lithic	Smooth	Blackens and burns with characteristic smell	Insoluble, pink color with nitric acid	Soluble	Uric acid
Bone-earth	White friable	Infusible	Soluble if powdered. Calcium oxalate precipitate with ammonium oxalate	Insoluble	Calcium phosphate
Triple phophate	White crystals	Yields ammonia and white residue	Insoluble	Soluble; ammonia evolved	Magnesium ammonium phosphate
Fusible	White crystals	Melts to form a near-white globule	Soluble in muriatic acid. Calcium oxalate precipitate with ammonium oxalate	Partially soluble; ammonia evolved	Mixture of phophates
Mulberry	Rough brown as mulberry	Swells to leave calcium oxide	Slowly dissolves	Insoluble	Calcium oxalate
Cystic oxide	Waxy	Decomposes with characteristic smell	Readily soluble	Readily soluble	Cystic oxide (cytine)

During this period Alexander also isolated xanthine for the first time, though he could not then have recognized its true nature. Alexander's discovery of xanthine and the attempts to establish its nature have been fully described (47). Alexander had a chemistry laboratory built in his house in Russell Square, London, and it is evident that Jane used it for carrying out at least some of the experiments recounted in *Conversations in Chemistry.*

The continuing interest of society gentlemen, who were often afflicted by stones, was shown by their reaction to the public disclosure of Joanna Stephens' supposed cure for kidney stones for which she received £5000 from Parliament in 1740. The award was conditional upon its efficacy being proved by many eminent men, including the Archbishop of Canterbury, the Lord President of the Council, and the Speaker of the House of Commons. These gentlemen apparently found that the cure worked, though one wonders why. In Stephens' entry (48) in the *Dictionary of National Biography*, the remedy is described as a powder (of calcined egg shells and snails), a decoction (prepared by boiling herbs with soap), and pills (of calcined snails). Nevertheless, the interest that Alexander Marcet was to take in such stones shows that they were still a significant problem for gentlemen in 1820 and later.

Public recognition of Alexander's contributions came about with his election to the Royal Society as early as 1808. This is even before his service to the sufferers of Walcheren fever in 1809. The citation read as follows (49).

> Alexander Marcet MD one of the Physicians to Guy's Hospital, a Gentleman eminent for his knowledge & acquirements in Chemistry & experimental Science, & author of a paper "on the Analysis of the waters of the Dead Sea & River Jordan" ... We ... recommend him as worthy of that honour...

The sixteen signatories of his nomination included Smithson Tennant, William Allen, Edward Jenner, and William Babington.

The Scottish Connection

Alexander knew several eminent Scots from his time in Edinburgh (1794-1797). He retained connections with them almost until he died. Many of these persons evidently spent part of the year in London as well as in Edinburgh, and some of them eventually became Alexander's patients. Their mutual relationships can be disinterred to a degree from letters in the archive of the National Library of Scotland (NLS).

Among Alexander's contacts were the families of Sir James Hall, 4th Baronet Dunglass, and Thomas Douglas, 5th Earl Selkirk (50). Sir James Hall was born in 1761 and married the Earl Selkirk's sister, Lady Helen Douglas. He became a baronet on the death in 1776 of his father, who had been notable for his interest in geology and chemistry. Sir James went to school in London, where he was supervised by his uncle, Sir Robert Pringle, the king's physician. He then moved to Cambridge, and later made a grand tour of the Continent. He settled in Edinburgh, and attended classes at the University, including some in chemistry under Joseph Black, though there is no record of his graduation. On a second Continental tour he imbibed the basics of chemistry, geology and architecture. He also met Napoleon Bonaparte and many scientists, including Lavoisier. He returned to Edinburgh in about 1785, and in 1786 married the next Lord Selkirk's sister, with whom Alexander subsequently became acquainted.

Sir James eventually became President of the Royal Society of Edinburgh, and was actively involved in the Hutton/Werner geological controversies of the time. He carried out numerous experiments on the effects of heat upon rocks and rock-forming materials, which served to support the Huttonian geological theory. He was one of the first to use platinum vessels in his experiments. Amongst those who proposed him for Fellowship of the Royal Society of London were Henry Cavendish, Humphry Davy and William Herschel. He was losing his memory by about 1811, perhaps due to dementia, but he lived until 1832. He and his wife had five children, included the chemist and geologist John (1787-1860), the travel writer and sailor Basil (1788-1844), who like their father became Fellows of the Royal Society, the painter James (1800-1854), and a rather mysterious William, discussed below. No daughters were ever mentioned in any of this correspondence.

Hall's brother-in-law, Lord Selkirk was educated at Rochement Barbauld's Unitarian school near Cambridge and then at Edinburgh, though he studied neither chemistry nor medicine, but philosophy, in which he was taught by Dugald Stewart. The name Rochemont suggests a connection with Geneva (cf., Pictet de Rochement). Selkirk went to Paris in 1791 with his brother-in-law, Sir James Hall, and the philosophical ferment there stimulated him greatly in the politics of reform. He ultimately became a proponent of the colonization of North America, and was the major activist in the establishment of the Red River colony in Western Canada. He envisaged such settlements as places where Highlanders, who had generally been small farmers living on large private estates in Scotland, could settle and safeguard their Gaelic language and culture. The Highlanders were expelled so that the large estates could be devoted to hunting for gentlemen (51). These expulsions are usually referred to as the Highland Clearances and correspondence shows that Jane disapproved of them. Sir James Hall's interest in the Clearances involved him in a lifetime of political and social turmoil (50). Jane Marcet's great uncle, Sir Frederick Haldimand, as British commander in the American colonies, had also been active in the disputes and politics of North America, so it is not surprising that Jane should have learned from these men and developed her own views on emigration to North America and on the Highland Clearances.

The Halls and the Selkirks were close, and they sought Alexander's advice as a physician, even after he moved to London. The earliest extant letters connecting both Lord Selkirk and Sir James Hall with Alexander are from 1803-1805, concerned with business, but Sir James was also interested in geological controversies, a visit of Mr. Davy, the loss of a child from measles (52), some experiments upon heat and compression, help for his wife from Jane (53), the composition of water from Brighton Chalybeate springs, the purchase of platinum tubes for his experiments (54), how he was going to use the new crucibles that Alexander had procured for him from Cary's in the Strand, and various geological theories (55). As might be expected of an exchange between learned gentlemen, there is little of a personal nature, apart from a ritual greeting to Jane at the end of each letter, and an unexplained sentence at the end of the last of Sir James's letters listed above: "What has become of my flame Miss Cleaver? I hope she is well."

Alexander's Death

Alexander died of "gout of the stomach" in 1822, in the presence of his wife and of Roget, who was a lifelong friend and admirer, perhaps in part because of their common connections to Geneva. Their relationship is described in some detail by Rennison (56) who describes Roget's distress at Alexander's passing. From an obituary which he does not specify but which he ascribes to Roget, he takes two quotations to illustrate the esteem in which Roget held Alexander: "the active zeal with which Marcet was animated for the advancement of knowledge and the interests of humanity" and "the variety of talents and rectitude of judgement which marked his progress in whatever he undertook." In fact, this obituary was published in the *Annual Biography and Obituary* for 1823 (57) as the following more extensive excerpt shows.

> The great number of objects, both public and scientific, which had thus engaged his attention, alone afford strong testimony of the active zeal with which he was animated for the advancement of knowledge and the interests of humanity. The persevering energy with which he pursued those objects, and the variety of talents and rectitude of judgment which marked his progress in whatever he undertook, are evinced by the success with which his exertions have been attended. Endeared as he was to a wide circle of friends, by the excellence of his heart, the warmth of his affections, and his high sense of honour, his death has left a mournful and irreparable chasm in their society. Gifted by nature with that constitutional flow of cheerfulness which imparts the keenest relish for the enjoyments of life, he conjoined with it that expansive benevolence which seeks to render others participators in the same feelings…

The influence of his activity and public spirit extended itself to many other institutions. Besides the leading part he took in conducting the affairs of The Medical and Chirurgical Society, his valuable assistance was also given to the to the Royal Society, the Royal Institution and to the Northern Dispensary. He was principally instrumental, through the late Sir Samuel Romilly and the Hon. H. G. Rennet, in bringing the Institution for the Cure and Prevention of Contagious Fevers, now known by the name of the London Fever Hospital, to the notice of Parliament and thus obtaining a pecuniary grant for that useful establishment. Alexander's reputation as a physician may also be judged from a very flattering anonymous account which was published by the Royal College of Physicians of London and which described him as "a most ardent promoter of useful public institutions, especially of those more immediately connected with his profession" (58). Medical science when Alexander died was still descriptive, without a great deal of understanding of real causes, and exemplified by Alexander's classification of body stones, the true nature of which he could not have understood, though their study contributed to his isolation of xanthine.

Roget's obituary of Alexander (57) also contains a list of some 33 publications ascribed to Alexander, some of which appeared without the author's name.

What was probably a version of his graduation thesis in Edinburgh was published as "History and Dissection of a Diabetic Case," *London Medical and Physical Journal*, 1799, vol. ii. p 209. His purely medical publications included a discussion with Jenner on how to procure fluid vaccine, an account of a French hospice, the dissection of a "blue girl", accounts of cases of hydrophobia, nephritis and of erythema, and of the effects on humans of laudanum, stramonium (thorn apple?), and "oxyd of bismuth" and more theoretical and practical discussions of the natures of urine, alkali in blood, dropsical fluids, chyle and chime, and "calculous disorders." He also published an introductory clinical lecture and a paper in French on vaccination. Somewhat surprisingly he also published a paper about a man who lived ten years after having swallowed a number of clasp-knives and his body after death.

His purely chemical papers concerned the use of silver nitrate as a test for arsenic; potassium and platina; and the inorganic contents of artificial mineral waters and of natural waters, often collected for him from distant places by his acquaintances. Such sources included Brighton, the Isle of Wight, the Dead Sea, and a range of oceans and seas around the world. He was aware of the unreliability of analytical methods, and suggested ways to improve the analysis of sea waters. The paper he wrote with Berzelius was on "the sulphuret of carbon" (39). He was also interested in methods of producing extreme cold, mainly using evaporation and the air pump, and extreme heat. This reflected a wider interest in chemical circles at the time in the nature of caloric.

A single completely unrelated paper is an account of the public state schools of Geneva. This was written for Bishop Howley at a time when the Church of England was trying to expand public education to include the lower classes. An original version of this account is held in the library of the official London home of the Archbishop of Canterbury, Lambeth Palace.

In summary, the material cited here provides an outline of Alexander's professional life. He came to London from Edinburgh in 1797, married in 1800, established himself as a fever doctor and physician at Guy's Hospital, and became physician to many prominent people as well as assisting in several national emergencies including Walcheren fever, the need for vaccination against smallpox, and the threat of Napoleon. He developed a lively interest in several activities within the vigorous and growing scientific community of his adopted country, including research in chemistry, the foundation of the Geological Society, and the initiation of what eventually became The Royal Society of Medicine. Perhaps his most valuable contributions were in the use of analyses to identify biological materials and to the beginning of the widespread application of medicine to protect the health of the public at large.

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About the Author

G. J. (Jeff) Leigh is an Emeritus Professor at the University of Sussex. After a lectureship at the University of Manchester and a year working in Munich with E. O. Fischer, he spent the rest of his employed career at the Unit (later Laboratory) of Nitrogen Fixation in Sussex, from where he published over 200 papers on the chemistry of nitrogen fixation. He first came upon *Conversations on Chemistry* in 1964 in a second-hand bookshop, and was intrigued by the fact that this book had been written as early as 1806 by a woman who was not a recognized natural philosopher. He has since intensively researched her life and that of her husband.

WALTHÈRE SPRING AND HIS RIVALRY WITH M. CAREY LEA

Laszlo Takacs, University of Maryland Baltimore County; takacs@umbc.edu

In the spring of 1894, a bitter dispute appeared on the pages of the *Zeitschrift für anorganische Chemie*, concerning priority over investigations on chemical reactions produced by mechanical energy (1-3). Walthère Spring ended the exchange with the following emotional words (3):

> As the circumstances did not allow me to work without interruption, I published my results in several preliminary papers since 1878 … If my plan will be executed by another researcher, like Mr. Carey Lea, his effort will certainly advance science. But whether I must lose all claims to my existing results, I leave for the judgment of my distinguished colleagues. [Translated by the author.]

Who were the opposing scientists? What was the basis of the dispute? Which party was right? What "circumstances" were behind the unusual sensitivity?

Of the two participants, Matthew Carey Lea is usually credited for establishing mechanochemistry as a separate discipline, as he was the first to show that mechanical action can cause chemical changes that are distinctly different from reactions caused by heat. Lea was an independently rich "gentleman scientist," who worked in his private laboratory in Philadelphia for the advancement of science and for his own satisfaction. Of his numerous papers only four dealt with mechanochemistry. They were his last important works, written between 1892 and 1894, when he was about 70 years old. Lea's life and his contribution to mechanochemistry were discussed earlier on the pages of this journal (4) and elsewhere (5).

The accusing party was Walthère-Victor Spring, Professor of Chemistry at

Figure 1. *Walthère-Victor Spring (1848-1911). Downloaded from the Bestor web site (9).*

the University of Liège, in the French-speaking Wallonia region of Belgium. He was active in several areas of physical chemistry, but his most important topic was the physical and chemical effects of high pressure on various materials and combinations of materials. His first paper on the subject appeared in 1878 (6) followed by comprehensive investigations in the early 1880s (7). Spring did not consider mechanochemistry a fundamentally new discipline as Lea did, but his investigations were more extensive and he started fourteen years before Lea. He continued publishing new results on the subject until 1907 (8), long after the exchange with Lea.

The life and achievements of Spring were described by L. Crismer (10) and a near complete list of his papers was published by E. Bourgeois (11). Only three more recent papers are known about Spring (12-14), but not from the point of view of mechanochemistry. This article focuses on the life of Spring and his research on mechanochemistry. Except for occasional comparisons, the reader is referred to the earlier publications for the details on M. C. Lea's (4, 5).

The Life of Spring

Walthère-Victor Spring was born in Liège on March 6, 1848 (10); thus he was 25 years younger than Lea. His father, Antoine Spring, was a distinguished professor of medicine at the University of Liège. To his father's dismay, the young Walthère had difficulties at school. He struggled with the Greek and Latin languages and had no interest in medicine. The timid boy felt more comfortable in his workshop, where he became highly skilled in working with wood and metal. Spring could easily have been lost to science without the intervention of his godfather, Jean-Servais Stas, the prominent chemist and good friend of Antoine Spring. He saw promise in young Walthère and became his mentor. With the support and encouragement of Stas, Spring entered the School of Mines of Liège in 1866, from which he graduated with high ranking (10).

From 1871, Spring studied science in Bonn. His chemistry professor was Kekulé, who gave him research projects on polythionic acids and the oxygen-containing acids of chlorine. In physics, he measured the thermal expansion and specific heat of metals and also studied the development of electrical charge on mercury as it flows through capillaries; his advisor there was Clausius. Spring's early results were documented in several publications, beginning in 1873 (11).

The programs in Bonn were excellent, the laboratories well equipped, and frequent new discoveries created an exciting environment. Spring could hardly get better preparation for his later role as professor of chemistry. Compared to him, Lea was an amateur. He learned the basics from a private tutor and studied practical chemistry at Prof. James Curtis Booth's consulting laboratory in Philadelphia, but otherwise he was self-taught (4).

Spring joined the faculty of the University of Liège in 1876 (10). His first assignment was a course in mathematical physics. Although he moved on to more fitting topics after only one year, his ability to teach a subject that far from his areas of interest is evidence of his solid general background. The next year he took over the course of organic chemistry and in 1880 added the chemistry of minerals. He remained responsible for those two fundamental courses in general chemistry for the rest of his life. Spring loved research, but first and foremost he was a teacher, and his first priority was to educate his students to the best of his ability. His courses were designed to the highest standard and he never compromised the quality of his teaching for any reason, not even to free up time for research.

One of Spring's early tasks was to develop teaching laboratories for science students. First he set up a temporary facility, and then in 1880 proposed a new world-class laboratory based on his experience in Germany. His meticulously devised plans were considered overly ambitious by the majority of his colleagues. After bitter, often personal fights, Spring's proposal was rejected and he had to settle for a much smaller and less suitable space with significantly reduced funding. This failure had lasting effect on Spring. He had never been comfortable in society, but now the resentment over this incident and the strained relationship with many of his colleagues made him even more withdrawn. Nevertheless, he played a pivotal role in advancing the chemistry curriculum for science and engineering students. His efforts were often met with hostility: while Spring emphasized the importance of solid scientific foundation, many of his colleagues pushed for more practical, directly applicable knowledge.

He fled from the confrontations at the university to an isolated private life. He was close only to his family and a small circle of friends. (His American rival, Lea, was also living the life of a recluse, but primarily for health-related reasons.) For recreation, Spring enjoyed hiking in the Alps. He marveled the beauty of nature and pondered the forces that created it. When he no longer had the stamina for the long walks, he retreated to his property in Tilft near Liège, where he enjoyed working in his garden (10).

Spring died during the examination period of 1911, on July 17. He needed an emergency tracheotomy, and that led to a pulmonary infection. He was survived by his wife, Jeanne Spring, née Beaujean, and two children, Suzanne and Hermann.

Walthère Spring was elected corresponding member of the Royal Academy of Belgium in 1877 and became regular member in 1887, at age 39. Among his many honors he treasured the honorary membership of the German Chemical Society the most (11).

Spring's Research

Spring published over 150 papers, of which only about 25 dealt with the chemical effects of high pressure. For a comprehensive review and a near-complete list of publications see Ref. 11.

Spring wrote his first papers in Bonn, under the direction of Kekulé and Clausius. He demonstrated his independent thinking with a paper on the crystallization process, in which he tried to correlate atomic and molecular volume relationships with crystal structure (15). While his ideas were necessarily naïve, the paper demonstrates Spring's desire to explain observable material properties from atomistic principles. His approach of analyzing a broad collection of data to arrive at general conclusions returned in many of his later studies.

Spring was not only fond of nature but also studied it carefully. With the collaboration of Prost, he measured the flow of the river Meuse and the sediment content of its water daily for a full year. From those data he could calculate that about 5 billion cubic meters of water flowed through that river at Liège during the year and it carried a billion and half kilograms of sediment (16). He also studied the climate of Liège and noticed that the temperature in the city was slightly warmer than the temperature in nearby areas. He explained the difference as a local greenhouse effect due to the large industrial carbon dioxide emission (13, 14). This idea was quite original in 1886, when the paper was published. The formation of rocks, not only by pressure, but also by sedimentation and recrystallization from solution, was also a frequent subject of Spring's works (11).

He invested much time and energy into studying the color of water. In the laboratory, he analyzed light that traveled through 26 meters of water-filled tubes. If the water was extremely pure, free from both solutes and floating particles, its color was blue. But the color of water samples from natural sources was always controlled by their impurities. Spring got interested in this subject in 1883 (17) and occasional papers appeared on the color of water and some other liquids until the end of his career (18). While developing methods to eliminate suspended particles from water, he realized that the particles were visible perpendicular to the light ray due to their scattered light, regardless of their very small size. The ultramicroscope developed by Siedentopf and Zsigmondy also used scattered light to detect submicroscopic particles. To Spring's disappointment, they never mentioned his work (11).

Research on the Effects of High Pressure

Spring's most influential research dealt with the physical and chemical effects of pressure on various materials and combinations of materials. He approached the problem from the point of view of geology, realizing that the high pressure deep inside the earth's crust had to play an important role in the formation of rocks and minerals (10). His interest emerged during his training at the School of Mines and it was reinforced by trips to the Alps. As soon as he got his own laboratory in Liège, he built a compressor and began investigating the compaction and reactions of powdered materials under pressure (6). With varying intensity, he continued the high-pressure studies almost till the end of his life (8). He was always aware of the relevance of his studies to geology. In fact, Crismer rightfully credits him with establishing the "mechanochemistry of geology" (10).

Spring designed and built a compressor using his substantial metalworking experience gained when he was a young boy. The apparatus consisted of a massive lever with a 12.5-fold mechanical advantage, loaded with weights at the far end and pressing on a piston close to the pivot (7). The piston tapered down to only 8 mm in diameter, allowing for pressures up to 25,520 atm, although most experiments were performed below 7,000 atm to avoid permanent deformation of the piston. The compression could be performed in vacuum as indicated by the pumping port shown on Spring's drawing of the apparatus. It is a pity that he did not provide details on the pump and the quality of the vacuum (7).

An unfortunate flaw of Spring's apparatus was that the piston did not fit tightly into the compression cylinder. The gap was a few tenths of a millimeter, sufficient for some material to flow out of the cylinder under pressure. Consequently, his compression was not uniform and uniaxial, but rather an uncontrolled combination of compression and shear. The ambiguous conditions resulted in irreproducible and inconclusive results and a few open disputes (19).

His measurements were interrupted when he accidentally broke his compressor; thus, to secure his priority, he published a short note after compressing only sodium nitrate, potassium nitrate, sawdust and dust from a grinding wheel (6). In order to better mimic the conditions of rock formation, he wetted the powders, expecting that the pressure would remove any excess water. He followed up with a long, comprehensive paper two years later (7). He reviewed ideas on how snow was compacted to ice in glaciers in a lengthy historical introduction, citing observations and explanations by several researchers starting from Faraday. He considered the explanation of Clausius the most plausible: as water expands upon freezing, pressure reduces its melting point. Therefore, compressed snow melts at the asperities (small points of roughness), followed by refreezing as the pressure gets removed by local flow. Water is unique in this respect, as most solids are denser than their melts. Yet, Spring claimed, it could be possible that high enough pressure would increase the interfaces between particles to such an extent, that local atomic movement could result in binding. The process is similar to the flow of a liquid, although it occurs in the solid state. To test this hypothesis, Spring compressed powders of several metals, metalloids, oxides, sulfides, salts and organic materials. The results were mixed, but generally softer materials could be condensed more easily, and Spring attributed this to the larger inter-particle contact surfaces under pressure. He seemed to observe the crystallization of some amorphous materials and the recrystallization of crystalline ones.

The paper described above is mostly about consolidation and not mechanochemical reactions. Yet Spring also tested a few powder mixtures that could react when compressed (7). He expected that pressure would promote or retard the reaction depending on the volume change, according to the principle of Le Châtelier. Indeed, no reaction was observed in a KI + HgS mixture, where the volume would have increased, but a FeS + S mixture reacted readily to form FeS_2 with decrease of the total volume (7). In the next two papers Spring reports on studies of the formation of six metal arsenides (20) and eleven sulfides (21) from elemental powder mixtures. Tin reacted with arsenic easily, but the other reactions required several "compressions," meaning that if a powder did not seem fully reacted, Spring repulverized it by filing and compressed the filings again. In some cases, like the reactions of both arsenic and sulfur with silver, up to eight cycles of compressing and filing were necessary to obtain a uniformly reacted block. Unfortunately, it is difficult to identify the roles of the different steps in such a complicated procedure.

The first dispute over Spring's results erupted in 1883, when Jannettaz, Neel and Clermont published a note, claiming that they tried to reproduce some of Spring's results using an apparatus that could produce pressures up to 100,000 atm, but most materials did not crystallize into a solid block (22). Spring was quick to respond. He contacted Prof. Charles Friedel who suggested the investigation and arranged for a demonstration in his laboratory at the Sorbonne. Spring took his heavy compressor to Paris and showed in front of several witnesses including Neel and Clermont, that, if performed correctly, his experiments indeed provided reproducible results. He reported on the successful demonstration immediately (23), and identified impurities and the presence of air as the most probable causes of the falsely negative results. He also pointed out that he never claimed that every powder could be crystallized by pressure. In fact, only 7 of the 83 materials investigated in his study did. Although Spring's rebuttal seemed more than satisfactory, the incident was widely reported (24) and raised lingering doubt over the validity of his results.

Embittered, Spring worked on. He realized that as several compressions were necessary to induce some metal-sulfur reactions, it was natural to ask exactly how much sulfide formed during each pressing-refiling cycle. He performed chemical analysis after each compression on mixtures of Ag, Pb and Cu with sulfur (25). In each case, the reaction took place gradually; only a few percent reacted during the first pressing and the yield was less than 70% even after six. He mentioned that the incompleteness of the reaction agreed with the observation of Jannettaz, maybe to mend fences with his colleagues in Paris. According to Spring's assessment, pressure was not a chemical agent, but a facilitator that increased the interfaces between the powder particles and thereby intensified chemical interaction.

Spring extended his studies from simple combination reactions to the exchange reaction between barium sulfate and sodium carbonate; the resulting papers are his most cited works (26, 27). In order to quantify the observed changes, he performed chemical analysis that required separating the water soluble and insoluble components by washing. Unfortunately, the presence of water affected the reaction much more than compression did; thus his analysis reflected the state after water was added and not the composition of the dry powder. Correction for the effect of water could not eliminate this problem (19).

A new dispute erupted in 1887, now with William Hallock of the U.S. Geological Survey. In a short and pointed paper, Hallock showed that solids do not liquefy under pressure, but flow in the solid state under large enough load (28). Spring was quick to point out that he never meant true melting, but flow in the solid state that resembled the flow of a liquid. His words were misunderstood and misrepresented (29). This could be true, but misunderstanding is often the consequence of unclear language and Spring's papers often lack clarity. This is understandable in a new research area where the terminology is still ambiguous, but it did result in problems. Hallock was ready to retract to avoid further conflict (30). But he also pointed out that many effects attributed to pressure by Spring were more likely the consequence of kneading due to the uneven distribution of pressure in his compressor or of regrinding the product. Spring's reply is probably the clearest and most compact formulation of his fundamental beliefs: "…pressure is not a chemical agent to the same extent as heat or electricity." It promotes the reaction between particles by increasing the contact surface and kneading is just another way of bringing surfaces into intimate contact, but the reaction itself takes place by ordinary diffusion. The time dependence of some reactions also suggested that diffusion was at play (31).

The Priority Dispute with M. Carey Lea

Spring's interest turned to other subjects during the late 1880s and early 1890s, but when he read Lea's paper on reactions induced by grinding that completely ignored his work (32), he decided to raise the question of priority. Interestingly, the dispute between the American Lea and Belgian Spring played out in the German *Zeitschrift für anorganische Chemie*. This is not an accident: Spring published primarily in Belgian and French journals, but he also wrote summaries and sometimes independent papers in German. Sometimes, like in the case of Ref. 21, the French and German versions differ so little that they can hardly be considered separate publications. Spring was also a member of the editorial board of *Zeitschrift für anorganische Chemie* (11). Lea's approach was quite different. He published his important papers simultaneously in the *American Journal of Science*, in *Philosophical Magazine* (identical except for the British spelling) and in German translation in *Zeitschrift für anorganische Chemie*. Between Spring and Lea, German was the common language. Interestingly, there is no record of the dispute in any other journal.

Lea had given Spring general credit for his work in mechanochemistry in his previous paper (33). But the article that raised Spring's ire (32) was strictly about endothermic reactions, and Spring never even mentioned that the exothermic or endothermic nature of a reaction could make any difference in how a system responds to mechanical agitation. Also, the note claiming priority over Lea (1) contradicts itself, in that he restates that the primary process in mechanochemical reactions is diffusion at the interfaces between particles and the reactions proceed toward chemical equilibrium as usual, while the essence of Lea's claim was that the continued supply of mechanical energy was required to bring about endothermic reactions. (Whether Lea's idea about energy transfer in exothermic and endothermic reactions is correct is another matter.) Spring also remarked that he would continue his long-term plan of experiments "as soon as conditions would permit." Maybe he was overwhelmed by his teaching duties, although he was publishing regularly on other subjects.

Lea was surprised by Spring's claim and refuted it by stating that his objectives, experiments and conclusions were entirely different from those of Spring (2). He reiterated that the possibility of inducing exothermic reactions by mechanical energy has been known for quite some time, but doing the same for endothermic reactions was widely considered impossible. In that sense, he considered his results fundamentally new, while the results of Spring were just further examples of a well-known fact.

Spring's reply immediately followed Lea's note (3). There he said that his "claims were not specifically about one or the other fact of the question but about the topic itself." He considered himself the first to carry out broad systematic investigations on the effects of mechanical action, specifically high pressure, on materials. On that account he was right. He also repeated his complaint about his "circumstances." He said the he was not able to work without interruption, but wanted to assert his ownership of at least the already published results.

Both Lea and Spring continued working after this incident. Lea published only one more paper on mechanochemistry, then moved on to other subjects and died three years later. Mechanochemistry never regained the central position in Spring's research to the degree it enjoyed in the early 1880s. But he did publish a few more papers on the subject, one right after the exchange, probably to demonstrate his continued interest in mechanochemistry (34). His last paper on chemical changes caused by mechanical deformation was published in 1907 (8), only four years before his death.

Spring's Legacy in Mechanochemistry

What is the place of Walthère Spring in the history of mechanochemistry? He was unquestionably the first person to carry out wide-ranging experiments on the compaction of powdered materials under pressure, with a close eye on their implications for geology. He also studied combination reactions and decomposition due to pressure. His questions were revolutionary and the breadth of his studies unparalleled in the 1880s.

The validity of his conclusions is a different matter. Johnston and Adams reviewed the literature on the effects of pressure on the physics and chemistry of solids (19). They were aware of the controversies and opposing views in the area and intended to be "as impartial as may be." Necessarily, they paid substantial attention to the works of Spring. One after the other, they showed that his methods were flawed and his conclusions incorrect. Many, although not all, problems were caused by Spring's leaky cylinder, that never produced uniform compression. This paper appeared in 1913, two years after Spring's passing. Whether the authors delayed the publication intentionally, or it just happened this way, is impossible to tell. Either way, it certainly avoided another exchange of harsh words.

Some of Lea's results are still frequently cited as clear proofs that the chemical effects of mechanical action are different from the effects of heating (4). His results were not only unique at their time, but they are still considered technically correct and one of the clearest demonstrations of the difference between mechanochemical and thermochemical reactions. Accordingly, he is rightfully considered the "father of mechanochemistry." On the other hand, Spring's results were disproved and the current ideas about the effects of pressure are essentially different from his way of thinking. But his works inspired substantial activity, thus they contributed positively to the development of mechanochemistry, especially from a geological point of view. Therefore, he also deserves his place among the early practitioners of mechanochemistry.

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About the Author

Laszlo Takacs is associate professor of physics at the University of Maryland Baltimore County, Baltimore, MD 21250. His primary research interests are mechanochemistry and its applications, including mechanically induced self-sustaining reactions. He can be reached by e-mail: takacs@umbc.edu.

2019 to be International Year of the Periodic Table

In December 2017, the 72nd session of the United Nations General Assembly proclaimed 2019 to be the International Year of the Periodic Table. 2019 marks the 150th anniversary of Dmitri Mendeleev's first version of the periodic table. Observations are being planned by UNESCO, IUPAC (which is also celebrating its 100th anniversary in 2019), and ACS among other organizations.

INTRODUCTION TO AN ENGLISH TRANSLATION OF MARKOVNIKOV'S FIRST PAPER DESCRIBING "MARKOVNIKOV'S RULE"

David E. Lewis, Department of Chemistry, University of Wisconsin-Eau Claire, Eau Claire, WI 54702-4004, USA; LewisD@uwec.edu

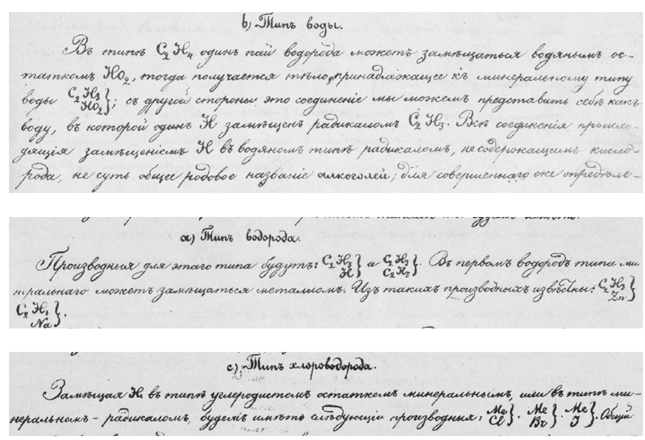
Translator's Preface (1)

Vladimir Vasil'evich Markovnikov (2)

The first volume of the brand new *Zhurnal Russkago Fiziko-Khimicheskago Obshchestva*, published in 1869, contained several key papers, including Mendeleev's first report of his periodic system of the elements (3) and Markovnikov's first publication of his observations on the formation of alkenes and the addition of unsymmetrical electrophilic reagents to unsymmetrical alkenes (4), which is the subject of this translation.

Vladimir Vasil'evich Markovnikov (1838-1904) was born to a member of the lesser nobility near Nizhny-Novgorod, and educated at Kazan University. He entered the university in 1856 as a student in economic science in the Cameral division of the Juridicial faculty, and in later years—despite his position as a leader of Russian organic chemistry—he spoke proudly of the fact that he had completed his degree in *economics*. At that time, Cameral students were required to take two years of chemistry; Markovnikov had intended to satisfy this requirement by study in technology, but following the departure of the Professor of Chemical Technology, Modest Yakovlevich Kittary (1825-1880), for Moscow in 1859, he turned to the course in chemistry taught Aleksandr Mikhailovich Butlerov (1828-1886).

At this time, Butlerov had just returned from his *komandirovka* in western Europe and was cogitating the structural theory of organic chemistry that he had heard in Paris (although he was not yet converted to the views of the structural theorists, Kekulé and Couper). The images in Figure 1 are taken from Markovnikov's lithographed version of his handwritten notes as transcribed by no fewer than three different calligraphers (5). They show that Butlerov had not yet been converted from a Type Theorist to a Structural Theorist.


b) Типъ воды.
Въ типѣ C_2H_4 одинъ пай водорода можетъ замѣщаться водянымъ остаткомъ HO_2, тогда получается тѣло, принадлежащее къ минеральному типу воды $\left.\begin{matrix}C_2H_3\\HO_2\end{matrix}\right\}$; съ другой стороны это соединеніе мы можемъ представить себѣ какъ воду, въ которой одинъ H замѣщенъ радикаломъ C_2H_3. Всѣ соединенія происходящія замѣщеніемъ H въ водяномъ типѣ радикаломъ, не содержащимъ кислорода, не суть общее родовое названіе алкоголей; для совершеннаго же опредѣле-

a) Типъ водорода.
Производныя для этаго типа будутъ: $\left.\begin{matrix}C_2H_3\\H\end{matrix}\right\}$ и $\left.\begin{matrix}C_2H_3\\C_2H_3\end{matrix}\right\}$. Въ первомъ водородъ типа минеральнаго можетъ замѣщаться металломъ. Изъ такихъ производныхъ извѣстны: $\left.\begin{matrix}C_2H_3\\Zn\end{matrix}\right\}$ $\left.\begin{matrix}C_2H_3\\Na\end{matrix}\right\}$.

c) Типъ хлороводорода.
Замѣщая H въ типѣ углеродистомъ остаткомъ минеральнымъ, или въ типѣ минеральномъ - радикаломъ, будемъ имѣть слѣдующія производныя: $\left.\begin{matrix}Me\\Cl\end{matrix}\right\}$. $\left.\begin{matrix}Me\\Br\end{matrix}\right\}$. $\left.\begin{matrix}Me\\J\end{matrix}\right\}$. Общій

Figure 1. *Excerpts from Markovnikov's notes of Butlerov's 1859-1860 course in organic chemistry (5). The headings of the excerpts are, in sequence, "Water Type," "Hydrogen Type," and "Hydrogen Chloride Type."*

Butlerov's view remained unaltered when this course ended, in September, 1860. Markovnikov quickly became Butlerov's enthusiastic disciple, and wrote his dissertation for the degree of *kandidat* in economic science on "Aldehydes and their relation to alcohols and ketones" (6). In it, Markovnikov uses Type theory throughout, showing that Butlerov was still a Type Theorist at the end of October, 1860 (otherwise, we would expect him to have shared his new theory with his star student). This 44-page, hand-written dissertation most closely corresponds to what would be an undergraduate honors dissertation at an American or British Commonwealth university and was used to determine if the student was ready for graduate work. It was not, from my reading, the equivalent of a modern Master's degree as I have asserted on many occasions in the past (7).

Nevertheless, by now he was clearly committed to a career in chemistry rather than a career in economics. Immediately following his graduation with the degree of *kandidat*, Markovnikov became Butlerov's assistant; two years later, he was assigned to teach the course in analytical chemistry. In order to enter the chemistry professoriate, the degree of *Magistr Khimii* (M. Khim.) was required; this degree was the equivalent of a modern Ph.D. In order to obtain this degree, Markovnikov needed to be admitted to the degree program in the Physical-Mathematics Faculty. However, since his *kandidat* degree was in the Juridicial Faculty, he could not become a graduate student in the Physical-Mathematical Faculty. It required Butlerov's intervention and strong recommendation for Markovnikov to be permitted to pursue the M. Khim. (just as Butlerov would later have to do for Aleksandr Mikhailovich Zaitsev). In 1863, Markovnikov had passed all the required examinations, and in 1865 he presented and successfully defended his M. Khim. dissertation, "On the Isomerism of Organic Compounds" (8).

Upon his graduation, Markovnikov was immediately promoted to Extraordinary Professor of Chemistry and shortly thereafter he was awarded a two-year *komandirovka*, which he spent mainly in Germany, in the laboratory of Hermann Kolbe. In Kolbe's laboratory, Markovnikov was allowed much more freedom than the other *Praktikanten* because he already held an advanced degree. Here he began working on the consequences of structural theory, and he became a strong advocate for acknowledging his mentor's (Butlerov's) claims for credit as one of the developers of structural theory (9, 10).

In Berlin, early in his *komandirovka*, he had been asked a very simple question by Graebe: "Why is the chlorine in acetyl chloride different from the chlorine in ethyl chloride?" This set in motion his thoughts on the mutual influences of atoms in a molecule that became the subject of his *Doktor Khimii* dissertation (11), and led to the publication of this paper in the inaugural volume of the *Zhurnal*.

The Translation

Many of the problems associated with the translation of pre-Soviet Russian into English have been addressed in the translators' preface to our translations of Kizhner's pioneering papers on the base-promoted decomposition of hydrazones to give hydrocarbons (12), and the reader is referred to that paper. It is worthwhile repeating the caveat that a literal (or close to literal) translation of the Russian original will result in very stilted English prose. Many Russian authors tend to write exceptionally long sentences, so it is not unusual to find that a whole paragraph may consist of a single sentence. In contrast to Markovnikov's *M. Khim*. and *Dr. Khim*. dissertations, where the writing certainly fits this pattern, the writing in this short paper is not full of such over-long sentences. Nevertheless, where necessary, I have permitted myself the small luxury of breaking overly-long Russian sentences into shorter English ones. In making these stylistic changes, I have sought to preserve the author's meaning, while making the English readable. It is my hope that I have accomplished this goal in the translation that follows.

Markovnikov's Russian is not always straightforward and free of idioms, and his quest for clarity of ideas sometimes leads to exactly the opposite outcome, often making it necessary to deduce the meaning of the archaic idioms and terms from the chemistry before translating the paper into good idiomatic English. The single reference in the original paper (to Markovnikov's *Dr. Khim*. dissertation, 11) has been relocated to the end of the translation in conformity with *Bulletin* practice.

As with any translation, there are places where a literal translation of the original into English leads to ambiguity. In those places, I have chosen to preserve, as best as I could, Markovnikov's intended meaning, rather than adhering slavishly to a verbatim translation. I trust that the reader will forgive these minor adjustments.

References and Notes

1. The transliteration from the Cyrillic alphabet presents a recurring problem for western writers, translators and publishers referring to Russian authors and articles. The exact transliteration used will depend on the writer, and on the language into which the article or name is translated/transliterated. In this paper, I have adhered to

my previous practice of transliterating the Cyrillic using the BGN/PCGN romanization system for Russian as the most intuitive for English speakers. In this system, the name of the subject chemist becomes Markovnikov. In German, Markovnikov's name is transliterated as "Markownikoff," and this spelling was also seconded to English until the last quarter of the twentieth century. In French papers, Markovnikov's name was transliterated as "Markovnikoff."

2. Obituaries of Markovnikov are available in several languages. (a) Russian: I. A. Kablukov, "Vladimir Vasil'evich Markovnikov (biograficheskiya svedeniya i kratkii ocherk nauchnykh rabot) [Vladimir Vasil'evich Markovnikov (biographical information and a brief essay on his scientific work)]," *Zh. Russ. Fiz.-Khim. O-va.*, **1905**, *37*, 247-303. (b) German: H. Decker, "Wladimir Wasiliewitsch Markownikoff," *Ber. dtsch. chem. Ges*., **1905** *38*, 4249-4259. (c) English: E. J. Mills, "Wladimir Wasiljewitsch Markownikoff," *J. Chem. Soc*., **1905**, *87*, 597-600. For other English-language biographies, see (d) H. M. Leicester, "Vladimir Vasil'evich Markovnikov," *J. Chem. Educ*., **1941**, *18*, 53-57. (e) G. V. Bykov, "Markovnikov, Vladimir Vasilevich," *Complete Dictionary of Scientific Biography*, 2008. (f) D. E. Lewis, *Early Russian Organic Chemists and Their Legacy*, Springer Verlag, Heidelberg, 2012, pp 64-69.

3. D. Mendeleev, "Sootnoshenie svoistv s atomnym vesom elementov [The correlation of properties with the atomic weights of the elements]," *Zh. Russ. Fiz.-Khim. O-va.*, **1869**, *1*, 60-77.

4. V. Morkovnikov, "K voprosu o vznaimnom vliyanii atomov v khimicheskikh soedineniyakh [On the question of the mutual influence of atoms in chemical compounds]," *Zh. Russ. Fiz.-Khim. O-va.,* **1869**, *1*, 242-247.

5. This is clear from the lecture notes of his course in organic chemistry taken by Markovnikov during the 1859-1860 academic year. ***Organicheskaya khimiya, sostavlennaya po lektsiyam ord. prof. A. M. Butlerova stud. Vl. Morkovnikovym [Organic chemistry compiled from the lectures of Ord. Prof. A. M. Butlerov by student V. Morkovnikov]***, Lit. A. Petersen at Kazan, 1859-1860 (166 pp). (Department of manuscripts and rare books of the N. I. Lobachevskii Science Library, Kazan Federal University.) Throughout these notes, Butlerov is a firm Type Theorist. The notes were published by Markovnikov at his own expense.

6. V. Markovnikov, "O al'degidakh i ikh otnosheniyakh k alkogol'am i ketonam [On aldehydes and their relationship to alcohols and ketones], Kand. Diss., Kazan, 1860.

7. For example, Ref. 2(f), p 34.

8. V. Markovnikov, "Ob izomerii organicheskikh soedinenii [On the isomerism of organic compounds]," M. Khim. Diss., Kazan, 1865.

9. H. M. Leicester, "Kekulé, Butlerov, Markovnikov: Controversies on Chemical Structure from 1860 to 1868," in R. F. Gold, Ed., *Kekulé Centennial*, *Adv. Chem.*, **1966**, *66*, 13-23.

10. D. E. Lewis, "Static to Dynamic: The Transformation from Chemical Structure to Reaction Regiochemistry," *Angew. Chem. Int. Ed.,* **2018**, *57*, accepted for publication.

11. V. Markovnikov, "Material'ny po voprosu o vzaimnom bliyanii atomov v khimicheskikh soedineniyakh [Materials on the mutual influence of atoms in chemical compounds]," Dr. Khim. Diss., Kazan, 1869, p 86. By convention, this was also published under the same title as a contribution to *Scientific Notes of Kazan University*, 1869.

12. V. Suntsov, D. E. Lewis, "Introduction to an English translation of Kizhner's pioneering papers on deoxygenation," *Bull. Hist. Chem*. **2015**, *40*(2), 61-64.

About the Author

David E. Lewis, a former Chair of HIST, is Professor of Chemistry at the University of Wisconsin-Eau Claire. He is a synthetic organic chemist with interests in asymmetric synthesis and the synthesis of new probes for fluorescence microscopy, and is the author of *Advanced Organic Chemistry* (Oxford University Press, 2016). He is also a historian of organic chemistry with particular emphasis on the development of organic chemistry in Russia. His works in English have been translated into Russian, and he is the author of *Early Russian Organic Chemists and Their Legacy* (SpringerBriefs in the History of Chemistry, 2012). He is the recipient of the 2018 HIST award.

PRIMARY DOCUMENTS

ON THE QUESTION OF THE MUTUAL INFLUENCE OF ATOMS IN CHEMICAL COMPOUNDS

V. Morkovnikov (1)
*Zhurnal Russkago Fiziko-Khimicheskago Obshchestva, **1869**, 1*, 242-247
Translated by David E. Lewis

I. The Conversion of Isobutyl Alcohol into Tertiary Pseudobutyl (2) Alcohol.

Much attention has already been paid to how the mutual influence of atoms is manifested in the elimination of hydrohalic acids from halides (3), in particular. I have formulated the general law that is seen in these reactions, as follows: *If an alcohol or a halide loses water or the hydrohalic acid, in the form of water, or acid, along with hydroxyl (OH) or halogen, the hydrogen bonded to the carbon directly linked to the carbon atom to which the hydroxyl or halogen was bound is always lost* (4). On the other hand, I have also suggested that the reverse reactions, i.e., when water or hydrohalic acids are added to unsaturated hydrocarbons that are not symmetrically constructed, the former are distributed in such a way that *the hydroxyl or the halogen always bonds to the least hydrogenated carbon* (5). The direct consequence of these two provisions is that when *eliminating* water from a *normal* alcohol containing more than three carbon units, we cannot obtain a *normal* homologue of ethylene, nCH_2 (6), and that by sequentially eliminating water from a primary alcohol and then adding water (7), one must move to secondary or tertiary pseudoalcohols. Thus, normal butyl alcohol should give the normal isomer of butylene, $4CH_2$ (8)

$$\begin{array}{l} CH_2OH \\ CH_2 \\ CH_2 \\ CH_3 \end{array} \quad - \quad H_2O \quad = \quad \begin{array}{l} CH'_2 \\ CH \\ CH_2 \\ CH_3 \end{array}$$

1st isomeric butylene

By attaching the hydrogen iodide to this butene also, we should get the iodide from the secondary pseudobutyl alcohol of de Luynes:

$$\begin{array}{l} CH_3 \\ CHJ. \\ CH_2 \\ CH_3 \end{array}$$

Similarly, isobutyl alcohol should go to the tertiary alcohol of Butlerov (9).

$$\begin{array}{c} CH_2OH \\ CH \\ \overbrace{2CH_3} \end{array} \quad - \quad H_2O \quad = \quad \begin{array}{c} CH'_2 \\ C' \\ \overbrace{2CH_3} \end{array}$$

isobutyl alcohol — 2nd isomeric butylene

$$\begin{array}{c} CH'_2 \\ C' \\ \overbrace{2CH_3} \end{array} \quad + \quad HJ \quad = \quad \begin{array}{c} CH_3 \\ CJ \\ \overbrace{2CH_3} \end{array}$$

tertiary pseudobutyl

Due to the difficulty of obtaining a normal alcohol, I used isobutyl alcohol (fermentation alcohol) for the study in this specified area. For my study, the alcohol boiling at 105-110° after multiple fractional distillations was used. The iodide prepared from this alcohol was subjected, in turn, to fractional distillation into several separate fractions; the 1st was collected from 115° to 118° and the 2nd from 118° to 123°. The determination of iodine in the product boiling from 118° to 123° gave 67.7% iodine; the formula C_4H_9J requires 69.02%. Consequently, this fraction contains a small admixture with amyl iodide. But the transformation of the tertiary alcohol into the iodide showed that both distillates mainly consisted of C_4H_9J.

Since Butlerov has shown that the butene obtained from a tertiary alcohol,

$$\begin{matrix} CH'_2 \\ C' \\ \overbrace{2CH_3} \end{matrix},$$

on bonding with HJ, also gives the iodide of the tertiary alcohol, I prepared my butylene by heating isobutyl iodide with a strong alcoholic solution of potassium hydroxide. It was, without much preliminary examination, directly converted to the iodide by shaking with fuming hydriodic acid. In general, this immediately led to the formation of an oil; the formation of the compound is so easy that shaking just a few tens of times led to the complete absorption of the gas. The resulting iodide boiled almost without decomposition at 98°-100°, if isobutyl iodide boiling from 115°-118° was used in its preparation; the later fraction, which boiled from 118°-123°, also gave an iodide, boiling from 98°-101°. At the same time, a part of the iodide was treated separately with freshly prepared silver oxide in the presence of water. This immediately resulted in the formation AgJ and the liquid acquired a strong camphor smell peculiar to the tertiary alcohol. The alcohol was isolated from the aqueous solution by drying with fused potash. When distilled over metallic sodium, both portions gave almost the same boiling point 81°-82°, 82°-83°. The latter, which was obtained from the iodide boiling at 115°-118°, solidified at once to a crystalline mass; the other fraction of the tertiary alcohol I could not get in a crystalline form, which was probably due to minor impurities and extraneous matter.

The boiling points of the iodide and alcohol, as well as the characteristic smell of the latter and the ability to crystallize it with a little cooling, show beyond doubt that I was dealing with tertiary pseudobutyl alcohol.

The results reported fully confirm my above conclusions.

Kazan, October 1869.

References and Notes

1. [The spelling of Markovnikov's name here would appear to be a misprint, but it is interesting to note that with the emphasis on the second syllable of the name, Markovnikov and Morkovnikov would sound alike when spoken aloud. The following explanation is provided by A. V. Zakharov (in *Kazan University: Chronology of the Formation and Development of the Chemical Laboratory and the Kazan School of Chemistry. Part I. 1806-1872*. Kazan University Press, Kazan, 2011; p 406, footnote 410); note that he cites verbatim from the biography of Zaitsev by Klyuchevich and Bykov: "Writing his family name using **o**—M**o**rkovnikov—was almost universal in official documents and journal articles in the 1860s, although it also occurs much later [*emphasis added*]. Markovnikov himself explained that Butlerov kept writing the first syllable of his name using **o**, and that he was imitated by others. According to the original version by A. Klyuchevich and G. V. Bykov, 'on admission to the university, he was named just M**o**rkovnikov on the passport. He later corrected it to "M**a**rkovnikov,"' [but] Butlerov did not always remember about this." (A. S. Klyuchevich and G. V. Bykov, *Aleksandr Mikhailovich Zaitzev (1841-1910)*, Kazan University Press, Kazan, 1980, p 18). —DEL]

2. [The prefix pseudo- is used to indicate branching of the main chain or its specific branching at the site of the functional group. Thus, both secondary alcohols and tertiary alcohols are referred to as pseudoalkyl alcohols. To distinguish the secondary from the tertiary alcohols, the tertiary alcohols are almost always referred to as tertiary pseudoalkyl alcohols. —DEL]

3. [The Russian term is the compound noun *galoidoangidrid* (haloidoanhydride), either used because these compounds were generally made from alcohols and the acids, or used to represent the fact that the compound is formed by the hydrocarbon gaining a halogen and losing a hydrogen. The balanced equation shows the replacement of water (dehydration) by the hydrogen halide to give the alkyl halide. —DEL]

4. [In modern terms, this would be specified as the β carbon. The major point that Markovnikov is making here is that the groups lost during an elimination reaction are lost from adjacent carbon atoms. —DEL]

5. See: Materials on the mutual influence of atoms, etc., p 86. Scientific Notes of Kazan University, 1869.

6. [This sentence is directed at the conventional wisdom of that time, held by a number of eminent chemists, that *n*-alkenes were chains of methylene groups with

the unsatisfied affinities at the terminal carbons, or what we would today call terminal carbenes. In fact, in his M. Khim. dissertation, and culminating in his Dr. Khim dissertation, Markovnikov had used addition reactions to prove that the unsatisfied affinities of alkenes are not on the terminal carbon atoms, but are, instead, on adjacent atoms (V. Markovnikov, Materials on the mutual influence of atoms in Chemical Compounds. Dr. Khim. Diss., Kazan, 1869; pp 30-31.) Markovnikov held what we would now call straight-chain 1-alkenes to be "normal" alkenes. The structure here for the first isomeric butylene is based on his Dr. Khim. dissertation, and the condensed formula above it is simply relaying the fact that the molecular formula corresponds to a tetramer of methylene. —DEL]

7. [This is describing the dehydration–rehydration sequence beginning from an alcohol. —DEL]

8. [There is a typographical error here; the CH carbon should be designated CH'. —DEL]

9. [The product is not the alcohol (*tert*-butyl alcohol) itself, but rather its iodide. —DEL]

HIST Elections 2018

Nominations are open for several posts within the Division of the History of Chemistry (HIST).

If you would like to nominate a HIST member for any of the positions listed below, please contact one of the members of the Nominations and Elections committee by September 30, 2018. Self-nominations are welcome.

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- Chair-Elect (2019-2020), to be Chair in 2021-2022 and immediate past chair in 2023-2024;
- Secretary-Treasurer (2019-2020);
- Councilor (2020-2022 term);
- Alternate Councilor (2020-2022 term) NOTE: no incumbent is running.

The positions and duties are described in HIST bylaws, available at http://www.scs.uiuc.edu/~mainzv/HIST/bylaws/bylaws-oct1995-HIST.pdf

One must be a member of ACS AND of HIST to be eligible for any of these positions.

To make a nomination (including a self-nomination) or an inquiry about any of these positions, please contact the chair of the Nominations and Elections committee, Gary Patterson (gp9a@andrew.cmu.edu) by September 30, 2018.

Thank you for your interest and membership in HIST!

Vera Mainz, Sec/Treas HIST for CHAIR of the Nominations and Election Committee

FORGOTTEN CHEMISTRY TIME CAPSULE REVEALED THE STORIES OF TWO EARLY FEMALE CHEMISTRY PROFESSORS

Mark A. Griep, Department of Chemistry, 736 Hamilton Hall, Lincoln, NE, 68588-0304; mgriep1@unl.edu

Abstract

On May 12, 2014, the Avery Hall cornerstone on the University of Nebraska-Lincoln campus was chiseled open to retrieve the time capsule inside. The capsule contained a collection of objects that summed up the Department of Chemistry as it was in 1916. Its historically most important object was the sole copy of a biography of Dr. Rachel Lloyd, the first American woman to earn a Ph.D. in chemistry. Shortly after earning her doctorate, she was hired as the second member of the Chemistry Department at the University of Nebraska. The biography was written by her brother-in-law in 1900 and it provided insights about Lloyd's life that were not recorded anywhere else. Prior searches of a dozen libraries and archives had not turned up a single copy of that book. Since many of the time capsule contents were related to the activities of Mary Louise Fossler, associate professor of physiological chemistry at the University of Nebraska, it is likely that she led the effort to create the time capsule. An examination of Fossler's life and career shows that she was at the height of her influence in the department. The looming world war, however, contributed to her decision to leave Nebraska within three years of compiling the time capsule. When the cornerstone was replaced in 2014, a new time capsule was set in place with items from the departments and programs that had occupied Avery Hall between 1916 and 2014.

Introduction

A time capsule is a unique blend of the past, present, and future. When time capsules are opened, those who open them learn how people in the past thought about their legacy (1). Our contemporary expectations about creating, caching, and then opening time capsules in the United States began with the 1876 World's Fair Century Safe in Philadelphia. In a well-publicized event, a selection of items was placed in a large iron safe, which was then locked and stored in a secure location for one century (2). After it was opened for the U.S. Bicentennial in 1976, the safe was replaced by another time capsule to be opened in 2076.

The term "time capsule" was coined in 1939 to describe the Westinghouse capsule, created with much fanfare for the 1939 World's Fair in New York (3, 4). It was a 7.5-foot long torpedo-shaped container of corrosion-resistant cupaloy (99.4% copper, 0.5% chromium, and 0.1% silver) holding 35 everyday objects, a collection of fibers and metals, microfilm, and other objects. After it was sealed, the capsule was buried in a prominent location on the fairgrounds and then covered with concrete. Its opening date is 6939, five millennia after its burial.

The custom of placing objects in building cornerstones has an ancient history in many cultures but placing time capsules in cornerstones became much more common in the U.S. after the 1876 World's Fair Century Safe (1). Since cornerstones are not associated with fixed opening dates, most of the enclosed time capsules are forgotten long before they are discovered during renovation or destruction. Nevertheless, cornerstones continue to be such popular building features that guidelines have been published to help ensure the relevance and longevity of the time capsule and its contents (5, 6). For instance, there are many things that we now know should not be placed in a time capsule such as newspapers, rubber, and plastics because they are prone to rapid decay. It is also recommended that the cornerstone be placed on the northwest corner of the building where the temperatures and humidity experience the lowest daily fluctuations and not on the southeast corner where those fluctuations are greatest.

The contents of some time capsules have proven disappointing (1). For example, a copper box was retrieved in 1991 that had been buried on the University of Massachusetts Amherst campus under a tree in 1878 (7), two years after the Century Safe in Philadelphia. The box was discovered when the tree was damaged and had to be removed. It contained a collection of waterlogged paper items, such as a newspaper, that required special treatments before they could be examined. Another example is a time capsule from 1927 at the University of Washington whose contents were so uninteresting (8) that it became the subject of a satirical piece in *The Onion* (9). Its entire contents were newspapers, a student handbook, an envelope containing a building permit, and a 1927 dime. It was in this frame of reference that the University of Nebraska-Lincoln's (UNL) 1916 Avery Hall cornerstone was opened (Figure 1).

***Figure 1**. Avery Hall Cornerstone on the University of Nebraska-Lincoln campus is inscribed "1916" to indicate the year it was set in place. It is located on the building's southeast corner. The building was ready for occupation in 1919.*

Opening the Avery Hall Time Capsule

The UNL chemistry department was in Avery Hall from 1919 until 1970, when it moved to the newly constructed Hamilton Hall. The time capsule was not opened in 1970 because it had been forgotten. Instead, the journey to open it began in 2012 after an online newspaper search for articles about Rachel Lloyd revealed an article titled "Lays Cornerstone for New Building" in the 22 June 1916 issue of the *Red Cloud Chief* from Red Cloud, Nebraska (10):

> Prof. Benton Dales, head of the Chemistry department of the state university, laid the cornerstone of the new chemistry building Thursday afternoon. Dean Lyman, of the college of pharmacy, Prof. R. J. Pool, head of the Botany department, and a number of instructors and students were all who witnessed the laying of the cornerstone. Copies of city newspapers, the Daily Nebraskan, the 1916 Cornhusker, university catalog, and a number of photographs were sealed in the box placed within the cornerstone. Included in the photographs were pictures of Chancellor Avery, Prof. H. H. Nicholson, first head of the chemistry department, **Prof. Rachel Lloyd, the second head,** [emphasis added; Note: Lloyd served as acting chair of the department in Spring 1892] and photographs of the chemistry societies. A number of chemicals were also placed in the stone."

The statement that there was a photo of Dr. Lloyd in the box was intriguing because the nomination for her to become a National Historic Chemical Landmark (NHCL) was being assembled. As the first woman from the United States to earn a doctorate in chemistry, she became the first female faculty member at a co-educational research institution, the University of Nebraska, where her research contributed strongly to the construction of the Sugar Beet industry in Nebraska (11-14). Lloyd's other legacy is that she encouraged many young women to pursue chemistry graduate and undergraduate degrees. In the 1880s and 1890s, such encouragement was extremely rare at research institutions throughout the world. When she "retired" from the University in 1894 for health reasons possibly related to overwork, her numerous friends and colleagues were very sad to see her leave.

The American Chemical Society (ACS) created the NHCL program in 1992 "to enhance public appreciation for the contributions of the chemical sciences to modern life in the United States and to encourage a sense of pride in their practitioners" (15). More than half of landmarks (40 out of 69) have been for products or processes such as Bakelite and catalytic cracking, about one-third (19 out of 69) have been for the life's work of prominent historical figures such as Joseph Priestley and Percy Julian, and the smallest number (10 out of 69) have been for a place that was the site of numerous seminal findings or is an archive. It became desirable to find a high-quality photo of Lloyd because her only known photo was from the 1895 University of Nebraska yearbook that used the low-resolution dithering process (Figure 2a). Even so, it was reproduced in the important biographical sketch about Dr. Lloyd written by Creese and Creese (11) and then on a wide range of websites.

***Figure 2**. a) Rachel Lloyd's photo from the 1895* Sombrero*, the University of Nebraska's Yearbook. All the photos in the yearbook were reproduced using a method called dithering that relies upon different sized dots.*

b) Rachel Lloyd's much higher resolution photo found in the time capsule. It was the frontispiece of In Memoriam *published after her death by her brother-in-law Clement Lloyd in 1900.*

Soon after finding the 1916 article, the possibility of opening the cornerstone was explored. Besides knowing that it contained newspapers that are prone to decay, a major concern was that vapors or liquids from the chemicals might have escaped to oxidize or dissolve the photos. Since there is no established protocol for opening time capsules, a request for information was submitted to the UNL Chancellor's office. The response was encouraging because it included a protocol: identify funds for the removal and replacement of the cornerstone; provide a justification that is more substantial than planning a nomination; and obtain permission from the Chemistry Department and the units that were presently occupying Avery Hall (Table 1).

***Table 1**. Units Located in Avery Hall since 1919.*

Program	Years of Occupation
Department of Chemistry	1919-1970
Department of Chemical Engineering	1958-2003
College of Journalism and Mass Communications	1972-2002
Women's Studies Program	1998-2003
Department of Computer Science and Engineering	2004-present
Department of Mathematics	2004-present
Center for Science, Mathematics, and Computer Education	2004-present

In late 2013, Dr. Rachel Lloyd was accepted to become a National Historic Chemical Landmark (16, 17). Her nomination had been submitted by the Executive Board of the ACS Nebraska Local Section because she was our earliest ACS member (she joined in 1891), had been an early faculty member at the University of Nebraska (from 1887-1894), had helped launch Nebraska's beet sugar industry (contributing to the state's economy ever since), was a founder of the Nebraska Local Section (in 1895), and had inspired many women to pursue chemical degrees. With the NHCL acceptance in hand, everything fell into place—the cornerstone was removed and the time capsule recovered (18-24).

Contents of the Avery Hall Time Capsule

The time capsule had dimensions of 15 in. × 15 in. × 10 in. and had been created by bending and welding several long copper metal sheets together. The top had to be pried open to gain access to the contents because all the joints were soldered and there was no latch. The exterior of the box had a dusty verdigris oxidation while the interior had the characteristic red-brown color of copper metal. The contents were assembled in seven layers, each sending a different message.

The topmost layer identified the date and contemporary events when the capsule was sealed. It consisted of four newspapers (Figure 3): *Lincoln Daily Star* of 8 June 1916, *Lincoln Daily News* of 8 June 1916, *Nebraska State Journal* of 8 June 1916, and the *Summer School Nebraskan* of 7 June 1916. Some headlines were about the U.S. military build-up as the Great War stagnated in Europe. The U.S. entered the war one year later in April 1917. Other items in the box were also dated June 7th and 8th, giving a very good reckoning of the day the box was sealed. One problem associated with the practice of adding newspapers is that the acidic paper causes significant browning of the newspaper itself and adjacent items. Both outcomes had taken place in this time capsule. In addition, the topmost newspapers were also spotted with fungal growth.

***Figure 3**. a) Newspapers were the last items placed in the time capsule and the first to be removed.*

b) The headline of the Lincoln Daily News *describes military operations related to The Great War.*

The second layer was a yearbook, a bulletin, and a stack of envelopes. The yearbook and bulletin provide context about the university's operations. The yearbook was from the College of Pharmacy and is dated 1916. Mary Louise Fossler, Assistant Professor of Chemistry, helped found the School of Pharmacy in 1915. Her photo in the Pharmacy yearbook indicates that she taught organic chemistry. Of the ten pharmacy faculty, there were two other women—Elsie Day and Leva B. Walker. Day was an instructor of pharmacognosy, the knowledge associated with extracting therapeutics from plants, at the university since 1909. There was also a Pharmaceutical Garden on campus near the Chemical Laboratory building. Walker had been hired to teach botany by the pharmacy school in 1915. The College of Pharmacy and Department of Chemistry were both located in the Chemical Laboratory when the time capsule was created. When the Chemistry Department moved into the New Chemical Laboratory in 1919 (renamed Avery Hall in 1948 when the chemical engineering addition was completed), the Pharmacy School remained in the Chemical Laboratory until it was torn down in 1958 to make way for the Sheldon Art Museum. *The Bulletin of The University of Nebraska* was for the 1915-1916 academic year. There were five sealed envelopes, one of which is labeled "Colors of the Nebraska Section; American Chemical Society; Eosin Pink & Malachite Green." Although it is not known why these colors were chosen, both were synthetic dyes used in cell staining, a topic taught by Prof. Mary Louise Fossler in her organic chemistry course. The 2014 board of the ACS Nebraska Local Section was not aware that its early members had chosen specific colors—a hot pink and a bright green—but immediately began using them again.

The third layer in the box was the 20 May 1916 issue of *Chemical Abstracts* with several loose pages inserted. *Chemical Abstracts* was a periodical published by the ACS that was used by researchers to keep up with the literature because it contained a cross-referenced abstract of every published chemical article, meeting presentation, and dissertation. The stamp on the cover indicates that it was the property of the Chemistry Department Library. Apparently, the symbolism of its addition to the time capsule outweighed the loss of research productivity by its absence from the library. One of the loose pages inside the issue lists the final grades for several chemistry courses. Sixteen students took Chem 4, which was Organic Chemistry 2, taught by Fossler. The sole female in the Spring 1916 course earned the top score. Ten students took Chem 14, which was Food and Sanitary Chemistry taught by Fossler in Spring 1916. Only one student in that course was male. Four students earned grades in Chem 16, which was Advanced Organic Chemistry, taught by Fossler in Spring 1916. Two students earned grades in Chem 34, which was Physiological Chemistry, also taught by Fossler in Spring 1916. The other loose pages were the final exams in Chem 3 and 4, basic organic chemistry, respectively taught by Fossler in Fall 1915 and Spring 1916.

The fourth layer contained photographs, communicating that it was about the people in the chemistry department. On top was a large print of Henry Hudson Nicholson, the Department's first chair. The script on the photograph doesn't give Nicholson's name but it does provide a distinguishing description, "Professor of Chemistry and Director of the Chemical Laboratories, 1882-1905." He hired Dr. Rachel Lloyd for the University in 1887.

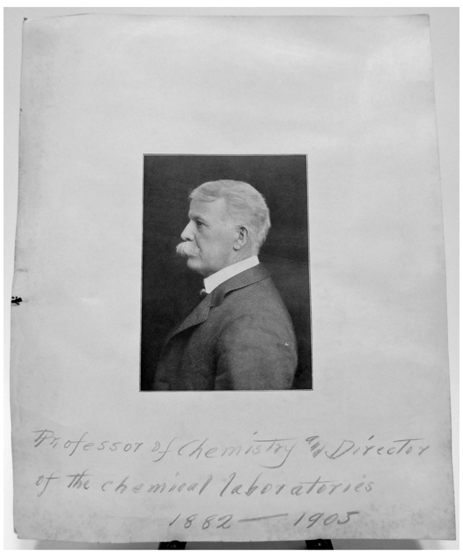
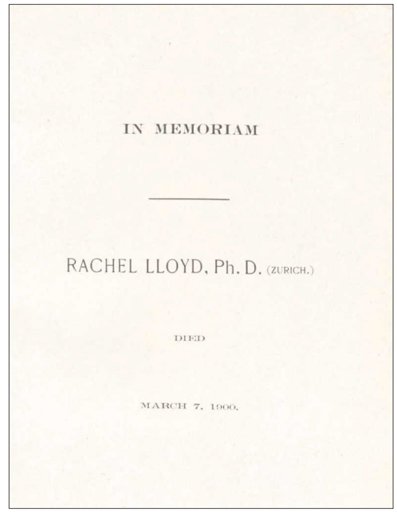


***Figure 4**. A photograph of Henry Hudson Nicholson as promised by the article in the* Red Cloud Chief *of 1916.*

A small white book was located immediately below Nicholson's photo. It was the world's only known copy of *In Memoriam: Rachel Lloyd, Ph.D.* (Figure 5), a biography by her brother-in-law Clement Lloyd (25). The book has now been digitized and is available online (26). Clement self-published the book after her death in 1900 and used an un-dithered image of her 1895 photo as the frontispiece (Figure 2b). It was the only photograph of Lloyd in the time capsule. The book provided insights and details about Lloyd's life that were not available anywhere else. For example, when she was on vacation in the Black Hills of South Dakota in summer 1892, she suffered partial paralysis on her right side from which she never fully recovered. Prior information indicated she had health problems (11, 12, 14) but there was no indication it was a debilitating stroke.



IN MEMORIAM

RACHEL LLOYD, Ph. D. (ZURICH.)

DIED

MARCH 7, 1900.

***Figure 5**.* In Memoriam: Rachel Lloyd, Ph.D. *title page privately published by Clement Lloyd in 1900.*

There were four photographs inserted between the pages of *In Memoriam*—portraits of Fossler and Samuel Avery (Figure 6), and two group photos of the Charter Members of Iota Sigma Pi (Figures 7 & 8). Fossler and Avery had known Rachel Lloyd when they were undergraduates and were now at the University as faculty in the chemistry department. In 1916, Fossler was an Assistant Professor of Chemistry while Samuel Avery had quickly risen to become Chancellor (27, 28). Avery earned his Chemistry B.A. from the University of Nebraska in 1892, his Chemistry M.A. in 1894, and then his Chemistry Ph.D. from the University of Heidelberg in 1896. He returned to Nebraska where he joined the Department of Agricultural Chemistry, became its Chair in 1902, and then the Chair of Chemistry when the two Departments merged in 1905. Next, he served as Chancellor from 1909 until 1927, making him the longest serving

***Figure 6**. Photographs of Mary Louise Fossler and Samuel Avery were inside the copy of* In Memoriam*. They had known Lloyd when they were undergraduates.*

Chancellor at the University of Nebraska. Unexpectedly, there are no photos of the other faculty from 1916—Chair Benton Dales or the new Assistant Professor Clarence Frankforter—perhaps because neither had ever met Lloyd. Also missing from the time capsule were photos of Rosa Bouton and John White, faculty who had been in the Department with Lloyd but were no longer at the University in 1916.

The Iota Sigma Pi chemistry honors society for women was created at the University of Nebraska during the Fall 1912 semester when Fossler and undergraduate Ruth Squires Winchester proposed its creation (29). Within a few months, the group had written a constitution and chose their name as an abbreviation that they translated as "Go, Scientists, Forward." Iota Sigma Pi gave fellowships to women who were pursuing a chemistry degree and encouraged women to become research assistants. The first officers were Edna Miller Gish as President and Ruth O'Brien as Secretary (Figures 7 & 8). The obverse of Figure 7 reads: "—Iota Sigma Pi—; Honorary Chemical Sorority for women. Founded at the University of Washington Oct. 7th, 1911. Charter granted to Nebraska Mar. 24th, 1914."

In Fall 1913, the Nebraska club reached out to Chi Alpha Pi at the University of Washington to propose forming a national society. Chi Alpha Pi was chartered on 7 October 1911 as a women's chemistry honors society. The women at UW were amenable and, on 24 March 1914, the two chapters merged. Nebraska became the Nitrogen Chapter because that element has the same symbol as the state, and Washington became the Oxygen Chapter because oxygen is important for combustion and they hoped to unite with many other chapters. The two chapters agreed to use Iota Sigma Pi as the name of their national organization and Chi Alpha Pi as their motto—because it stands for "Sisterhood for the Advancement of Chemistry."

In January 1916, three more chapters were added when Iota Sigma Pi merged with Alchemeia, a women's chemical honors society in California. The three new chapters were at the University of California in Berkeley (Hydrogen Chapter, for the mother of all elements), Stanford University (Carbon Chapter, "because we may be small but we are everywhere"), and the University of Southern California (Sulfur Chapter, because S also means south and because sulfur is found in nature). Since the Berkeley chapter had been formed earliest, in 1902, they became the mother house.

***Figure** 7. Photo found between the pages of* In Memoriam *shows Fossler (wearing the hat) and the charter members of Iota Sigma Pi in front of the Chemical Laboratory, possibly taken on 24 March 1914. The obverse lists the women as (left to right): Etta Carpenter, Geraldine Kauffman, Susanne Parsons, Edna Miller Gish [President], Ruth O'Brien [Secretary], Mary L. Fossler [Faculty Advisor], Ruth Squires, Sylvia Smith, Nell Ward, and Barbara Osborne.*

***Figure 8**. A second photo of the Iota Sigma Pi charter members in which they rearranged their positions compared to the first. This photo is not labeled on the back but they are (left to right): Barbara Osborn, Susanne Parsons, Catherine Kauffman, Ruth O'Brien (1915 M.A.), Prof. Mary Fossler, Edna Miller (1915 M.A.), Nell Ward (1915 M.A.), Ruth Squires, and Etta Carpenter.*

Three of Nebraska's Iota Sigma Pi charter members earned chemistry graduate degrees based on original research. Nellie Marguerite Ward earned her M.A. in 1915 working with Profs. Dales and Fossler on "Chrysophanic Acid as an Indicator [of pH]." President Edna Miller Gish earned her M.A. in 1915 working with Prof. Dales on "The Magnesia Method for the Separation of the Yttrium Group Earths." Secretary Ruth O'Brien earned her M.A. in 1915 working with Prof. Fossler on "Synthetic Indigo and its By-products." Among all the charter members, O'Brien's career advanced the farthest when she ultimately became the USDA division head for Textiles and Clothing at the Bureau of Home Economics in 1923. In fact, O'Brien has been described as "a dynamic personality that rose up in wrath at the suggestion that 'girl chemists' learn how to type instead of aiming for jobs in laboratories" (30).

The fifth layer of the time capsule was packed with a clay brick (Figure 9), many objects wrapped in paper (Figures 10, 11, 12), and a large tube in the green box (not shown). This layer is about the student research and the objects demonstrate the skills and knowledge they learned. The brick (Figure 9) was made by George Borrowman who dated it June 8, 1916. Borrowman was the first graduate student to earn a Ph.D. from the department, a feat he achieved in 1916. He earned an M.A. in 1907 from the Department working for Prof. Avery on "Chemistry of the Disintegration of Cinder Concrete: Some Nebraska Sands." In 1912, he returned to the department to work on "The Clays of Nebraska," under the joint tutelage of Prof. Dales and Geology's Prof. George Barbour. While analyzing the Nebraska clays, Borrowman devised a way to create green sand that could be used to soften water, a process he patented in 1920 (U.S. Patent No. 1,348,977) and then sold to many cities across the United States, including Chicago where he set up his business (31).

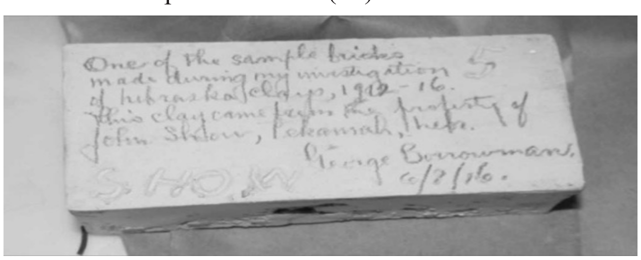


***Figure 9**. This brick was made by George Borrowman, who earned the Department's first Ph.D. in 1916. His message written in pencil says, "One of the sample bricks made during my investigation of Nebraska's Clays, 1912-1916. This clay came from the property of John Show, Tekamah, Nebr."*

George Borrowman.
6/8/16.

The wrapping paper around some of the bottles had been partially burned away by the chemicals, especially the bottle containing stannic alizrate [*sic*] (Figure 10, far right bottle). The alizarin ion complexes may have been contributed by Josephina Estella Graves who earned her master's in 1919 under Fossler's direction for her thesis "Processes with Nitrous Acid on Alizarin." The copy of Graves' thesis in the University of Nebraska Archives includes several pages of dyed cloth samples. Among the other items, a rubber stopper capping one bottle (Figure 11, top bottle) was now granular and emitted a sulfurous odor. The odor from the time capsule was quite strong at this level.

***Figure 10**. The fifth layer contained jars of chemicals wrapped in paper (top). When unwrapped (bottom), the bottle labels were: Ferric Alizarate, Synthetic Indigo, Cerium Rare Earths Fractionated, Alizarin, Chromic Alizarate, and Stannic Alizrate.*

***Figure 11**. Other objects that had been wrapped in paper were a bottle with a decayed rubber stopper that contained many test tubes and to which a note is attached with wire, a sealed glass tube with a note inside that says "G.E. Lewis," a sealed tube that says, "Theta of Alpha Chi Sigma," and a sealed tube that says "Mr. Donald D. Dow."*

The tube that read "G. E. Lewis" contained a photograph labeled "Spectra rare earths; G. E. Lewis" (Figure 12). Garland Edison Lewis was the second student in the department to earn a Ph.D. His 1917 thesis on "Contributions to the Chemistry of the Rare Earths of the Yttrium Group" was guided by Dales. Four years earlier, in 1913, Lewis had earned his M.A. for "Products of Bacterial Action on Sugars." Even though his master's thesis advisor is not listed, this topic was in Fossler's area of expertise.

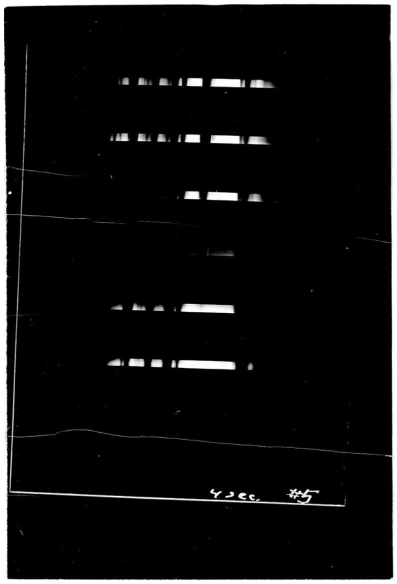
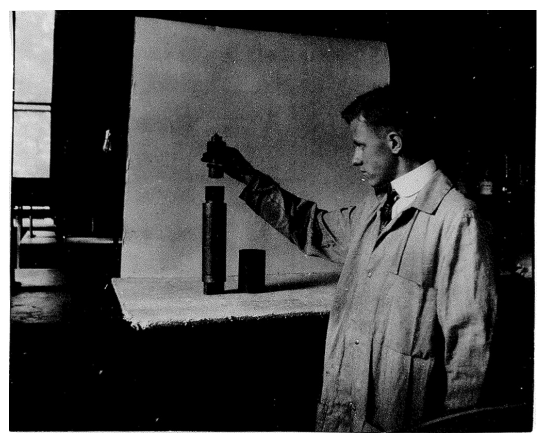


Figure 12. *This photo was in the tube labeled "G. E. Lewis." The back of this photo says: "Spectra rare earths G. E. Lewis."*

The tube in the green box contained two photos (Figure 13) and an explanatory note, all from Herbert Giles Tanner, who earned an M.A. in 1916 for "Preparation of Anhydrous Yttrium Chloride" under the guidance of Dales. One of the photos is enigmatically titled "Oyster Soup" (Figure 13a) and another shows him with his reaction bomb (Figure 13b). The explanatory note gives a summary of his research:

> At present no very satisfactory method of separating the yttrium group earths is known. Dr. Dales thought an investigation of the addition products of the anhydrous chlorides with various organic substances might prove of value. Large amounts of the anhydrous chlorides are necessary. It was found that such could be prepared by heating the rare earth oxides with carbon tetrachloride under pressure. Since glass tubes are found insufficient to withstand the necessary high pressure a steel bomb, shown in the photograph, was constructed. 6/8/16; Herbert G. Tanner

Figure 13. *a) This photo from the tube in the green box shows about thirteen young men and is titled, "Oyster Soup." The fellow closest to the camera appears to be Herbert Tanner.*



b) This photo is titled, "Herbert G. Tanner; June 8, 1916."

The sixth layer included a mimeographed list of Faculty in the Chemistry Department (not shown) and a copy of [*Wohler's*] *Organic Chemistry* that had been translated by Ira Remsen at Johns Hopkins (Figure 14). The textbook was signed one year earlier by "Mary L. Fossler" and is likely the one she used to teach her organic chemistry course. The textbook cover was in an advanced state of fungal decay and was a major contributor to the unique odor of the time capsule.

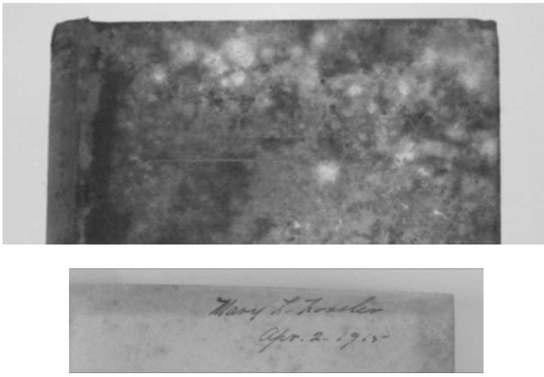


***Figure 14**. a) The cover of Organic Chemistry was in a state of decay due to fungal growth. b) Mary Fossler signed her name on the textbook's first page on April 2, 1915.*

The seventh and bottom-most layer comprised an envelope and a business card. The engraved business card was from the University's construction supervisor, E. L. Goldsmith. The envelope was from B. J. Jobst, General Contractor for the New Chemical Laboratory, which was later renamed Avery Hall. Inside the envelope was a letter on Jobst's business letterhead dated June 7, 1916. Here is the letter reproduced with original spelling and punctuation:

> Gentlemen,:
>
> B.J. Jobst, member of St John,s lodge #25, and contractor of this building requests that when this box is opened the Hon. Board of Regents at this time forward same to my decendents.
>
> It is with a feeling of gratitude that the names hereto affixed join me in the hope that this building may serve as a monument to all modern construction of this time.
>
> B.J. Jobst was born in Peoria, Ill, May 12th-1862 to Emma S. Jobst. Emma Shertz His wife born Jan. 28th-1862 in Limestone, Township, Ill.
>
> Signed B. J. Jobst

Regrettably, Jobst's two children died 20-30 years ago without leaving any descendants.

Replacing the Avery Hall Time Capsule

Before the replacement cornerstone was cemented into place, a new time capsule was created to fill the void where the original had been. Items were collected from the programs that had occupied Avery Hall in the past 98 years (Table 1) with the suggestion to outline their past and present using objects and a few documents.

Mary Louise Fossler's Education and Early Career

If time capsules tell us about the people who assemble them, then this one certainly tells us about the University of Nebraska chemistry department. Perhaps even more so, however, this time capsule tells us about Prof. Mary Louise Fossler because more than half the items have a connection to her life as a student, teacher, researcher, or advisor. In 1916, when she assembled the time capsule, she had been active in the Department for over two decades. The lamentable part of her story is that she left the University of Nebraska within three years of creating this time capsule and probably never had a laboratory or office space in Avery Hall. In retrospect, 1916 was probably a high point in her career.

The Fossler family was among the earliest pioneers of Lancaster County (Figure 15). Her parents had immigrated separately with their parents in the 1850s from Germany to Lima, Ohio, where they met and married. After having two children, George and Mary Louise, the young family moved in 1868 or 1869 to a farm just north of Lincoln. The nearby town of Raymond was platted a decade later. In the earliest years, farm parents in the area took turns teaching the local children in their homes (32). By 1874, when Mary Louise was seven years old, the first schoolhouse was constructed. Unless they were educated at home by their own mother, the Fossler children would have been educated in this school until 1893 when a new two-room schoolhouse was built.

***Figure 15**. The Christian and Katherine Fossler Family circa Summer 1886 in Lincoln. From the left: Christine 14, Christian 49, Mary 18, Margaret 8, Mabel 2.5, George 21, Kate 41, Anna 12.*

After growing up on the farm, Mary Fossler earned her Chemistry B.A. in 1894 (Table 2) and, as mentioned earlier, was an undergraduate laboratory assistant for Dr. Rachel Lloyd. The family obviously valued higher education because Fossler's sisters also earned degrees at the University of Nebraska—Christine, 1893 B.A. and 1904 M.A. Education; Anna, 1895 B.Sc. Zoology; Margaret, 1900 B.Sc. Education; and Mabel, 1907 B.A. Chemistry. Prior to his death in 1898, her brother George earned a teacher's certificate in 1888 at Nebraska State Normal School, taught school, took courses for two years in the University of Nebraska medical program, and then worked for several years at the Nebraska Experiment Station. The family moved to Lincoln around the time of son George's death.

Table 2. Mary Louise Fossler's Training and Career

Academic Training
1894, Chemistry B.A., University of Nebraska (Research Mentor: Dr. Rachel Lloyd)
1898, Chemistry M.A., University of Nebraska (Research Advisor: Dr. Samuel Avery)
Summer 1900, 1901, 1903, Attended University of Chicago
Summer 1902, Attended Northwestern Univ. Med. School, Evanston, Illinois
Positions Held
1894-1896, Weeping Water [*Nebraska*] High School Principal
1898-1900, Adjunct Professor of Chemistry, University of Nebraska
1900-1904, Lecturer in Chemistry, University of Nebraska
1904-1908, Assistant Professor of Chemistry, University of Nebraska
1908-1919, Associate Professor of Physiology, University of Nebraska
1919-1933, Assistant Professor of Biological Sciences, University of Southern California
1933-1938, Emeritus Assistant Professor of Biological Sciences, University of Southern California

After two years as the principal of Weeping Water School, located 30 miles east of Lincoln (Table 2), Mary Louise Fossler entered the University's chemistry graduate program. She also joined the ACS in 1897, which makes her the fourth woman to become an ACS member and the third from Nebraska. Fossler earned her Chemistry M.A. in 1898—the twelfth graduate degree awarded by the department but only the second to a woman. Her advisor was Dr. Samuel Avery and her research concerned the synthesis of phenylglutaric acids, which she published in the *American Chemical Journal* (33). Fossler played an active role in the ACS Nebraska Local Section, serving on the Executive Board eleven times (1900-1909, 1915, & 1919) and as Vice President in 1910 and 1914. The other early female Executive Board members were Rosa Bouton (serving eight times between 1895 and 1907; Bouton was the first woman to earn a master's degree from the University of Nebraska Chemistry Department and the third woman to become an ACS member) and Mariel Gere (serving four times between 1902 and 1906; Gere earned her master's degree in 1899, one year after Fossler).

After earning her graduate degree, Fossler was hired as an Assistant Professor, making her the Department's third female professor (Figure 16). For the four summers from 1900 to 1903, she attended graduate courses at the University of Chicago and Northwestern University Medical School (Table 2). At Chicago, she was listed as a student "not as yet admitted to candidacy" and at Northwestern as a "Special Student." Although her intentions are not clear, she did not earn a degree from either place. Fossler must have been taking classes in physiological chemistry (now called biochemistry) because that's what she taught when she returned to the University of Nebraska in 1904 and because she was promoted to Associate Professor of Physiological Chemistry in 1908. It was around this time that Fossler's father Christian died in September 1906 in Lincoln at age 68.

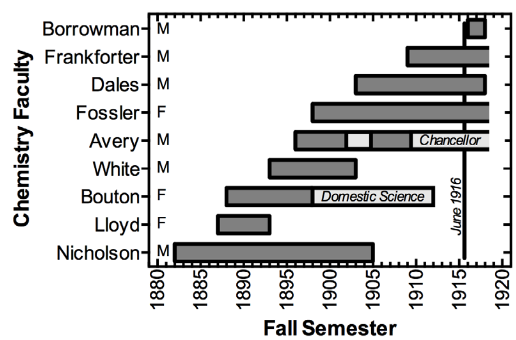


Figure 16. *Chemistry Faculty Timeline at the University of Nebraska, 1882-1918. Rosa Bouton left the Department in 1898 to found the School of Domestic Science at the University. Samuel Avery was Chair of the Agricultural Chemistry Department from 1902 to 1905 and became Chancellor of the University in 1909. The time capsule was assembled in June 1916.*

Fossler's second journal article was published in the *Journal of the American Chemical Society* about "A Safety Siphon" that was useful for preventing spillage when transferring precise but small volumes from a medium or large container (34). She devised it for the students in her Food and Sanitary Chemistry laboratory. Fossler was also an active promoter of membership in science clubs. Although she was the only female member of the Chemistry Club when she joined in 1907 as a faculty advisor, there were several female members by 1912. Described earlier was her role in co-founding Iota Sigma Pi in 1912 and then serving at the Nebraska Chapter's faculty advisor until 1919 when she left the University of Nebraska.

Fossler was an active research advisor, especially for the young women. Between 1913 and 1919, thirty-two students earned master's degrees in the Chemistry Department, seven of them under Fossler's direction. There are an additional two students who do not list an advisor in their theses but whose projects are in Fossler's area of expertise. The only colleague who advised more students during this period was the Chair, Benton Dales—fourteen by himself and two as co-advisor. Of the six women who earned master's degrees during this period, four of them were advised by Fossler, one was advised by Dales, and one was advised by Fossler and Dales.

Fossler's Life and Career After 1916

Even though Fossler was at the top of her academic game in 1916, her clearly reasoned thoughts against the U.S. entry into the Great War had a negative impact on her career. By 1916, the federal government decided it would be best to join the war that had been raging in Europe since 1914 so it began a campaign to sway the public's opinion. As part of a wider dialog in newspapers and magazines during 1917, some faculty at academic institutions across the nation wrote about their sympathies for the German cause or about the unacceptable loss of young lives during any war. To clarify their position at the University of Nebraska, Mary Fossler co-wrote a peace petition that was signed by her and five faculty colleagues on April 2, 1917. Unfortunately, this was four days before the U.S. agreed to join its British, French, and Russian allies in fighting the war. Over the next months, several Nebraska newspapers and State legislators called for the University to pressure its faculty to support the war. Even though Fossler's graduate advisor was the Chancellor at this time, he did little to mediate this pressure on his faculty perhaps because he strongly felt they should support the U.S. government's actions (35). In fact, by 1918, Chancellor Avery was called to Washington DC to serve nine months as assistant chairman of the chemical committee of the National Council of Defense. When the University of Nebraska Board of Regents finally convened its first hearing in June 1918, the very first action was to dismiss the charges against Fossler because there was no evidence that she lacked "aggressive loyalty" (35). The charges against most of the other faculty were eventually dropped, most often because they had already made statements that they supported the government's actions after war was declared.

Also in June 1918, the Nitrogen Chapter of Iota Sigma Pi hosted the first national meeting of Iota Sigma Pi at the University of Nebraska (29). Besides discussing a range of constitutional issues, the assembled members elected Prof. Mary Louise Fossler to a three-year term as President. Unfortunately, Fossler's career was disrupted at just this moment and she was unable to perform her national duties very effectively.

In Fall 1919, Mary Louise Fossler was an Assistant Professor of biological sciences at the University of Southern California (36). There are no statements that explain exactly why she left the University of Nebraska but two factors seem most likely. The first factor is that she may have felt less welcome at a University that had not supported her stance in favor of peace over war. In fact, several of the faculty who were investigated by the Regents in June 1918 left the University of Nebraska within a few years afterward. The second factor was that she was the only member of her family still living in Lincoln.

Fossler's specific choice of USC, which is in Los Angeles, is justified by the presence of her mother and sisters in nearby Pasadena. Fossler's sister Christine was the first in the family to move to Pasadena. In 1912, Christine and her husband moved there to teach at two different schools. They never had children but their presence in Pasadena served as a nucleus for the rest of the family. In 1916, Fossler's mother and two sisters, Margaret and Mabel, moved to Pasadena where they bought a small house. Margaret was a school teacher and Mabel took some classes at USC while also caring for their mother. When Mary Louise Fossler joined them in Fall 1919, they moved into a new house. The family was finally reassembled when Anna joined them in Fall 1921. Anna moved there to become one of the earliest librarians at the Southern Branch of the University of California, which was founded in 1919 and is now known as the University of California at Los Angeles.

While at USC, Fossler taught microbiology and physiology and, in 1925, even created a pre-medical physiological chemistry course, the precursor to today's biochemistry 2. She also maintained her focus on students. Soon after she arrived, the young women in the USC Chemistry program chose her to be the faculty advisor for the Sulfur chapter of the Iota Sigma Pi. Even when she retired in 1933 at age 65, she continued to teach as an emeritus assistant professor. She taught her final course in 1938. It was in these latter years that she developed USC's first course in ornithology. She was a member of the Cooper Ornithological Club and the Pasadena Audubon Society and gave public lectures in both clubs. In June 1935, Fossler presented a talk about the Pacific Coast Division of the American Association for the Advancement of Science about "The Death of Hundreds of Cedar-Waxwings" (37). Apparently, hundreds of these birds settled upon some date palms on the cold, wet morning of March 19, 1935. Shortly after they ate their fill, they hemorrhaged, died, and fell to the ground. An autopsy of several birds led Fossler to propose that the cause was hydrocyanic acid, which had built up in the fruit after prolonged rains and whipping winds.

Mary Louise Fossler died 22 January 1952 in Pasadena at age 84. She is buried with her mother and all four sisters in Mountain View Cemetery, Pasadena.

Mary Louise Fossler's biography was abstracted for two different compendia when she was still an active faculty member in 1921 and 1935 (38, 39). Shortly after her death in 1952, Fossler's scientific obituary was published in *The Auk*, the journal of the American Ornithological Union (40). Her career was summarized more recently in 1998 as part of Mary Creese's multivolume history of women chemists (12). Even so, these biographical sketches don't tell today's reader nearly as much about Fossler as do her selections for the time capsule of 1916. The contents of the time capsule tell us that she was inspired by Dr. Rachel Lloyd's example to use her considerable knowledge and skills to advance student research and interest in chemistry.

Conclusion

The Avery Hall time capsule provides a unique view of a maturing chemistry department in June 1916. It was created for the new and improved building that would house the chemistry department on campus. Unsealed in search of a photograph of Dr. Rachel Lloyd, the first woman to become a faculty member in the chemistry department at the University of Nebraska, its contents revealed so much more about the department's view of itself at the time. A few choice items about the chemistry department's origins, some contemporaneous items, and many unique items relating to the skills of its current graduate students were found. The departmental origins were signified by a list of all current and former faculty plus photographs of Hudson Nicholson, the first chair, Samuel Avery, a Nebraska chemistry student who was now chancellor, and Mary Louise Fossler, a Nebraska chemistry student who was now teaching organic and physiological chemistry. The photograph of Dr. Rachel Lloyd was inside a biography that described intimate details about her life that were not found anywhere else. As the world's first female chemistry professor at a research university, Lloyd's special legacy is that she and Nicholson created a culture in which both young men and young women were encouraged to earn chemistry degrees.

The bulk of the time capsule materials were connected to Fossler, strongly indicating that she assembled it. For example, she included a note saying she had been Lloyd's research assistant as an undergraduate. Fossler's German immigrant parents moved to a farm just north of the university when she was a child. All six of their children earned undergraduate degrees but Mary Louise was inspired to earn her master's degree in chemistry. Afterward, she joined the faculty to teach and mentor graduate research, which she did for almost 20 years. Ironically, Fossler never moved into the new chemistry building. Her public stance in support of peace right before the United States joined the Great War placed her at odds with the dominant sentiment, which must have been uncomfortable. She left Nebraska to join the Biology Department at the University of Southern California, undoubtedly because her mother and sisters were now residing nearby. The full impact of her Nebraska story was tucked away in the forgotten Avery Hall time capsule only to be discovered a century later.

Acknowledgements

I am grateful to the following groups and individuals for making this project a success. The American Chemical Society provided the funds for the National Historic Chemical Landmark program. The ACS Nebraska Local Section and the Department of Chemistry provided the funds for the associated celebration. The removal and replacement of the time capsule was funded by Drs. James and Karen Linder from the University of Nebraska. Ben and Chris Krivda were the stonemasons who removed the Cornerstone in search of the Time Capsule. Jessica Periago, Jon Velasco, Dr. Marilyne Stains, and David

Fitzgibbon helped document the removal and opening of the Time Capsule. The replacement Time Capsule was funded by the Departments of Chemistry, Chemical Engineering, Computer Science and Engineering, and Mathematics. The Krivdas and Mauricio Saavedra replaced the Cornerstone. The University of Nebraska Archives coordinated the digitization of In Memoriam and provided access to archival material. Marjorie Mikasen helped catalog the time capsule contents, discussed many features of this paper during development, and proofread the manuscript.

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Figure 15: reproduced with permission from the collection of the Nebraska State Historical Society.

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About the Author

Mark Griep is an associate professor of chemistry at the University of Nebraska-Lincoln. His research focus is on the interaction between bacterial primase and helicase, two enzymes that act on the lagging strand during DNA replication. He is the co-author with Marjorie Mikasen of *ReAction! Chemistry in the Movies* (2009; Oxford University Press). In 2013, he successfully nominated Lloyd for status as a National Historic Chemical Landmark. In 2017, Griep received the Helen M. Free Award for Public Outreach from the American Chemical Society for his movies project and for his long-term efforts to raise awareness about the life and career of Dr. Rachel Lloyd.

BOOK REVIEW

Cradle of Chemistry: The Early Years of Chemistry at the University of Edinburgh, Robert G. W. Anderson, Ed., John Donald, Edinburgh, Scotland, UK, 2015, 198 + xviii pp, ISBN 978 1 906566 86 9, £25.

This volume collects the contributions of a 2013 symposium on the 300th anniversary of chemistry at the University of Edinburgh. In December 1713, James Crawford was appointed the university's first professor of physick and chymistry. Later in the 18th century, a faculty of medicine was established at the university, and chemistry was taught by such luminaries as William Cullen and Joseph Black.

Overviews of the book can be found in both its first and last chapters, an introduction by editor Robert Anderson and an afterword by Hasok Chang. Anderson notes Edinburgh's pre-eminence for the study of chemistry in the later 18th century, although other nations and institutions would catch up and surpass it in the 19th. Chang looks back at the chapters that precede his, looking for clues on what facilitated the flourishing of chemistry at Edinburgh particularly at the time of Black.

The remaining chapters are arranged chronologically by their main subject. John Henry's chapter on "Science in the Athens of the North" traces the influence of Newtonian ideas via Scots sources not only to continental Europe but even to England. Among the key figures in the chapter are David Gregory, professor of mathematics at Edinburgh, and Gregory's Edinburgh friend Archibald Pitcairne. Gregory became the first Newtonian professor at Oxford. Pitcairne brought a Newtonian conception of medicine to the University of Leiden where he briefly taught.

The influence of Leiden on chemistry at Edinburgh is the subject of John Powers's chapter. Powers describes the chemistry of Herman Boerhaave and examines the courses of the first two Edinburgh chemists, both of whom had studied under Boerhaave at Leiden. Boerhaave's chemistry course was more theoretical than what preceded it, expanding it from a predominant emphasis on medical preparations to a conceptual framework of chemical "instruments" (namely fire, air, water, earth, *menstrua* (essentially solvents), and vessels). Edinburgh's first chemist, Crawford, appears to have modeled his course after Boerhaave's. Andrew Plummer, the member of the founding medical faculty who did most of the teaching of chemistry, appears to have taught a more preparations-focused course; however, Plummer's research in chemistry shows interest in Boerhaave's theory.

Georgette Taylor takes up the pedagogy of Plummer and his much better known successor, Cullen. The latter has a reputation as an effective and innovative teacher. That reputation is amply supported by copious historical evidence in the form of lecture notes, letters, and diaries of students preserved in various archives. Historical evidence about Plummer's teaching is much scarcer. Much less of the sort of evidence that establishes Cullen's reputation survives in Plummer's case. And on the basis of much more limited evidence, Plummer's reputation as an instructor—deservedly or not—is much worse. Taylor's paper raises fascinating questions of historiography: how to treat scarce evidence? what if anything can be read into its very scarcity?

The next five chapters touch on aspects of Joseph Black's time at Edinburgh, the last four decades of the 18th century. John Christie noted that students at the

Edinburgh school of medicine were not just passive recipients of their professors' professions. The student Medical Society (Royal Medical Society after it gained a royal charter in 1779) was just the most prominent forum for student papers and debates. Both phlogistic and antiphlogistic chemistry found student champions there. Matthew Eddy treats diagrams and tables Black used in teaching. They were visually simple but not self-evident, and this combination made them pedagogically effective.

The next three chapters deal more with artifacts than documents. Tom Addyman describes an archeological investigation in the Old College quadrangle of the University. Apparatus and chemical samples, likely dating to the time of Black and his successor Thomas Charles Hope, were found. Some of the glassware resembles the work of Archibald Geddes of Leigh Glassworks, a likely supplier to Black. A. D. Morrison-Low's chapter treats 18th-century chemical apparatus in a better state of preservation, namely pieces in the collections of the National Museums of Scotland. Items donated by Lyon Playfair during his tenure as Professor of Chemistry at Edinburgh include materials associated with Black and Hope. Peter Morris's chapter is on the location of Black's last home in Edinburgh and his place of death. In addition to an interesting piece of historical detective work, Morris observes that the dwellings of historical figures are not always noted or protected.

Anderson's own chapter focuses on Black's successor as professor of medicine and chemistry, Thomas Charles Hope. A comparison of Hope's career to Black's can hardly come out in Hope's favor. Still, Anderson notes that Hope was conscientious and his course rigorous and highly enrolled.

Andrew Alexander treats several important figures of the later 19th century story of chemistry in Edinburgh. These include the next three professors after Hope, a notable assistant, and a famous student. William Gregory was Hope's successor, but as professor of chemistry rather than chemistry and medicine. He published his own textbook. Lyon Playfair became the next professor of chemistry in 1858 after Gregory's death. Playfair was already a public figure at this time, and he returned to public life in London in 1869. Playfair appointed Archibald Scott Couper as one of his assistants to start in early 1859. Couper had left the laboratory of Charles-Adolphe Wurtz in 1858 amid recriminations over a delayed publication: Couper's recognition of the tetravalence of carbon got into print only after one by August Kekulé. Couper had a mental breakdown in May 1859 and was institutionalized in Glasgow. Playfair's successor as professor was Alexander Crum Brown, who also worked in structural chemistry. One of Brown's chemistry students was Arthur Conan Doyle, a medical graduate of Edinburgh. Doyle's literary creation, Sherlock Holmes, made considerable use of chemistry.

Carmen J. Giunta, Le Moyne College; giunta@lemoyne.edu

ESHS London 2018

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Dr. Carmen J. Giunta, Editor
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Department of Chemistry
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