THE CHANGING CONTENT OF *CONVERSATIONS ON CHEMISTRY* AS A SNAPSHOT OF THE DEVELOPMENT OF CHEMICAL SCIENCE

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Mrs. Marcet's two-volume *Conversations on Chemistry* was initially published anonymously in 1806 (1). The name of the author, Jane Marcet, first appeared on the thirteenth edition of 1837 (2), though her name and reputation were widely known long before then. A biography of Jane Marcet has been published (3), and there are numerous short articles about her, principally concerning *Conversations on Chemistry* and another popular book *Conversations on Political Economy*. *Conversations on Chemistry* was one of the most influential chemistry books of the nineteenth century. The way in which it came to be written has recently been described in detail (4, 5) though other writers have provided some of the background material (6). The appearance of the title page and the kind of content, a series of dialogues between two students and a teacher, were not novel for the period, and even already a little dated in 1805. That the anonymous writer and the teacher in the book, Mrs. B, were both women certainly was novel. Even more noteworthy is that the preface states that the book was directed at women. It also described experiments that could be performed at home, perhaps in the kitchen, though most were originally performed by Mrs. Marcet in the laboratory set up by her husband in her father's house in St. Mary Axe, in London. It is remarkable that a popular chemistry book first published in 1806 should still excite interest today, but it has concerned historians not only because the author was a pioneer in writing about chemistry but also because she was a rarity as woman writer in a field of science. *Conversations in Chemistry* was also an unusual chemistry book in that it was continuously revised by its

Table 1. The publication dates and print runs of the various editions of *Conversations on Chemistry*, data abstracted directly from the Longmans Archive at the University of Reading, UK.

Year	Edition or Impression	Print Run
1806	First edition	1000
1807	Second edition	1000
1809	Third edition	1500
Not recorded	Fourth edition	Not recorded
1813	Fifth edition	1500
1817	Sixth edition	1500
1819	Seventh edition	1500
1822	Eighth edition	1500
1824	Ninth edition	1000
1825	Tenth edition	2000
1828	Eleventh edition	2000
1832	Twelfth edition	1500
1837	Thirteenth edition	1000
1841	Fourteenth edition	1000
1846	Fifteenth edition	1000
1852	Sixteenth edition	1000

author throughout its sixteen editions, which are listed in Table 1, and the author took every opportunity in her text to echo the latest scientific developments. She personally knew luminaries such as Wollaston, Davy, Berzelius, Smithson Tennant, and Faraday, and she certainly relied upon them for the latest scientific information (6).

When Jane Marcet died in 1858, she was widely recognized as an expert in education, science and economics, despite never having attended a formal education establishment at any time in her life. After the French revolution of 1789, there was a widespread antagonism in parts of British society towards French ideas, but nevertheless after 1790 the "French chemistry" propounded by Lavoisier and his colleagues gradually established itself in both Scotland and England. This process took perhaps twenty years, and one of the major influences in its general adoption was *Conversations in Chemistry,* written by an author who was at the time of the original publication essentially unrecognized outside her family.

How this came about raises the questions of what kind of person the author, Jane Marcet, was. Her preoccupations were often not dissimilar to those of many contemporaneous researchers, as illustrated by Jenny Uglow's masterly accounts (7, 8) of the people who provided a significant impulse to the British Industrial Revolution in the 1780s.

Jane was the daughter of a wealthy Swiss banker and businessman, Antoine Haldimand, who settled in London after working for some time in Italy. He became a British subject and married the daughter of a British business acquaintance. Jane was born in 1769. He and later Jane maintained the connection with their Swiss relations. In 1794 Alexandre (later Alexander) Marcet was born in Geneva in 1770, and was banished from his home city as a consequence of his life and activities when the French Revolution finally reached there. He went to study medicine at what was then the foremost school of medicine in Europe, the University of Edinburgh, and there he came under the influence of Joseph Black and became interested in chemistry. He graduated in 1797 and moved to London where he practiced as a fever surgeon and physician. He married Jane in 1799 and remained interested in chemistry until he died in 1822. Whether he still pronounced his surname in the French style ("Marsay") or adopted an English variation ("Marset") is impossible now to determine.

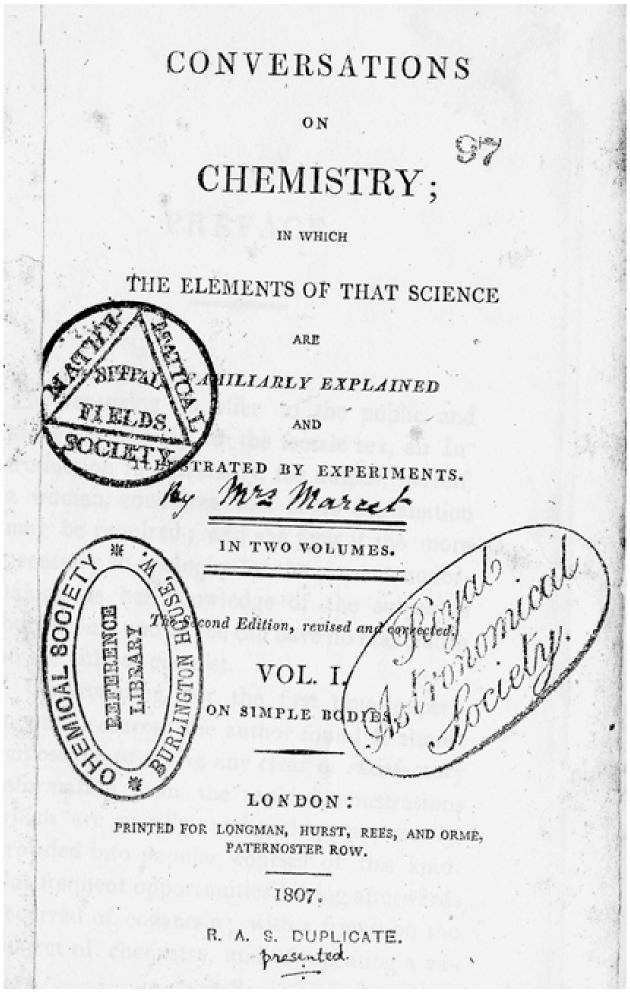
The Chemistry Content of *Conversations on Chemistry*

Chemistry books of the early nineteenth century, like *Conversations on Chemistry* itself, were generally directed to a voluntary audience (9, 10). Discussion of *Conversations on Chemistry* in the past has tended to be based upon selected editions, often the first of 1806, of which an account has recently been published (11). Though that account is titled *Chemistry in the Schoolroom: 1806*, there were precious few schoolrooms in which chemistry was taught at that time.

People who read such books usually studied alone and voluntarily rather than enrolling as students in classrooms. Jane Marcet revised her text throughout its publication life of about fifty years, so that a comparison of an early edition and a late edition provides an informative picture of how chemical science was changing. The reactions of the three participants in the *Conversations*, a tutor Mrs. B and two students, Emily and Caroline, also convey a picture of the political and social atmosphere of that period. *Conversations* is not a dry text. The participants emerge from the two volumes as real individuals. Here we compare the twenty-five *Conversations* of the second edition (12, Figure 1) with the corresponding *Conversations* in thirteenth edition (Figure 2), the first to bear the author's name, and described by her as enlarged and corrected (2), but it is not intended to imply that the changes noted in the thirteenth edition compared to the second edition were made only in 1837. Changes were made gradually in successive editions, but the thirteenth edition provides a useful place to summarize the changes up to that edition. In both editions, Volume 1 carries the subtitle On Simple Bodies, and Volume II the subtitle On Compound Bodies. We consider first Volume 1.

Conversation 1, On the General Principles of Chemistry

Mrs. B makes clear that Emily and Caroline should already be familiar with "elementary notions of NATURAL PHILOSOPHY" but Caroline is not so keen on learning more: "To confess the truth, Mrs. B I am not disposed to form a very favourable idea of chemistry, nor do I expect to derive much entertainment from it." This provokes a little lecture from Mrs. B: "I rather imagine, my dear Caroline, that your want of taste for chemistry proceeds from the very limited idea you entertain of its object ... Nature also has her laboratory, which is the universe, and there she is incessantly employed in



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CONVERSATIONS
ON
CHEMISTRY;
IN WHICH
THE ELEMENTS OF THAT SCIENCE
ARE
FAMILIARLY EXPLAINED
AND
ILLUSTRATED BY EXPERIMENTS.
By Mrs Marcet

IN TWO VOLUMES.

The Second Edition, revised and corrected.

VOL. I.
ON SIMPLE BODIES.

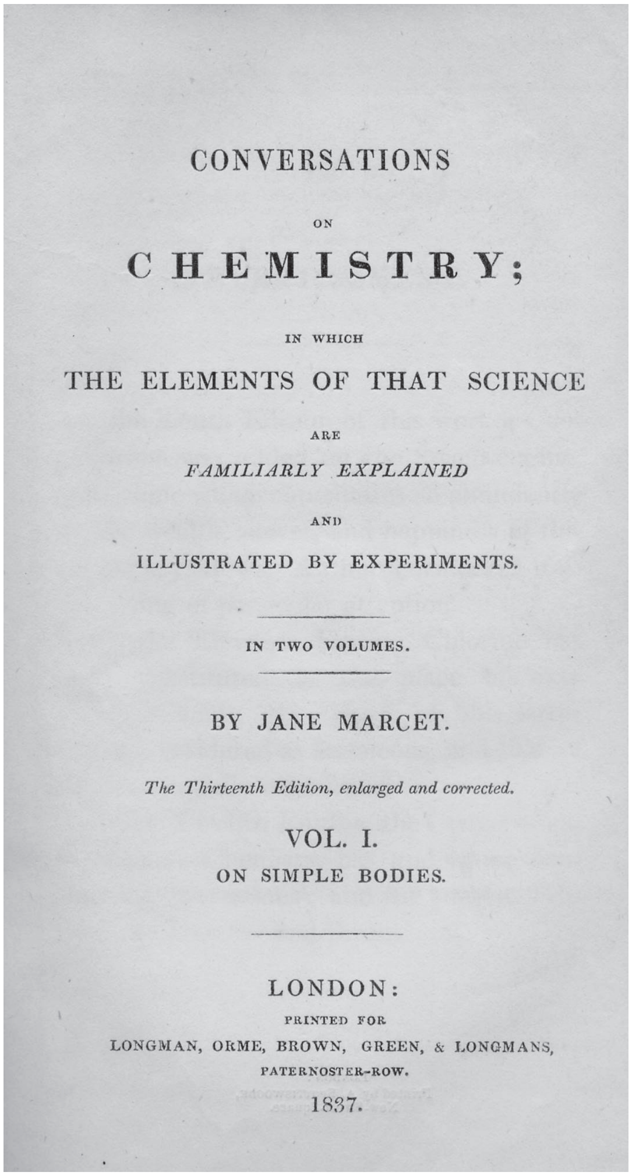
LONDON:
PRINTED FOR LONGMAN, HURST, REES, AND ORME,
PATERNOSTER ROW.

1807.

R. A. S. DUPLICATE.
presented

***Figure 1**. The title page of Volume 1 of the second edition of* Conversations on Chemistry *published in 1807. A facsimile of the first edition has recently been published by Cambridge University Press. The volume illustrated seems to have passed through the libraries of several learned societies in London, and is now in the library of the Royal Society of Chemistry. The hand-written words "By Mrs. Marcet" must have been added some years after publication, perhaps by a librarian.*

chemical operations." Caroline is still not entirely convinced until Mrs. B tells her that "Without entering into the minute details of practical chemistry, or penetrating into the profound depths of the science, a woman may obtain such a knowledge of chemistry as will not only throw an interest on the common occurrences of life, but will enlarge the sphere of her ideas, and render the contemplation of nature a source of delightful instruction." What is surfacing here is a common attitude of the period to what might be expected of a cultivated but leisured woman, and also a semi-religious justification of learning for its own sake.



CONVERSATIONS
ON
CHEMISTRY;
IN WHICH
THE ELEMENTS OF THAT SCIENCE
ARE
FAMILIARLY EXPLAINED
AND
ILLUSTRATED BY EXPERIMENTS.

IN TWO VOLUMES.

BY JANE MARCET.

The Thirteenth Edition, enlarged and corrected.

VOL. I.
ON SIMPLE BODIES.

LONDON:
PRINTED FOR
LONGMAN, ORME, BROWN, GREEN, & LONGMANS,
PATERNOSTER-ROW.
1837.

***Figure 2**. Title page of Volume 1 of the thirteenth edition of* Conversations on Chemistry *of 1837, the first that bore the author's name.*

Emily then asks about chemists and the philosophers' stone. Mrs. B dismisses alchemists with the observation that "chemistry ... has now become a regular and beautiful science" and she justifies it in terms of the useful products that have developed from it. Emily again interjects "But I do not understand by what means chemistry can facilitate labour: is that not rather the province of mechanics?" Mrs. B puts her right, citing, amongst other developments, the Steam-Engine, not today generally regarded as a chemistry subject, but chemists of the period were concerned about the mysteries of the amounts of heat involved in chemical reactions and topics such as the latent heats of melting and vaporization. In that context the steam engine was indeed applied chemistry. Mrs. B now gets down to work. She describes elementary bodies: "chemists now reckon no less than fifty-eight elementary substances." The second edition had mentioned only forty, plus possibly heat or caloric, light and electricity, so at least eighteen new elements had been identified in about thirty years since the beginning of the nineteenth century. It is difficult to assess precisely which were those elements regarded as new by 1837, but what is notable is that most of the elements "discovered" between 1803 and 1835 and which Jane Marcet would have considered to be new were actually discovered by people she knew well, Wollaston, Davy, Tennant and Berzelius. There are several accounts of the discovery of the elements, and a version available online is cited here (13). The new elements listed in the text are: palladium (discovered in 1803 by Wollaston), chromium (1803, Tennant), sodium (1807), potassium (1807), barium (1808), calcium (1808), strontium (1808), magnesium (1808), boron (1808) (all by Davy, though others contributed to the discovery of the last two), iodine (1811), lithium (1817), cadmium (1817), selenium (1817), silicon (1824), zirconium (1824) (the last three principally by Berzelius), aluminum (1827), bromine (1826), and thorium (1828, Berzelius). Though in 1837 she did not list rhodium (discovered by Wollaston in 1803) and indium (discovered by Tennant also in 1803) as new, she still listed ammonium as a metallic element giving rise to ammonia (p 15), though in Volume II she notes that ammonia was shown by M. Berthollet to be a compound of nitrogen and hydrogen (p 37), a result originally published in 1785, so this is one of Mrs. Marcet's few inconsistencies.

In 1805 the importance of oxygen in combustion had been recognized only recently. In 1837 Mrs. Marcet lists the agents capable of uniting with inflammable bodies as oxygen, plus chlorine, iodine, brome, and fluorine. Davy's battle with fellow chemists over the nature of materials such as chlorine, which had been posited to contain oxygen which allows it to support combustion, was well and truly won by 1837. This complexity overwhelms Caroline: "… instead of one single elementary earth, according to the simple science of the good old times, we have nearly a dozen, and all of them compounds. You must acknowledge, Mrs. B, that the philosophy of our ancestors had the advantage of simplicity." Identification of the new elements allowed the identification of many of their oxides as earths (in 1813 in *Elements of Agricultural Chemistry* Davy described siliceous, magnesian, calcareous and aluminous earths as four constituents of soils) so that the ancient concept of earth as one of four elements was truly dead, despite Caroline's desires (14). Mrs. B scolds her. "Simplicity has charms only in so far as it accords with the truth." The second edition did not mention the classes which so overwhelm Caroline but it included a magnetic fluid, which is not cited in this later version. An experimental demonstration is then described, involving observing the reaction of metallic copper with nitric acid, though a footnote explains that a mixture of nitric and sulfuric acid is an even better reagent for ultimately producing blue crystals, which move Caroline deeply. "How very beautiful they are, in colour, form and transparency! Nothing can be more striking, than this example of chemical attraction." Chemical attraction was still a mystery in 1837, and this *Conversation* ends with a statement that reflects Mrs. Marcet's religious views rather more than current chemical knowledge. "Chemical attraction is, probably, like that of cohesion or gravitation, one of the powers inherent in matter, in which our present state of knowledge admits of no other satisfactory explanation than an immediate reference to a Divine cause."

A close comparison of the two editions reveals many minor changes. All words ending in -ize, such as "characterize" in 1806, became uniformly "characterise" by 1837. The former spellings are still largely used in the United States but not in Britain where z has been replaced almost everywhere in such words by s. *Conversations on Natural Philosophy*, another of Jane's books, was cited in the thirteenth edition of 1837. It could not have been cited in 1807 as it was yet to be published. Pharmacy was important enough to be mentioned by 1837, but not in 1806. Very often there minor cosmetic changes. On page 6 the word "unfair" in 1806 becomes "injudicious" by 1837. During the period between 1807 and 1837, carbone lost its final e, and sulphat, phosphat, and nitrat received theirs. Some comments exchanged between Emily and Caroline in 1807 are combined and ascribed to Caroline alone in the later version. The phrase "on crumbling to atoms" on page 8 was excised by 1837, presumably because after Dalton developed his atomic theory after 1803 and finally published it in full in 1808 (15), by 1837 atoms were still not universally accepted to be the basic elemental units. The atomic theory, whether valid or not, does not seem to have affected daily chemical practice, and was to remain a theory until much later. Chemical industry, as it then was, used traditional methods, and was not professionalized and researched as it is today. Theory was the province of philosophers, though the adoption of quantitative methods in research, by pioneers such as Lavoisier, Wollaston, Berzelius and

Avogadro, clearly lent support to an atomic theory. The laws of constant proportions and multiple proportions were clearly consistent with atomic theory. However, chemists could never "prove" its truth, only demonstrate that many chemical fact were consistent with it. The final proof required the application of physics much later in the nineteenth century.

From the beginning Mrs. Marcet had used the element classification that is essentially that of Lavoisier, even though many British chemists did not at first readily adopt it, but the subsequent editions of *Conversations* go through this classification systematically.

Conversation 2, On Light, and Heat or Caloric

The nature of light was still a mystery in 1807, but by 1837 Mrs. Marcet used Herschel's experiment of 1800 to demonstrate what we now regard as infrared radiation (16).

Herschel had noticed that sunlight split into a visible spectrum by a prism also seemed to contain an invisible radiation which could be detected by a thermometer placed just beyond the red end of the spectrum. Mrs. B also mentions M. Pictet's related but similar observations published in Geneva in 1790, which have generally been ignored by historians of science (17). That the Pictet family were well acquainted with the Marcet family in Geneva could not have been a coincidence. The then current conclusion to such findings was that both caloric and visible light obey the laws of optics. In 1837 she also mentioned Wollaston's analogous demonstration of ultraviolet radiation. This was done in 1802 when he noted that invisible rays beyond the blue end of the normal visible spectrum could induce silver chloride to turn black, just as visible light does. The students were intrigued by the fact that white light can be split into colors and can also bleach colors. Mrs. B patiently explained it all in terms of the fluid caloric, either free or combined, as well as latent heat and chemical heat. She defends the description of the latter as forms of heat rather than forms of caloric because the terms were coined by Dr. Black before the French chemists introduced the word caloric, and "... we must not presume to change it, as it is still used by much better chemists than ourselves." She also demonstrates the expansions of a metal bar when heated by flame, and of water and colored alcohol in bulbs with attached tubes. These no-doubt expensive experiments are illustrated by the author's own drawings, professionally engraved. For the later editions these plates were sometimes amended, both in content and in the numbering of the Figures.

Mrs. B then used a pair of concave mirrors to show that the caloric given out by a heated bullet at the focus of one mirror can travel to a thermometer bulb suitably placed at the focus of another. Replacing the bullet by ice cools the further thermometer bulb. Finally, the two girls were shown Leslie's cube, which has four faces of different materials, all at the same temperature, but which radiate with different efficiencies to a thermometer. Mrs. B admitted that no clear explanation for these observations had yet been found. Sir John Leslie's book, replete with many experiments on radiation and heat transfer and titled *An Experimental Inquiry into the Nature and Propagation of Heat*, had been published in 1804. He published a further book, *A Short Account of Experiments and Instruments, Depending on the Relations of Air to Heat and Moisture,* in 1813 (18). I have found no correspondence to indicate that the Marcets knew Leslie personally, but he could have been an acquaintance of Alexander during his time in Edinburgh between 1794 and 1797.

Conversation 3, Continuation

The students discover by experiment that some bodies conduct caloric better than others. Sometimes the explanations become a little tortuous. Emily says: "Heat, whether external or internal cannot easily penetrate flannel; therefore in cold weather it keeps us warm; and if the weather were hotter than our bodies, it would keep us cool." This is accepted by Mrs. B without comment. Later Caroline states: "It is a very fortunate circumstance that air should be a bad conductor, as it tends to preserve the heat of the body when exposed to cold weather." Mrs. B replies that this "is one of the many benevolent dispensations of Providence, in order to soften the inclemency of the seasons and to render almost all climates habitable." A treatment of the atmosphere, wind, dew, water vapor, and steam are all additions to the earlier version.

Mrs. B later described Count Rumford's experiments on conduction in liquids, which dealt with convection, and which she illustrates with colored liquids. She knew both Rumford and his one-time wife, the widow of Lavoisier. She had been born Marie-Anne Paulze, she fought bravely to retain the family property after her husband, Antoine Lavoisier, was executed in 1794, and she married Rumford subsequently in 1804. Rumford believed that heat conduction in liquids occurred primarily by movement of particles, and Mrs. B shows, in an addition to the second edition version, this not to be entirely correct. She even comments on the radiation of heat by the earth, and when Caroline remarks on this waste of heat, Mrs. B sternly chides her: “Before you are tempted to object to any law of nature, reflect on whether it may not prove to be one of the numberless dispensations of Providence for our good.” She concludes that this loss of heat makes the earth comfortable for humans, an interesting gloss on current fears of the greenhouse effect and global warming. Without elaborating greatly, Emily introduces the idea of specific levity of gases, and this leads to a discussion of ebullition, evaporation and condensation, and the dissolution of solids by liquids. Dew is supposed to deposit more effectively on vegetables than on rocks, another wise and bountiful dispensation of Providence.

Mrs. B next uses a pneumatic pump to show the rapid evaporation and cooling of ether, upon which Mrs. Marcet’s husband, Alexander, had worked (19). This leads to the concept of latent heat and enables her to introduce the work on melting substances under pressure carried out by Sir James Hall, who, as it happens, was also well known both to Mrs. Marcet and to Alexander. Hall was a student of Black in Edinburgh during Alexander’s period there and was a chemist and perhaps the first experimental geologist (20, 21). He studied the melting and crystallizing of rocks and lava. Detailed personal correspondence in the archive at the Bibliothèque de Genève shows that the Marcets tried to help the Hall family who had a son who was evidently mentally disturbed. His family preferred to send him to London so that their immediate neighbors in Scotland might not learn of this family disgrace.

Conversation 4, On Combined Caloric, Comprehending Specific and Latent Heat

All the physical rationalizations cited by Mrs. B are based on the caloric theory and in this *Conversation* she continues to develop ideas about caloric to explain the phenomena of latent heat, specific heat, and the differing heat capacities of various bodies. The thirteenth edition account is much expanded compared to the second edition, with more experiments and even a new diagram. It is the experiments that impress the reader, as they did Emily and Caroline. For the discussion of latent heat, described as a form of combined caloric, Mrs. B invokes the work of her Swiss family friend Mr. Pictet, and Caroline sagely remarks that latent heat should really be called latent caloric. Mrs. B explains that the name latent heat is due to Dr. Black, and was coined before French chemists invented the notion of caloric (21). Dr. Black was the teacher from whom Alexander Marcet first learned of the new “French chemistry” while he was studying medicine in Edinburgh.

Caroline is continually amazed by the observations. That water boils at a constant temperature as heat is supplied is “wonderfully curious.” Mrs. B introduces Rumford’s steam kitchen, an early kitchen range, which was designed to use both the heat content and latent heat of steam both for large-scale cooking and for house heating. It used the volatilization of water and its subsequent condensation essentially as a heat transfer agent. Emily sagely remarks that that: “When the advantages of such contrivances are so clear and plain, I cannot understand why they are not universally used,” Mrs. B counters: “A long time is always required before innovations, however useful, can be reconciled with the prejudices of the vulgar … yet sometimes, it must be admitted, [they] prevent the propagation of error.” Rumford was an enthusiast for using science to improve the human condition, but in this particular case, the fact that there were reports of models of Count Rumford’s steam kitchen exploding, causing considerable injuries, might have discouraged its widespread adoption. Jane certainly attended chemistry lectures at the Royal Institution, of which Rumford (Benjamin Thompson) was a co-founder, and probably knew him personally, though no correspondence between them has been identified.

Mrs. B shows the girls an experiment in which the addition of sulfuric acid to a solution of calcium chloride causes the mixture to solidify, and to produce a “white vapour.” She warns Caroline: “You are not yet enough of a chemist to understand that. —But take care … for it has a pungent smell.” In the second edition this phrase was: “for it smells extremely strong.” The discussion next turns to cooling, and Leslie’s Cryophorus and a variant on Leslie’s experiment, with the following footnote: “This mode of making the Experiment was proposed, and the particulars detailed, by Dr. Marcet, in the 34th vol. of Nicholson’s Journal, p. 119.” Of course, Dr. Marcet was Jane’s husband, and he certainly demonstrated this apparatus to his friends, as some later personal correspondence shows (see also Ref. 19). The term “cryophorus” (bearer of frost) was actually coined by Wollaston who was certainly aware of Leslie’s work and who must also have discussed the problems of heat and cold with Alexander. In the text Mrs. B finally leaves open the question whether heat is a form of motion or is a distinct substance.

Conversation 5, On the Steam-Engine

This *Conversation* is not found in the second edition. In 1807 steam engines were not of general interest to chemists, but the subject was first introduced in the tenth edition of 1825. The 1837 edition presents an extensive discussion of the beam steam engine, with very detailed drawings (apparently not due to the author). Although Thomas Newcomen invented the steam beam engine in 1704, its efficiency was much improved by various engineers, especially Mr. Watt, whom Mrs. B particularly selects for praise. Such engines were widely used in mines throughout the nineteenth century and later and were partly a result of philosophers' interest in caloric. Caroline continues to effuse, Emily to pose questions, and Mrs. B to put everything into context. "But one would suppose the valve to be endowed with intelligence …" "Pray how are high-pressure engines constructed ...?" "It is our improved steam-engine that has fought the battles of Europe, and exalted and sustained, through the late tremendous contest [the Napoleonic Wars], the political greatness of our land … [and] that now enables us to pay the interest on our debts, and to maintain the arduous struggle in which we are still engaged, against the skill and capital of all other countries." Mrs. Marcet's interest in the embryonic science of economics makes itself evident here. She had published *Conversations on Political Economy*, using the same conversationalists, in 1816. This went through some six editions, continuously improved and enlarged (22).

Conversation 6, On the Chemical Agencies of Electricity

Again, this is an addition compared to the second edition. Mrs. B includes electricity here, though she cannot really define it, which upsets Caroline: "Well, I must confess, I do not feel nearly so interested in a science where so much uncertainty prevails …" This *Conversation* is a quick run through static electricity, Galvani (and muscular irritability of a frog's leg), Galvanism, Volta and the Voltaic pile, and an electrical machine based upon friction. Sir H. Davy receives his first mention (p 181), and as do Mr. Oersted and magnetism (p 184). Although Alexander Marcet had carried on an extensive correspondence with Berzelius, some of which concerned the latter's researches on electricity and magnetism, no mention of such work is made here. Caroline: "Well now that we understand the nature of the action of the Voltaic battery, I long to hear an account of the chemical discoveries to which it has given rise." "You must restrain your impatience, my dear … till we come to them in the regular course of our studies." So, after about one third of the text, and a quarter of the *Conversations*, we are about to embark for the first time upon what would be today considered as real chemistry.

Conversation 7, On Oxygen and Nitrogen

This starts with the definition of a gas, which excludes water vapor, since water is a liquid at normal ambient temperatures. Mr. Faraday's and Mr. Perkins's experiments on condensing gases by high pressure are mentioned here, though not in the 1807 version. The separation of oxygen and nitrogen by removing the former by burning wood in air is described. This is actually a form of the old candle experiment going back perhaps two thousand years (23). In this edition the chemistry of combustion is introduced. Heat given out in such combustions arises from the caloric contained in the oxygen gas as well as that in the combusted material. The girls are entranced. Caroline: "You astonish me." And "Since I have learned this wonderful theory of combustion, I cannot help gazing at the fire." Emily: "I have not yet met with any thing in chemistry that has surprised and delighted me so much as this explanation of combustion."

In the second edition, vapors and gases were considered to be different, and the word "gases" was spelled "gasses" and the word oxide was spelled "oxyd." The process of combining with oxygen is properly called oxygenation or oxidation in the later edition, and the products are oxides, and it is noted that metals increase in weight upon oxidation, which was one of the key observations that helped discredit the phlogiston theory. Nevertheless, one of the key researchers whose work helped establish the role of oxygen in combustion, Joseph Priestley, who died in Pennsylvania in 1804, apparently never lost his belief in the validity of the phlogiston theory (24).

Mrs. B demonstrates how heating manganese oxide in a retort can release pure oxygen, which is collected over water (p 202). This is a laboratory experiment clearly illustrated in Plate X (Figure 3), that would not be a feasible undertaking in domestic kitchens or drawing rooms. Jane had access to her husband's own private laboratory where she could certainly have carried out such an experiment rather than in her kitchen. However, that detail is not mentioned. The fact that oxygen combines with mercury and that the same amounts of oxygen and mercury can then be recovered was revealed by Lavoisier at least by 1789, and he was already very skeptical about phlogiston by 1785 (25). This must have been well known to Mrs. Marcet, but Mrs. B also implies in her discourse that no weight is overall gained or lost in experiments such as these; in other words, she refers to the law of the conservation of mass, also due to Lavoisier, though this is not mentioned. At no time does Mrs. B imply that oxygen and nitrogen in the air are combined together in some fashion ("… in the atmosphere these two substances are separately combined with caloric, forming two distinct gases"), though this idea had at least been ventured in some quarters (26). Even in 1837, Mrs. B follows Sir H. Davy in believing that atmospheric nitrogen may be a "compound body," presumably meaning not an elementary substance (p 213).

Conversation 8, On Hydrogen

Although Mrs. B mentions here all the halogens (which halogens had not been discovered in 1807 when the second edition appeared) along with oxygen as bodies capable of effecting combustion, she skips them to move to hydrogen (p 214), which apparently cannot be considered a simple substance because, as a gas, it is combined with heat. Caroline is overwhelmed to learn that water is a compound of hydrogen and oxygen. "Really! Is it possible that water should be a combination of two gases, and that one of these should be inflammable air?" This allows Mrs. B to explain the difference between compounds and mixtures, but the idea of fire (in the burning of hydrogen) producing water entrances Caroline. "You love to deal in paradoxes to-day, Mrs. B —Fire, then, produces water?" A discussion of the decomposition of water allows Mrs. B to introduce electrolysis of water using a Voltaic battery, which Caroline finds "wonderfully curious." No mention of the Voltaic battery was made in the second edition.

Next Mrs. B generates hydrogen from metallic iron and sulfuric acid (p 223), though this is explained by the greater affinity of iron for oxygen than for hydrogen. The hydrogen is collected over water and the experiment is described in considerable detail. The hydrogen is ignited with a candle flame, producing "a detonation" ("as chemists commonly call it"), regenerating water (p 227). The girls take some convincing that all this is true, but Mrs. B uses experiment to convince them. Caroline: "How glad I am to that we can see that water is produced by this combustion." Emily: "It is exactly what I was anxious to see; for I confess I was a little incredulous." At this stage Mrs. B invokes both Mr. Cavendish and "the celebrated French chemist Lavoisier" who recognized the composition of water, but she omits to mention that the latter had been executed some 40 years earlier during the French Revolution.

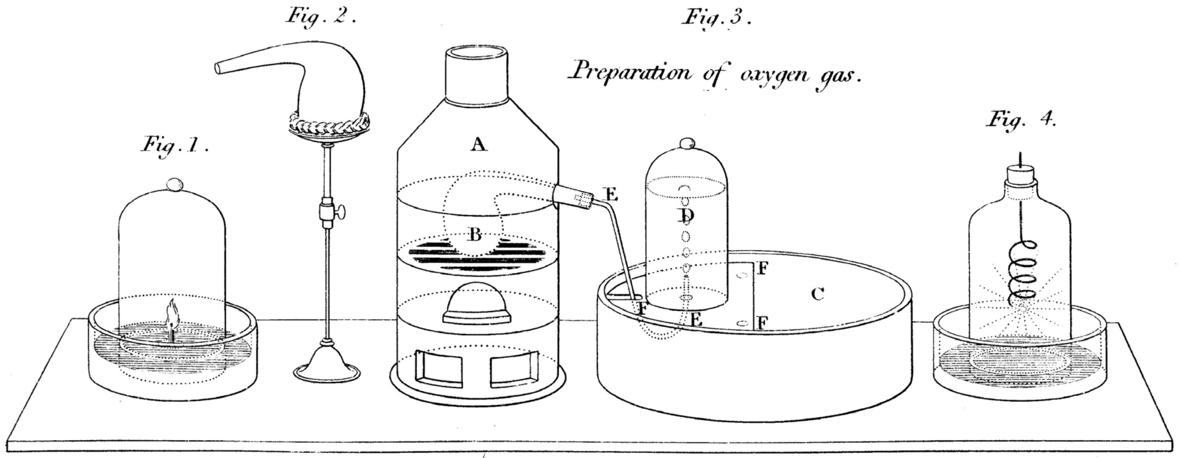


Fig. 1. Combustion of a taper under a receiver. _ Fig. 2. A Retort on a stand. _ Fig. 3. A *Furnace.* B *Earthen Retort in the furnace.* C *Water bath.* D *Receiver.* E.E *Tube conveying the gas from the Retort through the water into the Receiver.* F.F.F *Shelf perforated on which the Receiver stands. Fig. 4. Combustion of iron wire in oxygen gas.*

Drawn by the Author. *Engraved by Lowry.*

Published by Longman & C.º Paternoster Row.

***Figure 3**. The preparation of oxygen, from an illustration between pages 204 and 205 of Volume I. In the text it is designated Plate X, and is from a drawing originally made by the author.*

The sound produced by a gentle hydrogen flame burning at the end of a long glass tube is next demonstrated, and the mechanism of sound generation rationalized by a combination of glass vibration, gas condensation, gas formation and influx of air. Why this is introduced is made clear by the footnote on p 233: "This ingenious explanation was first suggested by Dr. De La Rive. —See Journal of the Royal Institution, Vol. I, p. 259." It is no accident that Dr. De La Rive was a Genevan friend of Alexander Marcet, distantly related by marriage, and who shared his study exile in Edinburgh. She ascribes all flames to the burning of hydrogen. She does explain that the novel gas lighting uses inflammable coal gas or hydro-carbonate and she describes how the gas is produced industrially. Gas lighting as "one of the happiest applications of chemistry to the comforts of life, and even to the morals of large cities …. Gas lights are excellent policemen" (p 239). But she adds that application to illuminating homes had "not yet been found desirable."

Mrs. B produces soap bubbles of hydrogen, to acclaim. Caroline: "Now a bubble ascends; it moves with the rapidity of a balloon. How beautifully it refracts the light!" Thunder and lightning are ascribed to detonations of hydrogen, and finally Sir Humphry Davy's safety lamp is described in detail (p 248). It was invented in 1815 and used from about 1816, and, of course, this is an addition compared to 1807. It effectively prevented the detonation of what was termed hydro-carbonate by chemists or fire damp by miners, and for this invention Davy was publicly thanked and honored throughout Europe. Mrs. B is effusive about its value, but she also mentions Mr. Tennant's contribution to its early development, though she ignores others. The need for such an apparatus had long been recognized, and Leonard Horner had written from Edinburgh to Dr. Marcet in 1815 about another proposal for a safety lamp (27). Caroline expresses the situation very well. "This is indeed a most interesting discovery, and one which shows at once the immense utility with which science may be practically applied to some of the most important purposes" (p 250). It is striking that nowhere in this context does Mrs. B mention methane and inflammable marsh though methane was discovered by Volta as early as 1778.

Conversation 9, On Sulphur and Phosphorus

Here Mrs. B starts by saying that she will consider these elements, their compounds with oxygen, and their properties as acids. This echoes the Lavoisier concept of acids being oxygen compounds. She describes sublimation of sulfur using an alembic, though she does not demonstrate it, but she does burn sulfur and dissolves the resulting gas in water to generate an acid "because it [sulfur] unites with oxygen, which is the acidifying principle." This causes Caroline to ask why water isn't an acid. The rather unsatisfactory reason is because hydrogen "is not susceptible to acidification." Although Mrs. B follows Lavoisier's acid hypothesis, she admits that Sir H. Davy has shown (p 258) that halogens possess to some, though insignificant, degree the same property as oxygen, of being able to generate acids, which is new compared to 1807. Acidification, she says, always implies previous oxidation. Acidic character requires a higher degree of oxidation than simple oxide formation, but she correctly distinguishes between the two degrees of oxidation associated with sulfurous and sulfuric acids. Caroline, under instruction, fills a gas bottle with oxygen ("Very well; you have only let a few bubbles escape, and that must be expected on a first trial.") and this is then used to burn sulfur in order to make sulfuric acid. It is notable that in this text, as in other texts of the time, no distinction was made between sulfur dioxide and sulfurous acid. Sir H. Davy had shown that submitting sulfur to the action of the Voltaic battery generates hydrogen at the cathode, which raised the question of whether it contained hydrogen rather than being an elementary substance (p 261), but sulfur and hydrogen can also react to form sulfuretted hydrogen gas, as found in "Harrowgate waters" (in 1807 or "Harrogate waters" by 1837, as it is spelled today). The analysis of waters from various different sources was another of Dr. Marcet's chemical interests (28). Caroline finds sulfur boring, and wants to move on to phosphorus.

It appears that phosphorus may also contain hydrogen, though it is considered to be a "simple body" (p 264). Mrs. B explains that phosphorus was known to Brandt (he isolated it in 1669 from a large volume of urine while searching for the philosopher's stone), Kunckel (who discovered Brandt's recipe for phosphorus in about 1678), and Boyle (he was involved in the commercial production of phosphorus in London by 1680), but she is too refined to discuss its source, though she reveals that it is extracted "by a chemical process" (29). However, even Emily is overwhelmed when Mrs. B burns phosphorus in oxygen. "What a blaze! I can hardly look at it. I never saw anything so brilliant. Does it hurt your eyes, Caroline?" "Yes: but still I cannot help looking at it." The product is phosphoric acid, but exposure of phosphorus to atmospheric oxygen yields phosphorous acid (p 267). The girls are delighted with phosphorescence, matches, and the spontaneously inflammable phosphoretted hydrogen gas [phosphine] ("phosphorated" in 1807), supposedly the origin of the Will-of–the-Wisp [also known as marsh gas]. After a short discourse on nomenclature, phosphoret of lime [calcium phosphide] is also used to make phosphine, but this is done outside the house, because the smell "is so extremely fetid that it would be intolerable in the house." The detonating bubbles of phosphine excite Caroline, but she does not understand the chemistry. Mrs. B thinks the explanation is too complex for Caroline to understand (p 273). "It is the consequence of a display of affinities too complicated, I fear, to be made intelligible to you at present." Nevertheless, the fact that both sulfur and phosphorus are stated to be found widely in nature promises more excitement in the future for the assiduous student.

Conversation 10, On Carbon

Some of Davy's work which was not included in 1807 is described here in 1837. Mrs. B states that Davy believes that purest form of carbon then attainable must contain hydrogen, and that 100% pure carbon would probably turn out to be a metal (p 277). Davy knew that carbon is widespread in nature, and he popularized the concept of the natural carbon cycle originally postulated by Lavoisier and Priestley (30). Mrs. B states that carbon may be produced pure as charcoal, by a process with which Emily, at least, is familiar: "I have seen the process of making common charcoal." Caroline is startled to learn that the diamond in Mrs. B's ring is also carbon: "Surely you are jesting, Mrs. B?" Mrs. B increases the wonderment: "There are many other substances, chiefly consisting of carbon that are remarkably white. Cotton, for instance, is almost wholly carbon." Caroline is amazed, "That, I own, I could never have imagined!" There follows a discussion of the difference between analysis and synthesis and their value to the experimentalist, but Mrs. B doubts whether chemists will ever be able to synthesize animals and plants. "…the principle of life, or even the minute and intimate organization of the vegetable kingdom, are secrets that have almost entirely eluded the researches of philosophers; nor do I imagine that human art will ever be capable of investigating them with complete success" (p 279). The combustion of carbon to give carbonic acid gas, and even Tennant's demonstration of the combustion of diamond announced in 1797 are described in detail. The combustion of diamond was actually first investigated by Lavoisier but in Tennant's case it was assisted in part by Alexander Marcet himself, as other personal correspondence shows. The generation of Seltzer water, its value and its properties are also described (p 289). The fact that a burning flame may be visible is again ascribed to the presence of some hydrogen. Helpfully, the lead in lead pencils is not really lead but a carburet of iron (p 294).

The occurrence of carbon in graphite and steel and the decomposition of water by hot charcoal are also demonstrated. Finally, the widespread occurrence of carbon in what we would today term organic compounds is described, though how carbon, oxygen and hydrogen could make so many different materials was beyond the chemical theory of 1837.

Conversation 11, On Metals

The metals are treated in various classes, a beginning of the kind of classification that would lead ultimately to the Periodic Table. In *Conversation* 1 metals (including ammonium) had already been classified as those forming alkalis upon oxidation, those forming lime or earths upon oxidation, those malleable metals occurring naturally, and brittle metals. The Voltaic battery features in this *Conversation*, whereas in 1807 the use of the Galvanic pile to oxidize metals was the sole mention of electricity. The *Conversation* begins with the statement that the metals that form alkalis on oxidation will be discussed later because they were more mysterious and of recent discovery, which prompts Caroline to say that the mystery makes them more exciting. Mrs. B reprimands her. "You are not aware, my dear, of the interesting discoveries made by Sir H. Davy respecting this class of bodies. By aid of the Voltaic battery …" (p 301). So, back to the boring well-known metals, such as copper, lead and iron. Their oxidation in the atmosphere and in furnaces is treated at some length. Caroline seems a bit blasé about all this, perhaps because her father seems to own a lead mine in Yorkshire. This may be an oblique reference to Jane's friends, the Cleaver family, who lived in Yorkshire, and are mentioned in her personal correspondence. Emily wonders whether white lead "with which houses are painted" is lead oxide, and is told that it is a carbonate (p 305). After mention of the other oxides, Mrs. B shows the girls how to use a blowpipe (p 307), and though the girls would like to burn gold in this way, Mrs. B tells them that gold, silver and platina cannot yet be burnt by a blowpipe, though it can be done with sparks from a Voltaic battery. The characteristic colors emitted by metals upon oxidation which she mentions (p 305) are an interesting forerunner of spectral analysis.

One of Jane's sources of information at this time were the popular public lectures of Davy and, later, of Faraday at the Royal Institution in Albemarle Street, London. She tells her pupils that "You will see these experiments performed in the most perfect manner, when you attend the chemical lectures at the Royal Institution." Jane knew Davy personally, but her relationship with Faraday was very special. He clearly respected her greatly, and he recounted that, when he was apprenticed as a bookbinder, reading *Conversations on Chemistry* after work was a major influence upon his decision to take up science. On June 7, 1847, Faraday wrote another note to Jane from the Royal Institution, to which he had ordered that she be admitted whenever she so wished, in which he addressed her as "Dear Mistress" and closed with the sentence: "These come with my duty from your devoted and affectionate pupil."

The fact that "platina becomes incandescent by exposure to a current of hydrogen gas, even when the temperature of the metal is lowered by a frigorific mixture eight or ten degrees below the zero of Fahrenheit," is one of several "singular phenomena [which] remain as yet without satisfactory explanation" (p 313). After this exciting diversion, the problems of oxidation, rusting, and reduction of metal oxides are dealt with at length. Mrs. B always gives the current rationalization of the phenomena she describes. "I imagine that it is because lead cannot decompose water that it is so much employed, in the form of pipes, for its conveyance." Lead pipes for carrying water had been used for at least two thousand years, from Roman times. Mrs. B: "Certainly; lead is, on that account, particularly appropriate to such purposes." The toxic properties of soluble lead compounds were already well known long before 1837.

The action of acids on metals is also ascribed to oxidation (p 320), because Lavoisier's theory of oxygen as the ultimate source of acidity was still accepted in 1837. Mrs. B drops some nitric acid onto metallic copper, which causes Caroline to remark: "Oh, what a disagreeable smell!" Salt formation follows, but "you will be careful to remember that metals are incapable of entering into this combination with acid, unless they are previously oxidated." The girls crystallize iron(II) sulfate, much to Caroline's delight. They learn of soldering and plating, and talk of hot springs and comets. They discuss mercury, and how to solidify it, and this gives Mrs. Marcet the chance to mention once again her husband's device for producing cold by harnessing the evaporation of diethyl ether, though he had died long before, in 1822.

The discussion of the caustic nature of acids leads onto consideration of verdigris and poisons, and then Mrs. B pulls a masterstroke. She sprinkles some water and some copper nitrate that they had made previously on some tin foil, and suddenly folds the tin up and presses it into a lump. Caroline: "What a prodigious vapour issue from it! —and sparks of fire, I declare!" (p 336). After a brief excursion into invisible or sympathetic ink, Mrs. B finishes with a paean extending over several pages to Sir H. Davy and his use of the Voltaic cell to discover the alkali metals, which she believes only the illiberal, ignorant and narrow-minded would regard as simple curiosities (p 337). The students experiment with reactive materials such as sodium and potassium, which especially enchant Caroline. The chemical preparation (in about 1808) of potassium in large quantities by Thénard and Gay-Lussac is mentioned (p 344). Later on this same page Mrs. B speaks of Davy's great skill in investigating the chemistry of this metal even though he could prepare only "a few atoms of this curious substance." This was phrase was probably the use of common language rather than a reflection of atomic theory. Davy is also stated to have ascertained that ammonia also contains oxygen, and to be derived from a metal (p 345), even though Berthollet had shown by 1785 (see Volume II, p 37) that this was not the case. Evidently Davy was still convinced that the formation of ammonium salts was the result of a reaction between an acid and the oxide of some unknown metal, analogous to the alkali metals he himself had isolated. Mrs. B concludes the volume with further praise of Humphry Davy "Thus in the course of two years, by the unparalleled exertions of a single individual, chemical science has assumed a new aspect …. In geology new views are opened…. it is reasonable to suppose that the interior of the earth is composed of a metallic mass … The eruptions of volcanos, those stupendous problems of nature, admit now of an easy explanation. For if the bowels of the earth are the grand recess of these newly discovered inflammable bodies, whenever water penetrates into them, combustions and explosions must take place; and it is remarkable that the lava which is thrown out is the very kind of substance which might be expected to result from these combustions."

This extraordinary and erroneous claim closes Volume I of the 1837 edition. However, the 1807 version contained *Conversations* which were transferred to Volume II by 1837. Volume II deals with compound bodies, in a sequence which follows Lavoisier's classification of bodies.

Conversation 12, On the Attraction of Composition

Mrs. B now discusses "the attraction of composition, or chemical attraction or affinity." She lists six "laws of chemical attraction" (pp 1-8), most of which are generalizations that still hold today. Attraction occurs "only between the most minute particles of bodies." These minute particles are not here defined, and Mrs. B does not mention Dalton, whom she possibly met, or his ideas, and it is notable that she always tries to avoid quantitative questions involving matters such as yields and compositions. Modern chemists often do not realize that Dalton's ideas concerning atomic theory and published in 1805 had very little immediate impact. The theory was, in any case centuries old. It was a theory which did little to illuminate real chemistry practice at the time, even if it was the concern of some philosophers. Wollaston had published his Table of Chemical Equivalents in 1814, and had taken some time to develop it but he did not readily adopt atomic theory. Avogadro was already promulgating ideas about gaseous molecules by 1811 and Berzelius was an early adherent of Dalton's theory. Jane and Alexander Marcet must have discussed it with Berzelius in 1812, and perhaps also with Dalton. In 1837 a mention is made of chemical atoms, and the law of constant proportions, by weight for solids and by volume for gases, is related to their existence on pp 12-14. Such atoms are not further divisible by mechanical means. However, as Mrs. B states on pp 14 and 15: "Philosophers have not yet been able to give us any decisive information upon this point ["the singular uniformity in the law of combination"] ... we may suppose that the smallest particles or portions in which bodies combine (and which we may well call chemical atoms) are capable of uniting together ..."

Compound bodies are stated to include oxides, acids and salts, and Mrs. B explains the nomenclature of salts, as exemplified in names such as nitrate of copper and sulfite of potash. Mrs. B acknowledges measuring the force of attraction between different chemical entities was a problem, but she presents a set of relative affinities, based upon observations of selected displacement reactions. Caroline: "I confess I do not understand this clearly." Mrs. B's explanation is based upon the reaction of nitrate of lime and sulfate of soda yielding sulfate of lime and nitrate of soda (p 9) and illustrated by a diagram. The reaction takes place because of the different relative affinities of acids and alkalis, though how this was studied in practice is not clarified. Nevertheless, Caroline thinks it is now very clear, though she queried the use of the words quiescent and divellent (p 10). Quiescent forces are those that tend to stop compounds reacting, whereas divellent forces are those that promote reactivity. The problem of affinity was a considerable worry to chemists of the period, and Berthollet published at least as early as 1799 the idea that chemical combinations are affected not only by relative attractions but also by the proportions of the materials involved in the preparative reaction, by the heat evolved, and by other circumstances. These views were challenged by several investigators such as Proust in 1806, and Mrs. B acknowledges that Berthollet's ideas are not consistent with the law of definite proportions (p 12). Of course this law was clearly explained by the theory of indivisible chemical atoms, Mrs. B was evidently of the opinion that chemical theory was becoming too difficult for her immature students to master. A footnote on page 16 mentions that Dr. Wollaston had produced a table of chemical equivalents (in 1814), but "we must not run the risk of entering into difficulties which might confuse your ideas, and throw more obscurity than interest on this abstruse part of the philosophy of chemistry."

The *Conversation* finishes with some interesting electrolysis experiments, purporting to show decomposition of salts into the acids and alkalis from which they were formed. The material in this *Conversation* did not appear as a separate *Conversation* in 1807, though some of it was presented elsewhere in that earlier version.

Conversation 13, On Alkalies

The three alkalies are potash, soda and ammonia. They all affect the color of vegetable dyes such as turmeric. Potash is obtained primarily from wood ash. Caroline wants to use potash for laundering clothes, but needs to be told that it is too caustic (p 26). There follows a disquisition on nomenclature. Mrs. B states that even Lavoisier who established the new nomenclature thought it more prudent to use established names for some substances even if more explicit names could be coined. Customary usages might have to be retained. Emily infers that carbonate of potash is formed by the union of carbonic acid with potash. This earns a pat on the head: "you see how admirably the nomenclature of modern chemistry is adapted to assist the memory" (p 27). Would that this were always still the case! However, a disquisition on Lavoisier and his colleagues' nomenclature is then introduced. A footnote adds that despite the admirable systematics, some acids contain hydrogen and some alkalies contain oxygen. Nevertheless, Caroline, when told how potash can give rise to saltpetre correctly exclaims: "then saltpetre must be nitrate of potash?" (p 33).

Soda combines "with a peculiar acid" to form common salt. Like potash, soda gives rise to glass and soap. Finally ammonia, or volatile alkali, is identified with hartshorn. Mrs. B opines that the name ammonia arises from "*Ammonia*, a region of Libya" though this is probably not the case (p 24). Since sal ammoniac is made from ammonia and muriatic acid, Caroline rightly says that it should be called muriate of ammonia. Berthollet "a celebrated French chemist" has shown "a few years since" that passing electric sparks through heated ammonia gas produces about four parts of nitrogen to one part of hydrogen by weight and one part of nitrogen to three arts of hydrogen by volume (p 37). Ammonia is a product of putrefaction of both animals and of plants and it forms an amalgam [a compound with metallic mercury] in an "extremely curious experiment" (p 38).

Conversation 14, On Earths

The nine earths are silex, alumina, barytes, lime, magnesia, strontites, yttria, glucina, and zirconia (p 44), the last three being very new to chemistry. The list of earths of 1807 also contains the name "gargonia" which had disappeared by 1837. The alkaline earths are named as barytes, magnesia, lime and strontites (p. 49). The girls confuse chemical earths (natural metal oxides with basic properties) with soils. Once this is sorted out, the discussion moves on to crystallization and precious stones. The devout Mrs. B never once questions the geological age of the earth or the modern geology that was beginning to emerge in Mrs. Marcet's time. "The characteristics of earths are insipidity, dryness, unalterableness in the fire, infusibility, &c." Caroline immediately asks how silex [silica] fits this pattern, as in the fire it forms glass. This is ascribed to the fact that it is normally not pure.

The earths are then treated in order, which provokes Caroline to say "I confess that the history of earths is not quite so entertaining as that of simple substances" (p 53). Apparently Mrs. B agrees, and the rest of the *Conversation* is a cursory gallop through the earths: silex, alumine (a constituent of clays with a non-systematic name, as Caroline notes, though it is sanctioned by history), barytes, lime (used in medicine to counter stomach acidity, and which, in a furnace, gives rise to quick-lime, that Mrs. B treats with water, to Caroline's delight: "how the quick-lime hisses! It becomes excessively hot! —It swells, and now it bursts and crumbles to powder …", p 58), magnesia (identified by Tennant and used as a medicine, like the related Epsom salt: and as Caroline must observe "and properly called sulphate of magnesia, I suppose!"), and strontian or strontites (identified in 1791-2 by Dr. Hope (31), a student of Black, and professor of chemistry and medicine at Edinburgh from 1799 until he died, and another close friend of Dr. Marcet from his Edinburgh days, p. 65). It was Davy who isolated the element strontium, though this is not mentioned here.

Conversation 15, On Acids

This *Conversation* is completely reorganized in 1837 when compared to 1807, and it starts with a definition of acids. "They all change vegetable infusions to a red colour: they are all more or less sour to the taste; and have a general tendency to combine with earths, alkalies, and metallic oxides" (p 66). The nomenclature is described, in a manner of which Lavoisier would have approved. The terminations -ous and -ic had already been described in 1807. Mrs. B states that the only members of the class of the forty known acids that don't quite fit the oxygen theory are muriatic and fluoric, for they had yet to yield their free bases. In fact Scheele had isolated chlorine in 1774 and Davy had proposed it to be an element in 1810, though fluorine was first isolated by Moissan as late as 1886. Acids are divided into three classes, those of known and simple bases (the mineral acids); those of double bases, of vegetable origin; and those of triple bases, or animal acids (p 70). These are listed in 1837 as lactic, caseic, prussic, formic, bombic, cetic, sebacic, margaritic, oleic, zoonic and lithic. Some of these names are retained today, but the identities of most were not understood, just like the organic agents involved in digestion, chime and chyle, which were assumed to be distinct compounds. The action of acids on material such as wood is described by Mrs. B as involving the transfer of oxygen, just like combustion (p 75).

Conversation 16, Of the Sulphuric and Phosphoric Acids; and of the Sulphates and Phosphates

This 1837 version is similar to that of 1807, though reorganized, and again it begins with nomenclature (p 76). Sulfuric acid was once obtained by dry distillation of vitriol (iron(II) sulfate) and so was called oil of vitriol, but Mrs. B says she has changed the label on the bottle obtained from the chemists (p 77) to sulphuric acid to forestall any questions! However, it is evident that the differences between sulfurous and sulfuric acids and that between phosphoric and phosphorous acids is due the different degrees of oxidation of the original sulfur and phosphorus.

If it were possible to remove all the water from sulphuric acid, it should then become a solid, and the girls note the evolution of heat when the strong acid is diluted with water (p 78). It decomposes vegetable matter, such as wood, and then Caroline causes a diversion: "I have very unintentionally repeated the experiment on my gown, by letting a drop of acid fall upon it, and it has made a stain, which, I suppose, will never wash out" (p 79). It will burn a hole, says Mrs. B, but that doesn't stop Caroline next dropping some on her hand. Mrs. B tells her to wash her hands immediately though Caroline says: "It feels extremely hot, I assure you." After that there is a lecture on how to handle acids, and it is recommended that one's fingers should always be wet, in order to dilute any acid spilt on them!

Mrs. B describes the lead acid process for the manufacture of sulfuric acid (and at the same time, some sulfurous acid), its use "in a state of great dilution" as a medicine. A very dilute solution mixed with an aromatic substance, presumably to make it palatable, appears to have been the mysterious elixir of vitriol which was sometimes prescribed by Dr. Marcet to his patients. Meanwhile, Emily has a spot of mulberry juice on her gown, and this is removed with sulphurous acid that merely bleaches the vegetable dye, and does not destroy the fabric (p 85). Caroline asks where is sulphurous acid to be found, and Mrs. B answers that "We may easily prepare some ourselves simply by burning a match." Stain removal is effected by dampening the stained material and then holding a lighted match under the stain, so that the vapor of the burning match which contains sulfurous acid (or more properly, sulfur dioxide) ascends to it. This was apparently a common way to remove stains, as Emily says, but Mrs. B ensures that the girls appreciate the chemistry involved.

Finally, Mrs. B enumerates the salts of sulfuric acid, their occurrence and their uses, especially that of writing ink (iron sulfate plus gallic acid). Phosphoric acid is dismissed cursorily. It can be made from bones, in which it is combined as calcium phosphate.

Conversation 17, Of Nitric and Carbonic Acids; and of the Nitrates and Carbonates

The 1837 version is also similar to that of 1807 version, though reorganized. Caroline objects to the smell of nitric acid (p 96), and were she not headed off with an apology, would have complained about its name, as she did later (p 98). It always contains water, and has never been obtained pure and its composition had been determined both by "the celebrated Mr. Cavendish" in 1785 after passing an electric spark through moist air (10 parts of nitrogen to 25 parts of oxygen) and Sir H. Davy in 1800 who reported the nitrogen:oxygen ratio as 1:2.389 (p 97) [which actually corresponds to a weight ratio of these elements close to NO_2] (32). In neither case does Mrs. B make clear whether she is referring to weights or gaseous volumes, but what she terms nitric acid is probably principally derived from nitrogen dioxide. What Mrs. B refers to as the caustic properties of nitric acid are demonstrated by its reaction when poured over dry, warm charcoal, which bursts into flames (p 96). There follows an interesting discussion on nomenclature and how this acid was obtained before oxygen and nitrogen could be combined using the electric spark. This was from a salt of potash called nitre. Caroline: "Why is it so called? Pray, Mrs. B, let these old unmeaning names be entirely given up, by us at least; and let us call this salt nitrate of potash." Apparently this riles Mrs. B. She says the old names have to be used until the newer ones are more widely adopted, and then she describes how nitric acid is produced from the potash, in a form diluted in water "and commonly called aqua fortis, if Caroline will allow me to mention the name" (p 98).

Pure nitrous acid is a gas and then described, though to modern chemists this gas seems suspiciously like a nitrogen oxide. Nitrous air is more properly called nitric oxide gas. Mrs. B converts some to nitrogen dioxide, which Emily finds "very curious," but she rationalizes the observation correctly. Mrs. B then converts nitrous oxide gas into nitrous acid gas. Nitrous air (otherwise nitric oxide gas) apparently reacts with air to generate an orange color "like nitrous acid" (p 102). The girls claim to understand all this, even if to modern minds the exposition seems rather complicated. Then Mrs. B mentions Sir H. Davy and another modification, gaseous oxide of nitrogen, otherwise exhilarating gas, now known as nitrous oxide, or, conventionally, laughing gas. Caroline wants to try it, but she is not allowed to do so, even though they prepare some by heating ammonium nitrate. The final subject in this area is nitre, or saltpetre, or nitrate of potash, and gunpowder and its detonation, and some other nitrates. Silver nitrate (lunar caustic) was apparently used by surgeons to destroy animal fiber (p 111), presumably to avoid using the knife! In this period even nitric acid was used medicinally, often to treat syphilis, though is ingestion probably did little to cure the patients. What is evident from this discussion to a modern chemist is that the precise identities of the oxides of nitrogen were not all clearly identified by 1837, though Mrs. B does describe how exhilarating gas can be prepared by heating nitrate of ammonia (p 106).

Carbonic acid gas and carbonates are next. Priestley's observation that the gas can promote plant growth is mentioned (p 120), though his name is not. By 1837

Priestley was long gone, but his unpopularity as a non-Conformist preacher who supported the ideals of the French and American revolutions may not have been entirely forgotten in some British circles! Mrs. B describes the widespread occurrence of carbonates in rocks and animal and plant nature as well as the use of what she terms carbonic acid in Seltzer water and mineral waters (p 120).

Conversation 18, On the Boracic, Fluoric, and Muriatic Acids; On Chlorine; and on Muriates — On Iodine and Iodic Acid — On Brome

According to Mrs. B in 1837, boracic acid was apparently imported for industrial purposes "from the remote country of Thibet" as a sodium salt, often called borax (p 122). Despite the acid initially being considered "undecompoundable," in 1808 Humphry Davy (and also some un-named French researchers, actually Thénard and Gay Lussac) decomposed the acid using either the Voltaic battery or metallic potassium to yield the basis, called boracium by Davy, but now called boron. Boron burns in oxygen, and Mrs. B even mentions what analysts might now call the borax bead test (but no more is reported on this acid.

Fluoric acid is obtained from fluor, found in Derbyshire, and it was identified (as early as 1771) by "Scheele, the great Swedish chemist," who was a co-discoverer of oxygen (p 125). Mrs. B describes the preparation of the acid by treating the mineral fluor with sulfuric acid and distilling the mixture into a glass receiver which becomes etched. It is doubtful whether she would have undertaken this herself, for she mentions the want of a suitable container. Caroline wants to etch glass with it, but she forgets that a glass bottle would not be able to hold it. The acid seems to contain a little water, and so it is called hydro-fluoric acid. The acid consists of hydrogen and an unknown principle Sir H. Davy termed fluorine. He could not break it down further, even using potassium (p 126).

Muriatic acid is a gas which may be liquefied by "impregnating it with water." Again, Sir H. Davy could not obtain the basis, but "The celebrated chemist Scheele, while examining the action of muriatic acid on oxide of manganese discovered that a peculiar gas was disengaged," and termed by French chemists "muriatic acid gas," and even oxymuriatic acid gas. Finally "in the year 1811, Sir H. Davy proved it was a simple body" not containing oxygen, and named it chlorine. This is all new compared to the 1807 version. Only the subsequent discovery of brome (1826) and iodine (1811) finally convinced all the chemical community of this fact.

Chlorine is the only material other than oxygen to be able to support combustion (p 130). Caroline keeps her handkerchief to her nose to avoid the smell while phosphorus is exposed to chlorine, and she then exclaims: "Look, Emily, it burns almost with the same brilliancy as in oxygen gas." Mrs. B even burns gold leaf in chlorine. The girls are told that chlorine is used as bleach and as a disinfectant in fever hospitals and prisons. This offends Caroline: "But I think the remedy must be nearly as bad as the disease, the smell of chlorine is so dreadfully suffocating." The remedy, apparently, is to keep one's mouth shut and to wet one's nostrils with "liquid ammonia." However, the vapor of nitric acid is to be preferred for such purposes (p 136)!

The oxides of chlorine and the salts of muriatic acid or "as it is now frequently called, hydro-chloric acid" are then described. Gunpowder is discussed, but the existence of chlorine oxides, though probably observed by Faraday and others, was too contentious for consideration in 1837. Mrs. B then offers to show what happens when you mix potassium chlorate, phosphorus and sulfuric acid "on condition that you will never attempt to repeat it by yourselves" (p 141). The girls apparently agree not to try and are very impressed with this burning of phosphorus.

The discussions of iodine and brome, both of which are inspected in the free form as provided by Mrs. B, are relatively short, and the *Conversation* finishes with a description of the work of Mr. Faraday ("this celebrated chemist") on the liquefaction under pressure of chlorine (1823, p 146) and many other gaseous materials, though not yet air or oxygen.

Conversation 19, On the Nature and Composition of Vegetables

From this *Conversation* onwards what would today be recognized as chemistry is lacking. This involves what are termed organized bodies. Organized bodies "bear the most striking and impressive marks of design" (p 150), but they require an unknown principle called life in order to function. The girls discuss the characteristics of life, and Emily remarks critically: "Yes, Caroline, you have told us what life does, but you have not told us what it is" (p 151); and that sets the pattern of the discussion. Mrs. B describes sugar and sugar candy, starch (which may also be converted in part to sugar, according to "some foreign chemists"), gum Arabic, gum senegal, honey, bread and gluten, various oils and waxes, resins and varnishes, tannin, and vegetable dyes and mordants. Their natures, origins and uses are described at some length, but with little about their real constitutions. Without irony, Mrs. B tells how the sugar-beet industry in Europe arose as a result of "Bonaparte's prohibitory system, which deprived his subjects of the use of West Indian produce…" (p 158). There is also a reference to a Dr. Peschier of Geneva, who detected potash in plants.

Mrs. B notes that all these materials contain hydrogen and carbon in various proportions, plus some oxygen (p 183). Otherwise this *Conversation* is really a listing of materials, their occurrences and uses. It finishes with two lists, the first of vegetable acids (p 184), the names of some of which, for example, oxalic (from a name for wood sorrel, oxalis) and succinic (from the Latin name for amber) are still in use today. Other names such as kinic and boletic acids are no longer immediately recognizable. Their modern names are now quinic and fumaric acids, their sources being Peruvian bark and a variety of the fungus boletus, respectively. The second, short list is of native vegetable alkalis, which seem to be principally narcotics and alkaloids (p 188). Some materials listed here, such as strychnia and quinia were not mentioned in 1807, and Mrs. B adds a footnote that such alkalis were first given names such as quinine and strychnine, etc., but these have since been renamed quinia and strychnia, etc., names consistent with their nature as alkalis! Finally and ironically, Mrs. B closes the *Conversation* with a discussion of the antipyretic quinine (p 189).

Conversation 20, On the Decomposition of Vegetables

Caroline relates that the previous *Conversation* has left her unsatisfied. "What I wish particularly to know is, how do plants obtain the principles from which their various materials are formed …" Mrs. B replies that "This implies nothing less than a complete history of the chemistry and physiology of vegetation," and a footnote refers the reader to Mrs. Marcet's *Conversations on Plant Physiology*, a book which was yet to be written in 1807. In 1837 Caroline was advised to rely on this current *Conversation* for the time being.

Decomposition occurs when plants die, eventually reaching "putrefaction, which is the final state of decomposition." New plants then take up the principles released by these processes. Mrs. B lists four kinds of fermentation which occur in nature, some of which are employed in making products such as wine, beer and bread. Emily has seen the fermentation of wine in Switzerland (p 201) in which sugar gives rise to alcohol but there is no real chemistry in the modern sense. Mrs. B distils some port wine to demonstrate the production of alcohol. Emily asks earnestly "And, pray, from what vegetable is the favourite spirit of the lower orders of people—gin—extracted?" The answer is juniper berries (p 207).

The physiological effects and chemical and physical properties of alcohol are seriously discussed (p 209). It is correctly noted that alcohol burns in air to yield "a small quantity" of carbon dioxide and "a great proportion of water" (p 214). This inaccurate statement is as close as the text gets to a quantitative discussion. Removal of "a certain proportion of carbon" from alcohol using acids generates ether (p 215), a reaction which had been known to alchemists for perhaps three hundred years. Mrs. B shows how a hot platinum wire can glow with white heat when bathed in alcohol vapor in air, which is, as she says, an effect observed by Davy (and others) by 1817, though she does not mention the concept of catalysis, which had been recognized as a general phenomenon first by Berzelius, but as late as 1836. Some modern authorities suggest that ether was not used medically as an anaesthetic until the 1840s, but its properties had been recognized by authorities such as Paracelsus. Mrs. B answers a question from Caroline by stating that ether is used medicinally and is "one of the most effectual antispasmodic medicines," though in excess it can intoxicate (p 217).

Acetous fermentation includes yeast fermentation in bread making, and a process is described for making alcohol, based upon the fact that an ounce of alcohol is produced in the fermentation of every quartern loaf. Mrs. B states that "the final operation of Nature" is putrid fermentation. It is notable that earlier in this chapter (p 195), before the discussion of fermentation, there are hints at a natural cycle of materials in nature ("No young plant, therefore, can grow unless its predecessors contribute both to its formation and support: and these furnish not only the seed ... but likewise the food by which it is nourished.") Such a cycle was proposed a little later by Liebig (1852) to account for the occurrence of nitrogen in both plants and animals.

Conversation 21, History of Vegetation

This *Conversation* is slightly expanded compared to the 1807 version and deals with soils and manures. There is much description and little chemistry. Mrs. B agrees with Emily that an important function of vegetation is to convert carbon, hydrogen and oxygen into a form suitable to feed animals. This is Nature's principal objective (p. 229). There is a long discussion of seeds and germination and the function of manure, with no real understating of chemistry and chemicals involved. Today this material might be considered to me more appropriate to a treatise on botany and agriculture. Caroline wonders why animal products produce better manure than vegetable products which contain more materials which plants require. This is because animal products contain more nitrogen than the vegetable and are more complex, and therefore decompose more rapidly (p 233). Caroline again has conceptual problems. "But Mrs. B, though experience daily proves the advantage of cultivation. A certain quantity of elementary principles exists in nature, which it is not in the power of man to augment or diminish" (p 235). The consequence is that the more of these that are contained in animals that eat plants, the fewer plants will be able to grow. Apparently, Caroline's misconception arises because there is much more of these principles in nature than plants and animals need. "Nature, however, in furnishing us with an inexhaustible stock of raw materials, leaves it in some measure to the ingenuity of man to appropriate them to its [sic] own purposes" (p 236). Emily wonders whether producing carbonic acid by combustion of coal might not increase vegetable growth, but Mrs. B points out that another consequence is London smoke, which was notorious then (p 237), and for more than a century after. The last great London fog was in 1952.

Agriculture is seen as a beneficial process, able to support industry and workers for the benefit of all even though, though, as Emily remarks, "Health and innocence are frequently sacrificed to the prospect of a more profitable employment" (p 238). It is remarkable that statements similar to these are still being made today.

The final part of the *Conversation* is a very descriptive account of seed germination and the functions of leaves. Mr. Senebier of Geneva has shown that plants reared by lamplight close their petals when the lights are extinguished. Plants whilst growing produce oxygen which is apparently derived from their chief sustenance, water (p 246). Priestley observed such oxygen evolution by 1774, perhaps earlier, but again his name is not mentioned. Animals can then use the oxygen. Emily remarks on the "harmony of nature" and Mrs. B comments on "the admirable design of Providence which makes every different part of creation thus contribute to the support and renovation of the other" (p 247). It may be more than an accident that the name of the non-Conformist Priestley is ignored in all this discussion, whereas Sir H. Davy is continually alluded to.

The *Conversation* finishes with a description of woods, resins, and growth, flowering, and deciduous and evergreen trees. The dispensations of wise Providence and Divine Wisdom are referred to more than once.

Conversation 22, On the Composition of Animals

This is the "last branch of chemistry" (p 259). The fundamental principles of animals are oxygen, hydrogen, carbon, and nitrogen, forming just gelatine, albumen and fibrine, the basis of all the parts of the animal system, an idea which the girls find surprising as animals are so complex (p 260). Phosphorus and some metals are also found in animals, especially in bones.

Bones and gelatine are related, and gelatine is clearly prized. Emily is surprised that the "common people" don't use bones to make gelatine (p 266), but Mrs. B reminds her that "There is a prejudice amongst the poor against a species of food that is usually thrown to the dogs." In any case, the best method for extracting gelatine uses too much fuel to adapt to the lower classes, though it is used by some charitable soup establishments. Bones are also used industrially to make hartshorn and sal ammoniac, originally imported from Egypt, but now exported to the Levant (p 267). This leads to a consideration of glue and leather and of cooking, which may be regarded as a variety of chemistry.

Albumen is effectively what we would now term protein, and it contains a little sulfur. Animal oil contains nitrogen, unlike vegetable oils. Animal acids are often formed by decomposition of animals. Prussic acid can be obtained from blood and caustic alkali, but also in other ways and from other sources. Prussic acid (or hydrocyanic acid) and cyanogen have been analyzed by M. Gay-Lussac (in 1815), and since they contain no oxygen, Sir H. Davy thinks the acid properties may be due to the presence of water (p 274). This question of the source of acidity was also posed in 1807, with the comment that not everyone accepted the oxygen/acid explanation of Lavoisier. This has been omitted by 1837 though overall the *Conversation* has been enlarged. The colors produced by prussic acid with metal oxides and with solutions of iron are described, especially Prussian Blue, and the degree of oxidation of its iron content is investigated (p 276).

Conversation 23, On the Animal Economy

This discussion of animalization, the way in which food is assimilated and converted to tissue, is very like the 1807 version. Caroline asks whether the disease rickets is due to a deficiency of phosphate of lime (p 281). Mrs. B states it is due to too rapid growth of muscles or poor digestion. Emily suggests it is due to bad nursing. Anyhow, exercise is good for muscular development. Then come arteries and veins, and lymph, and chyle, and blood, which is a very complex substance. "Females are furnished with another system of absorbent vessels, which are destined to secrete milk for the nourishment of the young" (p 286). The word breast would certainly not have been acceptable in 1837, and probably a reference to cows and udders would not have been regarded as in good taste. Finally nerves are mentioned, all joined ultimately to the brain. "Every organ of sense is a peculiar and separate ornament and the skin finally conspires to render the whole the fairest work of creation" (p 292). In this *Conversation*, discussion of chemistry is again conspicuous only by its absence.

Conversation 24, On Animalisation, Nutrition and Respiration

This is very like the 1807 version. Digestion occurs in the stomach, and the process and the subsequent assimilation of suitable matter into chyme, chyle and blood is outlined (p 296). The mechanism of breathing, using a mechanical model for illustration, is described, but the purpose ascribed to the circulation of the blood seems to be the "nourishment of every part of the body." Respiration involves the absorption of oxygen and the emission of carbonic acid gas, the bulk [volume] of the two being equal. The lungs supposedly purify the blood by oxidizing using oxygen all the impurities scavenged by the blood during its circulation (p 305). The quantities of gas involved for a normal adult are equivalent to eleven ounces of solid carbon in 24 hours (p 308). Perspiration is rather like transpiration of plants. Again, there is little chemistry in this *Conversation*.

Conversation 25, On Animal Heat and on Various Animal Products

Emily starts by saying how similar respiration seems to be to combustion (p 314). Mrs. B approves of the idea, but Caroline is shocked "A combustion on our lungs! that is a curious idea, indeed!" The problem that Mrs. B admits is that this heat evolution cannot be taking place in the lungs and she does not know exactly how carbon and oxygen can be converted to carbon dioxide in the body, because it is unlike a direct combustion, but it does produce heat. Perhaps light is involved and she does know that "It has been calculated that the heat produced by respiration in 12 hours … is such as would melt 100 pounds of ice" (p 315). This is the source of animal heat, and there follows a discussion of the effects of exercise, fever and climate on body temperature, normally constant. Mrs. B describes Sir Charles Blagden's new experiment of sitting in an oven at a temperature near that of boiling point of water and suffering no discomfort apart from "profuse perspiration" and also the experiment of M. De la Roche in Paris. He covered himself with resin, apart from his forehead, and remained in an even hotter oven, when his forehead "sent forth a copious stream of water" (p 320). This last experiment was already described in the 1807 version.

Even fish, which generate much less heat than animals, need oxygen dissolved in the water in order to breath, and birds breath more air in proportion to size than animals, because flying is so strenuous. There are some generalizations about the muscular strength of different kinds of animals. Milk, butter, cream and then animal products such as spermaceti, ambergris, wax, lac, musk, civet and castor are discussed. Animal matter decays in only a single step, putrid decay. In 1807 Mrs. B described a process in Bristol for manufacturing spermaceti, leather and phosphorus via the putrid fermentation of horse corpses under water. In 1837 she notes that this was not a commercial success (p 336).

And finally (p 336), a sermon from Mrs. B: "To GOD alone man owes the admirable faculties which enable him to improve and modify the productions of nature, no less than those productions themselves. In contemplating the works of creation, or studying the inventions of art, let us, therefore, never forget the divine Source from which they proceed: and thus every acquisition of knowledge will prove a lesson of piety and virtue." There is no chemistry in this *Conversation*, but Nature is clearly wonderfully designed, for the general benefit of mankind.

Because of the continuous revision, each edition of this book is a mirror of the state of chemistry of its time. Academic chemistry grew out of medicine, and this was very evident in the interests of Dr. Marcet, Jane's husband, who studied chemistry after exposure to Dr. Black's lectures when he arrived in Edinburgh to study medicine. Eventually he became more interested in chemistry than in medicine. The texts of *Conversations* are a reflection as much of his interests as of those of Mrs. Marcet. They contain a lot of descriptive matter, and precious little chemistry. However, the book also conveys a religiosity that was apparently Jane's and was surely characteristic of comfortable upper-class people of the period. The text reflects a disdain for people of the lower classes perhaps stronger than might have been expected from someone exposed to the rather patronizing but charitable influences of her Swiss husband and his compatriots from Geneva. The Genevan education system was adapted to the needs and requirements of all members of society, including those of the "lower classes."

The Novelty of *Conversations on Chemistry*

The above comparison of an early and a late version of *Conversations* is unique. It is difficult for us today to appreciate the impact that this book had in Britain, the United States, and even Europe. The contents of successive editions changed as the science of chemistry developed, and a consensus as to the breadth of the subject gradually grew. These editions provide a guide to the state of chemical science at the time each was published. For example, the thirteenth of 1837 notes that the tenth edition received a new *Conversation* on the steam engine, in the eleventh oxymuriatic acid became chlorine, possibly as a result of Davy's influence, and the twelfth had a revised *Conversation* on Electro-Chemistry. The approach even in 1837 is completely descriptive, non-mathematical and without a single atomic symbol or equation. This is equally true of Thomas Thomson's huge four-volume textbook for serious chemists, *A System of Chemistry* (33) which was published in 1802. Textbooks such as this were already available when *Conversations* first appeared in 1806, but were considerably less easily portable, let alone digestible. As late as 1860, Muspratt's two-volume treatise of over 2000 pages contained very few formulae (34). The style of Jane Marcet's writing is very different from that of a formal text book or reference work, being a joy to read even today. Nevertheless, this popular text was actually used as a textbook, often by medical students, confirming that *Conversations* was both comprehensible and up-to-date. Despite the different audiences to which they appealed, the organizations of the material in both *System* and *Conversations* are not very different. It is perhaps surprising that *Conversations* was used so widely and for so long in the United States, although many authorities there felt it necessary to amend, correct and expand the text, rather than writing their own books. That Mrs. Marcet treats Dalton's atomic theory as just an unproven theory shows how little influence it initially had upon practical chemistry.

Chemistry and medicine grew from a common source, as exemplified by the influential teachings of Joseph Black and his contemporaries in Edinburgh. Evidently the physicians who followed chemistry were eager to use the newer materials isolated by chemists in medicinal treatments, even if they had no idea of what these materials were likely to do. Some were certainly poisonous. Alexander Marcet was interested in kidney stones, termed calculi, and treatments for such inflictions, required often by gentlemen of quality, was apparently based upon the idea that such stones must be essentially mineral in content and therefore soluble in acids. This relationship of biology and chemistry is evident in many parts of the exposition purveyed by *Conversations*.

Conversations contained not only engravings based upon Mrs. Marcet's own drawings, but also descriptions of experiments, most apparently carried out by her in the laboratory she used in her father's house in St. Mary Axe, in London. This must have been set up by her husband, who later constructed a laboratory in their newer house in Russell Square. That Jane also included experiments in her text was not unusual for books of this kind. *A Grammar of the Principles and Practice of Chemistry*, apparently written by the Rev. David Blair, similarly contains no formulae but does describe experiments for the student to perform (35). The name Blair may be a pseudonym, and modern reproductions ascribe the book to its original publisher, Richard Phillips.

While Volume II, which initially tries to concentrate on chemical facts, is less fun and of less attraction than Volume I, one can begin to appreciate, even after almost two hundred years, why *Conversations on Chemistry* had such an impact. First, the dialogue format is between people who have some kind of individuality; they are not just ciphers. Caroline is bubbly and not inhibited in expressing her feelings, whereas Emily is a serious student. Many of those reading the book would have been able to identify with either or both Emily and Caroline. These characters were probably based upon two daughters of Sir John Sebright (4).

Secondly, despite the reluctance of the Marcet figure, Mrs. B, to claim any expertise for herself, the material contained in the book represented a large part of the contemporary corpus of chemistry. In a society in which the writing of school textbooks was not yet a widely recognized activity, teachers must have found this invaluable. Thirdly, many of the experiments seem to be derived from demonstrations at the Royal Institution. They would often have required considerable amounts of expensive equipment and experimental skill, and would have appealed most to teachers in institutions that could supply both. This might also explain the tendency for US copiers to add experiments that were more appropriate to a home environment. Certainly some of the British contemporary rivals did the same in their books. In any case, it must have been tempting to US writers to edit the text to make the references to purely British circumstances more palatable to US readers. Finally, Mrs. Marcet has managed to convey the excitement of research and the wonder of the new discoveries, and it is probably the girls Emily and Caroline rather than the didactic Mrs. B. who realize this. One can see perhaps a reflection of the young Jane Marcet in Caroline, delighting in the spectacle, drama, and value of the new chemistry, and in Emily a reflection of her studious husband, always trying to explain things. That the whole production is dressed in female clothes also argues for a much more enlightened philosophy of middle-class society than was then common. The religious, social and political attitudes displayed by Mrs. B reflect those of many upper middle-class ladies of the period, and confirm much that has been discovered from study of the Marcet archive in the Biblithèque de Genève (36).

The text of *Conversations* suggests that Emily and Caroline are not sisters, whatever the relationship of the persons upon whom they were based. They are probably of a similar age. Though Caroline's father is said to own a lead factory in Yorkshire, one guesses from the way she says this that Emily's father does not. Emily had travelled, at least to be able to have seen winemaking and charcoal manufacture. Caroline does not say she has also done so. Both girls wore muslin dresses even in 1837, though their clothes are not otherwise described. Nevertheless, the tutor and students together form a group of individuals whose excitement and attitudes still come through to us after more than two hundred years.

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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 researched her life intensively, and unearthed a considerable amount of new material about her, including a large number of personal letters, about which he is currently writing a further paper.

Conference: The Laboratory Revolution

The University of Groningen is presenting a conference titled "The Rise of the Laboratory and the Changing Nature of the University, 1850-1950" on 26-27 October 2017, at the University of Groningen, The Netherlands. The conference is part of the program "History of the University of Groningen (1614 to the present)."

Laboratories are the ultimate place where knowledge is created. What originally had been the workplace of chemists and alchemists, by the end of the nineteenth century had become a standard element in the infrastructure of science. The rise of the laboratory revolutionized the sciences in many ways and continues to do so. This development has been studied over the past decades by many historians, but the tremendous impact the rise of the laboratory had on the university is less well studied. In the nineteenth century, simple lecture halls were replaced by purpose built science laboratories, that could dominate the city scape. Even academic disciplines that on the face of it needed no laboratory space to develop, like astronomy, psychology and linguistics, each acquired their own laboratories. Also metaphorically, the laboratory became the paradigmatic site for scientific and scholarly research, as is shown by the historians, who liked to compare their libraries to laboratories. Finally, the nature of the academic community was tremendously changed by the rise of the laboratory, each laboratory becoming a small, self-contained community of professors, technical assistants, students, and administrative personnel. The conference 'The Laboratory Revolution' intends to bring together scholars from different backgrounds to study how the laboratory changed both science and the university. By merging the expertise of historians of science and scholarship, historians of architecture, social and cultural historians, and historians of the university, the organizers hope to create a better understanding of the revolution brought about by the rise of the laboratory – a revolution that is still going on.

Keynote Speakers include

- Antonio Garcia Belmar (Alicante University)
- Klaas van Berkel (University of Groningen)
- Ernst Homburg (Maastricht University)
- Alan Rocke (Case Western University)
- Geert Vanpaemel (University of Leuven)
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