



Alexander Marcet

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Resumen

Alexander John Gaspar Marcet (1770-185) un médico y químico suizo-inglés que estudió en detalle las aguas de diferentes océanos y lagos, en particular las del Mar Muerto; con Berzelius determinó las propiedades y composición correcta del bisulfuro de carbono y las propiedades refrigerantes de su vaporización; diseño una poderosa lámpara de alcohol; estudió la síntesis del tricloruro de nitrógeno, comparó la composición del quilo producido por dietas estrictamente vegetales o carnívoras, y confirmó la opinión (equivocada) de Wollaston de que la sangre de un diabético no contenía azúcar y que ella pasaba directamente del estómago a los riñones, sin participación del torrente sanguíneo.

Palabras clave

Agua del Mar Muerto, azúcar en la sangre, bisulfuro de carbón, quilo, tricloruro de nitrógeno.

Abstract

Alexander John Gaspar Marcet (1770-185) was a Swiss-British physician and chemist that carried a detailed study of the waters from different oceans and lakes, particularly those of the Dead Sea; with Berzelius determined the properties and correct composition of carbon disulfide and the strong cooling effect of its vaporization; designed a powerful alcohol lamp; studied the synthesis of nitrogen trichloride, compared the composition of the chyle produced from strictly vegetable and meat diets, and confirmed Wollaston's (wrong) belief that diabetic blood did not contain sugar and that sugar passed directly from the stomach to the kidney, without participation of the blood torrent.

Keywords

Dead Sea water, carbon disulfide, chyle, chyme, nitrogen trichloride, sugar in blood.

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Life and career (*Anonymous, 1823; Coley 1968; Garrod, 1925; Moore, 2020*)



FIGURE 1: Alexander Marcet (1770-1822).

Alexandre John Gaspar Marcet (Figure 1) was born in Geneva Switzerland, on August 1, 1770, the son of Marc Marcet, a merchant, and Louise-Marguerite Nadal. He received his school education there. In 1794, after studying business for two years, he decided that it was not to his taste and started to train for a career in law. The political unrest in Geneva after the French Revolution led to his imprisonment and banishment abroad for five years. Marcet took this opportunity to enroll in the University of Edinburgh from where he graduated as a physician on 24 June 1797, after successfully defending a thesis about diabetes (Marcet, 1797). After graduation, he worked as assistant physician at Cary Street Dispensary, as physician at the Finsbury Dispensary for Administering Advice and Medicines to the Poor and at Guy's hospital (1804), where he served until his early retirement in 1819. By a special act of the British Parliament, passed in 1800, he became a naturalized subject of England. While in Guy's hospital, he taught chemistry (1804-1809) and specialized in

medical chemistry, serving briefly at the temporary military hospital at Portsmouth in 1809 when it housed troops suffering from a virulent fever contracted during the expedition to capture Flushing and Walcheren (an unsuccessful British expedition to the Netherlands in 1809 intended to open another front in the Austrian Empire's struggle with France during the War of the Fifth Coalition). After the death of his father-in-law he inherited a large fortune and decided to leave the practice of medicine and pursue scientific research. Consequently, he moved from London to Geneva, where he was appointed honorary professor of chemistry.

In 1799 Marcet married Jane Haldimand (1769-1858). Three children were born of this union: Louisa, Sophie, and François.

In 1799 Marcet was admitted to the Royal College of Physicians and in 1815 was elected Fellow of the Royal Society. He was a founder member of the Medico-Chirurgical Society of London and its foreign secretary until his death in 1822.

Marcet passed away during a visit to London, on October 19, 1822, after suffering an attack of gout in the stomach. He was buried at Battersea and was survived by his wife.

Scientific contribution

Marcet wrote near 30 papers and books (e.g. Marcet, 1818, 1829) on the topics of inorganic and organic chemistry, saline waters, physiology, toxicology, etcétera In addition to the few subjects described below, he reported the effects produced by a large amount of Landanum

taken internally and the means to counteract its effects (Marcet, 1809); the analysis of the waters of an aluminous chalybeate spring (Marcet, 1811c); discussed the nature of the alkaline matter contained in dropsical fluids and in the blood serum (Marcet, 1811a, 1812c), the use of silver nitrate for the detection of minute portions of arsenic (Marcet, 1812b, 1815c), the medicinal properties of the thorn apple (*Datura stramonium*) with illustrative cases (Marcet, 1816), and the medical treatment of calculous disorders (Marcet, 1817); studied the properties of seawater in different parts of the ocean and suggested a correct procedure for their chemical analysis (Marcet, 1819, 1822); he also gave an account of a urine, which turned black after being discharged (Marcet, 1823); etcétera.

Analysis of the Dead Sea water

In 1772, Antoine-Laurent Lavoisier (1743-1794) reported the use of evaporation with a solvent to perform the analysis of seawater (Lavoisier, 1772). He wrote that the basic problem in the analysis of mineral waters was the separation of the different substances that composed it and their purification from the mother liquor and other extractive matter, such as the bituminous ones. He had found that the separation procedure was significantly improved using the fact that the salts present in seawater were very soluble in diluted alcohol, without inducing any reaction between them. The result of his experiments indicated, among other things, that aqueous alcohol dissolved easily sodium chloride and the calcareous nitrates, while pure alcohol did not dissolve sodium chloride, sodium hydroxide, sodium sulfate (Glauber's salt), and magnesium sulfate (Epsom salt). Pure alcohol dissolved only the crystallization water of Glauber's salt and deposited a fine powder. Lavoisier added that seawater was the result of the washing of the surface of the globe and dissolution of all the salts encountered by the water on the way to its final destination (Lavoisier, 1772).

The analytical procedure developed by Lavoisier began by putting a known quantity of water in a glass capsule and slowly evaporating it to dryness over a water bath heated by an alcohol lamp. As the salt concentration increased, the selenite (mineral gypsum) and the gypsum salts began to deposit naturally until traces of sodium chloride started precipitating. At this point the solids were removed, dried, and weighed, and the concentration renewed. Alcohol was then added to the final dried saline mass. The new residue was heated with a two-to-one mixture (by volume) of alcohol and water until completely dissolved. Upon cooling, the crystallized Glauber's salt and Epsom salt were separated, dried, and weighed. Lavoisier provided a detailed description of the procedure to identify the components of each of the fractions he had separated (Lavoisier, 1772).

In 1778, the Académie des Sciences commissioned Pierre-Joseph Macquer (1718-1784), Lavoisier, and Balthazar-Georges Sage (1740-1824), to analyze a sample of water from the Dead Sea that had been sent to Paris by the mineralogist Jean-Étienne Guettard (1715-1786) in well-sealed bottles. This water was limpid, odorless, tasting bitter and spicy, and contained a small deposit of crystalline sodium chloride, indicating that it was saturated with this salt. First measurements indicated that this water had a specific gravity of 1.2406, an extraordinary high value, unknown in the mineral kingdom (Macquer, Lavoisier, & Sage, 1778). Five liters of the water, evaporated to dryness in a glass vessel, deposited first 85.05 g of soaking crystalline cubes of earth-based sodium chloride, followed by the precipitation of a variety of other salts. The committee used the analytical method developed by Lavoisier, (based on aqueous alcohol) to determine that one kilo of

Dead Sea water contained 7.284 g of sodium chloride mixed with a small quantity of earth-based sodium chloride, and 37.944 g of earth-based sodium chloride, composed of about four parts of sodium chloride mixed with Epsom salt and three parts of ordinary earth-based sodium chloride. Macquer, Lavoisier, and Sage added that their analysis of the water of the Dead Sea showed that it did not contain "even one atom" of bituminous material, repudiating the claim of certain authors that the bitter and disagreeable taste of the water was due to the presence of bituminous matter. They believed that the particular taste of the water was caused by the presence of magnesium or Epsom salt (Macquer, Lavoisier, & Sage, 1778).

Marcet wrote that although the obvious particularities of the waters of the Dead Sea had been known for a long time, very little was known about its composition; it seemed that the only serious attempt had been made by Macquer, Lavoisier, and Sage (Marcet, 1807). The correct statements of these respected scientists were not accompanied by the accuracy of their results; improved analytical procedures were now available that could significantly improve the correct determination of the chemical composition of the waters. He had now come into possession of a very small amount of the water (about 43 g), kept in a careful corked bottle, recently brought from the Dead Sea together with a specimen of the water from the Jordan River. This river discharged directly into the Dead Sea and hence, its water might be expected to hold in solution ingredients analogous to those of the sea itself (Marcet, 1807).

The small size of the sample forced Marcet to make a variety of comparative experiments on artificial solutions of known composition. These experiments allowed him to judge the relative degree of accuracy of the several methods available for the analysis of multicomponent saline solutions. His first step was determination of the properties of the Dead seawater: (1) it had a relative density of 1.211, a value substantially high than all known waters; (2) it was perfectly transparent and did not deposit any crystals on standing in closed vessels; (3) its taste was particularly bitter, saline, and pungent; (4) solutions of silver nitrate produced a copious precipitate, showing the presence of sodium chloride; (5) oxalic acid indicated the presence of calcium salts; (6) treatment of the filtrate from the calcium precipitate with caustic hydroxide or carbonate, indicated the presence of magnesium; (7) solutions of barium hydroxide produced a cloud, showing the existence of sulfates; (8) treatment with succinic acid and ammonia indicated the absence of alumina; (9) addition of a small amount of pulverized sea salt induced no precipitation, showing that the water was not saturated with sodium chloride; and (10) the water did not react with any of the known infusions used to determine acid or basic character. In summary, all these tests indicated that the water contained calcium chloride, magnesium chloride, common salt, and selenite (mineral gypsum) (Marcet, 1807).

Marcet described then in detail the two gravimetric procedures he had followed to determine the amounts of the three chlorides mentioned above, when present in the artificial solutions and in the sample of Dead Sea water. Its final results indicated that 100 parts of the seawater contained 3.792 parts of calcium chloride, 10.100 of magnesium chloride, 10.676 of sodium chloride, and 0.054 of calcium sulfate, for a total of 24.622 parts of these salts. Marcet added that his results were substantially different from those reported by Macquer, Lavoisier, and Sage. These differences were not surprising when considering the inadequate methods used by the latter for the separation and drying of the salts, as well as deficient methods for estimating their quantities and proportions. In addition, the

difference in the values of the relative density was indicative of previous evaporation, as shown by the presence of crystals in their samples of the waters (Marcet, 1807).

The small amount available of water from the Jordan River, and its high relative dilution, did not allow him carrying similar experiments. Anyhow, the partial results suggested that it was very plausible that they were the source of the saline components of the Dead Sea (Marcet, 1807).

In 1809, Martin-Heinrich Klaproth (1743-1817) published a short note claiming that the results reported by Marcet were inconsistent, and for this reason he had decided to carry the analysis the waters of the Dead Sea using a large sample collected a few years before by the mineralogist William Thomson (1760-1806) (Klaproth, 1809). This water was colorless and transparent, except for a small degree of muddiness, obviously owing to the cork stopper, tasting bitter, salty, and sharp, and having relative density 1.245. Five hundred parts of this water, evaporated to dryness, gave 13.80 parts of dry salt, which were digested with five times its weight of alcohol (Lavoisier's procedure). Chemical analyses indicated that 100 parts of the water contained 24.20 of magnesium chloride, 10.60 of calcium chloride, and 7.80 of sodium chloride, for a total of 42.60 parts of salt. These results were different from those reported by Marcet. According to Klaproth, the difference was probably due to Marcet's complicated calculation procedures, and to his salt not being dried completely (it was known that earthy nitrates absorbed water from the atmosphere while cooking). In addition, there was also a difference in the value of the density of the raw water. Klaproth postulated that the water used by Marcet was probably collected not far from the place where one of the streams of the Jordan River fell into the Dead Sea (Klaproth, 1809).

Klaproth's paper was sharply criticized by Marcet (Marcet, 1813c). He wrote that Klaproth had mentioned that Marcet had used complicated calculation procedures, but Klaproth's paper did not give any indication of the procedure he had followed to obtain his numerical results. Marcet described again the main features of his analytical procedures and the fact that he had carried all analysis using solid phases in a state of perfect desiccation, such as could only be achieved by a red heat. Again, he mentioned that Klaproth had not reported how he had carried this operation. He described the operations carried by Klaproth and left to the reader to compare them with his and decide which one appeared the simplest, the most direct, and the most likely to be accurate (Marcet, 1813c).

Carbon disulfide

Wilhelm Augustus Lampadius (1772-1842) accidentally discovered carbon disulfide when trying to determine how much sulfur the mineral pyrite (FeS_2) would furnish when heated with charcoal. He also prepared it by distillation of pyrites mixed with carbon or sawdust. The synthesis was very difficult and inefficient, yielding only 20% of the product. In all cases he obtained a very sulfurous liquid that he suspected was a compound of hydrogen and sulfur and which he named *alcohol sulfur* (*Schwefelalcohol*). He was unable to determine its composition; he only reported that it was very volatile and seemed to be an alcohol containing sulfur (Lampadius, 1796, 1803). In 1802 Nicolas Clément (1779-1842) and Charles-Bernard Desormes (1777-1862), without knowledge of Lampadius' work, rediscovered this compound during their experiments about the nature of carbon that tried to demonstrate that it did not contain hydrogen (Clément & Desormes, 1802). It was known that under the action of the most intense heat, carbon obtained by the decomposition

of organic matter still contained volatile compounds to which it seemed to be attached. This assumption was based on the fact the combustion of carbon usually generated water, which meant that it contained hydrogen, and that the amount of CO_2 formed was less than with diamond. Many chemists believed that carbon monoxide was a combination of carbon, oxygen, and hydrogen, and that the latter was responsible of the flammability of this gas. Clément and Desormes conducted experiments under different conditions and concluded that carbon did not contain hydrogen and that water was present in it due to its hygroscopicity. They found that sulfur and carbon combined at high temperature and probably in different proportions. The most interesting product was one that was liquid at room temperature and pressure, which they prepared by passing vaporized sulfur through an ignited porcelain tube containing carbon in fragments and powder (it could also be prepared by heating antimony sulfide with carbon). The pure compound was transparent and colorless, had a disagreeable and pungent smell, was heavier than water, and cooled strongly during evaporation without leaving a residue. Submission of the compound to a series of experiments showed that it was a combination of sulfur and carbon, with no traces of hydrogen; hence it should properly be called *carbureted sulfur*. Claude Louis Berthollet (1748-1822) repeated the experiments of Clément and Desormes and concluded that carbureted sulfur was actually a compound of sulfur and hydrogen and did not contain carbon (Berthollet, 1802). A few years later Louis Nicolas Vauquelin (1763-1829) recognized Lampadius as the discoverer of carbon disulfide replicated the experiments of Clément and Desormes, using a slightly modified apparatus that allowed distillation of the product of the reaction (Vauquelin, 1807). The resulting liquid (*liquid sulfur*) was slightly yellow green due to the presence of sulfur; distillation yielded a perfectly translucent liquid, which caught fire promptly when coming close to an ignited body, releasing SO_2 and depositing a yellow powder, which seemed to be sulfur. It was much heavier than distilled water and had a strong fetid and penetrating smell similar to garlic. Vauquelin reported its reaction with sulfuric and nitric acids, KOH, ammonia, alcohol, etcetera. Passing its vapors over heated copper resulted in the formation of carbon and copper sulfide, indicating the presence of carbon and sulfur. Vauquelin added that Pierre Jean Robiquet (1780-1840) had carried the pertinent reactions, under his direction (Vauquelin, 1807).

In 1813, Jöns Jacob Berzelius (1779-1848) and Marcet reported the results of a long research project upon the preparation, properties, and composition of carbon disulfide (Berzelius & Marcet, 1813). They repeated that Lampadius had considered this substance to be a compound of sulfur and hydrogen, Clément and Desormes, a combination of sulfur and charcoal, Berthollet, a triple combination of sulfur, charcoal, and hydrogen, and Vauquelin and Robiquet, a binary compound of sulfur and hydrogen. These varieties of opinions among so famous chemists led Berzelius and Marcet to reexamine this compound to determine its composition and the ratio of its components. The pertinent experiments were conducted with four objectives: (1) determination of properties of compound; (2) experiments to test the presence of hydrogen; (3) experiments to test the presence of carbon; and (4) experiments to determine the ratio of the components (Berzelius & Marcet, 1813).

Berzelius and Marcet prepared their carbon disulfide by the method of Clément and Desormes, that is, by slowly volatilizing sulfur through red-hot charcoal in a porcelain tube, and condensing in water the resulting oily liquid. The resulting fluid, of relative density 1.321, was of a pale yellow color, very volatile, and producing a strong cold during evaporation, while depositing crystalline sulfur. The raw condensate was purified by distillation at 100 to 110 °C in the presence of some dry calcium chloride to obtain a

moisture-free product. The pure compound was a transparent and colorless liquid, acrid, pungent, and somewhat aromatic, and smelling nauseous and fetid. Its relative density and refractive power was 1.278 and 1.645, respectively. It boiled between 40.560 and 43.33 oC, and did not freeze when cooled down to -51.11 oC. It was highly volatile and caught fire at a temperature slightly exceeding 357 oC; it burned in a bluish flame, emitting copious fumes of SO₂. It was readily soluble, although not completely, in alcohol and ether. Berzelius and Marcet reported the action of a variety of reagents with the purified product, among them, water, potassium, mercury, amalgams of silver or lead, alkalis, phosphorus, etcetera (Berzelius & Marcet, 1813).

A variety of experiments with a Volta eudiometer proved that the compound did not contain hydrogen, and combustion experiments with pure oxygen and dissolution in baryta water showed that it contained carbon, and hence, that the compound was a true *carbon sulfuret* (carbon sulfide). Distilling the sulfide through ignited iron oxide and analyzing the resulting iron sulfide and gas mixture of SO₂ and CO₂ determined the proportion of carbon and sulfur. The results of these procedures indicated that the alcohol of sulfur contained, by weight, 84.83% sulfur and 15.17% carbon, that is, two atoms of sulfur to one of carbon corresponding to the formula CS₂, in perfect agreement with the law of fixed proportions (an appendix by Berzelius gives a detailed description of the pertinent calculations) (Berzelius & Marcet, 1813).

Berzelius and Marcet described in detail the reaction of carbon disulfide with ammonia, calcium, barium, and strontium to form the pertinent carbon sulfides. For example, ammonia gas and liquid carbon disulfide were introduced in a receiver filled with mercury and left alone to react. After some hours, a saline yellow substance, non-crystalline, began to deposit until all the disulfide had disappeared. The product had a strong ammonia smell and was so deliquescent that it could not be transferred to another vessel without alteration. The resulting solution was first red and then deep orange. Distilled in its wet state it sublimed and deposited crystals of ammonium sulfide. Berzelius and Marcet also reported the synthesis of a new compound produced by the continuous action of aqua regia on carbon disulfide: a portion of carbon disulfide exposed to the action of a fuming mixture of fuming nitric acid with concentrated HCl acquired instantly a peculiar odor resembling that of sulfur chloride. The carbon disulfide assumed a reddish orange color while slowly releasing nitrous gas. After about three weeks, the whole transformed into a solid white crystalline body, having the appearance of camphor. This substance, washed with water, turned colorless, tasted acrid and acid, and sublimed without leaving a residue. The alcoholic solution had a very acid and disagreeable taste, it turned red litmus paper and dissolved zinc while releasing an extremely fetid gas. All the results seemed to indicate that this substance contained sulfur and carbon in combination with oxygen. Chemical analysis indicated that it contained, by weight, 48.74% HCl, 29.63% SO₂, and 21.63% CO₂ (Berzelius & Marcet, 1813).

In 1811 John Leslie (1766-1832) illustrated the well-known fact of the production of cold, by actually freezing water, as the result of a rapid process of vaporization from the water itself. He put water over a vessel containing sulfuric acid and applied vacuum by means of an air pump. The pump cooled the water as the exhaustion process proceeded and as a result, converted it into ice. Leslie wrote that he had used the same process to freeze mercury without difficulty (Leslie 1811). In two following papers, Marcet proved that Leslie's method could be successfully improved by using, instead of water, the strong cooling effect produced by the evaporation of ether and carbon disulfide (Marcet, 1813ab).

He mentioned that adding a few drops of carbon disulfide on top of the bulb of a small alcohol thermometer covered with a bag of fine flannel or lint, resulted in the rapid drop of the temperature from 15.60 to -17.8 oC. A temperature drop of only 10o or 6.7 oC accompanied a similar experiment conducted with ether or alcohol, respectively. He added that the humidity of the air seemed to have some influence on the intensity of the effect, as indicated by carrying the experiment in a glass bell under vacuum. Experiments with a mercury thermometer resulted in the freezing of the mercury. Marcet warned against working the vacuum pump too rapidly, for in this case the amount of heat generated by the air rushing out could be sufficient to ignite the carbon disulfide (Marcet, 1813b).

Marcet *also* achieved the freezing of mercury by modifying William Wollaston's (1766-1828) cryophore, replacing the cold produced by evaporation by the one produced by an ordinary freezing mixture (Marcet, 1815a). He also developed a very ingenious modification of the alcohol lamp to produce in small scale, a degree of heat that had never been achieved before, except by the voltaic battery of John George Children (1777-1852) (Marcet, 1813d, 1815a). His modification consisted simply in intensifying the flame of the lamp by a current of oxygen. The flame of his artifact burned a diamond in a few minutes; platinum and iron wires of a moderate thickness were instantly melted; and small needles of quartz were readily melted and vitrified. Wollaston used this apparatus to draw extremely fine wires of platinum (Wollaston, 1813).

Nitrogen trichloride

In 1812 Marcet wrote to Jean Louis Prévost (1790-1850) that a young student at Cambridge had found by accident that emptying a bell containing HCl gas into a solution of ammonia or ammonium nitrate resulted in the formation of oily drops, heavier than the liquid, which after some hours, transformed partially or totally into gas (Marcet, 1812a). Humphry Davy (1778-1851) prepared this oil in the presence of Marcet and noticed that approaching a candle to a drop of it, it caught fire immediately and burned with a distinct flame, accompanied by a small explosion (Davy, 1813). He also reported that heating the drop in a closed glass tube resulted in a strong explosion that shattered the glass. Mixing the oil with olive oil at room temperature led to its immediate ignition, while mingling it with turpentine caused a powerful explosion, with no further consequences (fortunately). Marcet *also* prepared it without incidents. After some days, Davy prepared it again, this time with terrible results: a glass fragment from the resulting explosion hit one of his eyes and left him temporarily semi-blind (Marcet, 1812a).

Marcet believed that this new compound was a combination of chlorine and nitrogen.

According to Thenard and Berthollet, Pierre Dulong also prepared this substance in 1811 by reacting chlorine with ammonia (Thenard & Berthollet, 1813). Dulong, like Davy, was unaware that the product was shock-sensitive and the discovery also cost him dearly, he lost a finger during the first experiences and almost an eye during the analysis of the product. The compound was a new substance that not only had explosive powers; it also had theoretical interest because its synthesis took place with heat storage from the energy released by a parallel reaction. Thus during the action of ammonia on chlorine, nitrogen chloride was formed by the reaction of hydrogen and chloride, a reaction that provided the necessary energy. This stored heat was the energy released during the decomposition of nitrogen chloride, with serious consequences (Thenard & Berthollet, 1813).

Today we know that nitrogen chloride, or trichloroamine, is the only stable pure ammonia halamine. It is a shock-sensitive yellow liquid that boils at 71°C with a volatility similar to that of chloroform. In the gas phase it can be completely decomposed to nitrogen and chlorine by spark initiation at a concentration of only a few percentages in air.

Chyle and chyme

In 1815 Marcet reported the results of the experiments he had done to determine if there was any sensible chemical difference between the chyle obtained from a dog previously fed with vegetable food alone, and chyle provided by another dog, after a meal consisting solely of animal food. In both cases the material was collected from the thoracic duct of the dogs within three hours after they had been fed (Marcet, 1815b).

According to Marcet, fresh vegetable chyle appeared as a semi-transparent colorless fluid, having a very slight milky color, like very diluted in water, and was slightly alkaline. It contained a semi-transparent and nearly colorless coagulum having the appearance of the white of an egg and presenting minute reddish filaments on its surface. The serum was separated by decantation and found to have specific gravity between 1.0215 and 1.022. No putrefaction was observed after 10 days. Heat did not coagulate it but made it somewhat turbid and milky. Addition of nitric acid precipitated abundant white flakes, while concentrated sulfuric acid or HCl produced dense white precipitates, which disappeared on dilution with water, and reappeared upon addition of nitric acid. Dilute sulfuric acid and HCl produced no precipitate but nitric acid did; the latter disappeared on boiling. According to Marcet, all these results indicated the presence of albumen. The serum was evaporated until constant weight; the resulting yellow residue corresponded to 4.8% of the original liquid (Marcet, 1815b).

The chyle from the animal food had similar properties, except that it was white and opaque like cream. The residue of the coagulum putrefied within three days. The serous portion was also somewhat different: on standing a white opaque cream rose to the surface. The amount of solid in the serum was found to be 7% (Marcet, 1815b).

Marcet evaporated to dryness in glass tube a small quantity of vegetable chyle and observed that it turned black immediately, frothed abundantly, and released first a whitish vapor of water mixed with ammonium carbonate and then a brown oily one, amounting to about one-third of the mass. The charcoal residue, amounting to about 3% of the total, proved to contain salts of iron and other elements. The animal chyle behaved in a similar manner but appeared to contain more ammonium carbonate and oil and less carbonaceous matter than the vegetable one. Marcet added that the chyle from vegetable food seemed to hold about three times as much charcoal as that from animal food (Marcet, 1815b).

Marcet also examined the chyme of a turkey that had been fed vegetable food alone. This substance appeared as a homogenous brownish opaque pulp; slightly acid, and smelling like poultry. It was scarcely fluid but on shaking it turned into large clots. At the end of twelve hours it was quite putrid. Evaporated to dryness it left a residue weighing about one-fifth of the original mass. Burnt in a platinum crucible it left a carbonaceous matter amounting to 12% of the chyme being examined (Marcet, 1815b).

Sugar in the blood of diabetes patients

At one time, Wollaston told Marcet that he had conducted experiments, which proved that the blood of persons suffering from diabetes did not contain sugar. In 1811, Marcet, who was strongly interested on the subject, wrote Wollaston requesting information about these experiments. Wollaston answered him that his first attempts to detect sugar in the blood were done after he had read Dr. John Rollo's treatise on diabetes (published in 1798) (Wollaston, 1811).

According to Wollaston, it seemed that although Rollo and his partner Dr. William Cruickshank had not obtained enough serum to conduct chemical experiments and test the existence or non-existence of sugar in the blood of persons suffering from diabetes, they were persuaded of its presence. Cruickshank determined the amounts of oxalic acid that could be formed from serum or from the blood in its natural state, and from the same serum or blood after the addition of a known amount of sugar. According to Wollaston, this procedure suffered of two shortcomings: (1) an excess of other ingredients beside sugar would increase the quantity of oxalic acid formed, and (2) slight variations in the process for forming oxalic acid would unavoidably occasion differences in the result (Wollaston, 1811).

Wollaston found that heating the serum in the presence of a small amount of diluted acid assured total coagulation and crystallization of the salts it contained. Addition of ten grains of sugar to an ounce of serum previous to coagulation prevented totally the crystallization of the salts. Wollaston knew that the sugar obtained from diabetic urine was different from common sugar. For this reason, he repeated the experiment adding this particular sugar instead of common sugar and found the same results. As a further test of the absence or presence of sugar he had added a small amount of nitric acid to the salts that remained after crystallization. He reasoned that if the serum had been successfully coagulated in the absence of sugar, the nitric acid would convert the chlorides into nitrates and sodium nitrate would crystallize without foam. If sugar had been added, foam would form, and this foam would become black in proportion to the quantity of sugar present. Wollaston proceeded to analyze specimens of serum or blood from diabetics under different conditions, whose urine contained different amounts of sugar. All the results indicated that none of the serum or blood samples showed the presence of any perceptible amount of sugar (Wollaston, 1811).

Wollaston reasoned that to account for the presence of sugar in the urine required assuming that the kidneys had the capability of forming this new product by secretion, assumption which seemed to negate the knowledge about this organ; or to suppose that the sugar was formed in the stomach by a process of imperfect assimilation, which required the existence of a channel that would carry it from the stomach to the kidney, without passing through the blood system. To avoid these assumptions, Wollaston used a very ingenious alternative: ingestion of sodium prussiate by a healthy person. This done, the pertinent urine secreted was examined every so many hours and found to be turned deep blue by ferrous sulfate after four hours. Samples of the blood taken from the arm and the serum were tested for prussiate, with negative consequences. All these results convinced Wollaston of the presence of a channel between the stomach and kidney, undetected yet (Wollaston, 1811).

Marcet carried a series of experiments to test Wollaston's hypothesis, more or less according to the following example: a young woman suffering of diabetes mellitus was fed

five grains (0.32 g) of potassium prussiate dissolved in water, and this step repeated every hour until she had taken fourteen doses. After the fifth dose her urine tested positive upon addition of ferrous sulfate. At this time a blister was applied to her stomach and cut off after a few hours. The serum was separated and found to test negatively with ferrous sulfate, in spite of the urine testing positively for the next fifteen hours taking potassium prussiate. The same experiment was repeated in the opposite direction: the patient was fed ferrous sulfate and the urine tested with prussiate. This time the result was negative; no iron was detected in the urine (Marcet, 1811b).

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