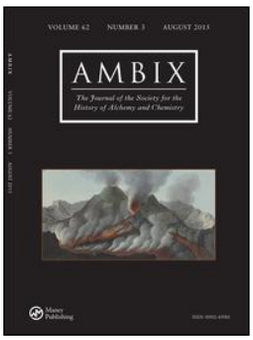

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MATEU ORFILA'S *ELÉMENS DE CHIMIE MÉDICALE* AND THE DEBATE ABOUT THE MEDICAL APPLICATIONS OF CHEMISTRY IN EARLY NINETEENTH-CENTURY FRANCE

BY JOSÉ RAMÓN BERTOMEU SÁNCHEZ AND ANTONIO GARCÍA BELMAR

...Le docteur Vaucorbeil pouvait, sans doute, les éclairer.
Ils se présentèrent au moment de ses consultations.
– 'Messieurs, je vous écoute! quel est votre mal?'
Pécuchet répliqua qu'ils n'étaient pas malades, et ayant exposé le but de leur visite:
– 'Nous désirons connaître premièrement l'atomicité supérieure.'
Le médecin rougit beaucoup, plus les blâma de vouloir apprendre la chimie.
– 'Je ne nie pas son importance, soyez-en sûrs! mais actuellement, on la fourre partout! Elle exerce sur la médecine une action déplorable.' Et l'autorité de sa parole se renforçait au spectacle des choses environnantes'

Bouvard et Pécuchet, Gustave Flaubert (1880)

THE *Elémens de chimie médicale* by Mateu Josep Bonaventura Orfila i Rotger (1787–1853) may be considered to be one of the most important chemistry textbooks published in France during the first half of the nineteenth century. The first edition was published in Paris by Nicolas Crochard in 1817. The two thousand copies of this edition quickly ran out and a new edition was published two years later. Several translations appeared in these two years: one in Italian, one in Spanish by the author and an English abridged version by John Redman Coxe of Philadelphia. Between 1819 and 1820, a German translation by Friedrich Trommsdorff appeared with notes by Johan Bartholomäus Trommsdorff. At a later date, new Spanish and Italian translations were published. The book was diffused even more widely after the publication of an abridged version by one of Orfila's students in 1828; it was re-published several times and translated into Spanish, Italian and Dutch.[1]

Orfila's textbook is a valuable source for the study of the characteristics of French chemistry textbooks during the first half of the nineteenth century, a period of great change in the teaching of chemistry in France. Student numbers increased as a result of the development of science teaching in secondary schools and in medical faculties. These changes contributed to consolidating chemistry textbooks as a genre of chemical literature, with special formats and specific contents.[2]

In the first edition, Mateu Orfila stated that his book was aimed mainly at students of medicine and pharmacy attending his chemistry courses in Paris. Such students provided one of the most important readerships of chemistry textbooks during these years. Like Orfila, many chemistry textbook authors were physicians or pharmacists and aimed their books at this group. In

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different ways, these works were adapted to the requirements of these readers, with interests related to medical applications of chemistry. However, not all doctors of the period had the same opinion of the possible uses of chemistry in medicine and an important debate on this question took place in France.

This paper deals with the reception of Orfila's textbook by the French medical community, analysing one of the principal contexts in which chemistry textbooks were written, published and read in France during the first half of the nineteenth century. Our study also aims to shed light on the factors which shaped the definitive characteristics of the chemistry textbook as a genre of scientific literature.

1. The Teaching of Chemistry for Medical and Pharmaceutical Students

Students of medicine, surgery and pharmacy during the first half of the nineteenth century in France were not a homogeneous group because of the variety of titles allowing the holder to practise these professions and the different ways in which they were obtained. After the unification of medicine and surgery in late-eighteenth-century France, new legislation established two different titles enabling their holders to practise: 'docteur en médecine' and 'officier de santé'. According to the *loi du 19 ventôse an IX* (9 March 1803), a would-be docteur en médecine had to study at one of the three medical faculties–established in Paris, Strasbourg and Montpellier–and to pass certain examinations, which included chemistry as one of the subjects. At the end of their studies, they had to present a thesis written in French or Latin. By contrast aspirants to the title of officier de santé could take their degree without spending several years in a medical faculty or in an 'école sécondaire de médecine'. They could instead be examined by a 'jury medical' after obtaining practical training as apprentices with a doctor or in a hospital.[3]

Consequently, the chemical studies that were necessary in order to obtain these titles were very different. Whilst it was obligatory for doctors to study chemistry during their first years in the medical faculties, officiers de santé could obtain their titles without an academic education in chemistry. According to the first set of regulations of the Ecole de Santé of Paris, the course on chemistry and pharmacy was to begin with some general principles, followed by a chemical description ('histoire chimique') of the animal, vegetable and mineral kingdoms, and conclude with the relationship between practical and theoretical knowledge of chemistry and the art of pharmacy.[4] During the early years, these courses were taught by Antoine Fourcroy (1755–1809) and Nicolas Vauquelin (1763–1829). After the dismissal of liberal professors and the changes in medical curricula during 1823, the name of this course was changed to 'medical chemistry'. Mateu Orfila was its professor for the rest of the first half of nineteenth century. In 1837, the course on pharmacology was changed to 'pharmacy and organic chemistry' and Jean Baptiste Andre Dumas (1800–1884) was its professor thereafter.[5]

In addition to the theoretical courses, there were also some practical chemistry courses but these were limited to a small group of students from the 'Ecole practique' every year.[6] In 1835, a new course on chemical manipulations was created: groups of 120 students attended thirty practical sessions devoted to revising all relevant organic and inorganic pharmaceutical preparations. Some of these operations had to be done by the medical students and others by the 'aide de chimie'. For example, the regulations required the aide de chimie to demonstrate chemical experiments for identifying salts and other chemicals. In addition, this practical training included a daily discussion of these chemical experiments under the guidance of a 'chef des travaux chimiques'. This position was held by Octave Lesuer (d. 1860), Orfila's brother-in-law who collaborated with him on several publications on toxicology.[7]

Chemistry courses were also established in Montpellier and Strasbourg. During the early nineteenth century, Chaptal was in charge of a course on 'medical chemistry applied to the arts and pharmacy' in the Montpellier Medical Faculty.[8] After 1803, this course was denominated 'medical chemistry and pharmacy' and, as happened in Paris, one of its purposes was to prepare students for the first examinations they were to take after registering in a Medical Faculty.[9] After 1834 a new course was established on 'general chemistry and toxicology' and Jacques-Etienne Bérard (1789–1869) was appointed professor. A chemical laboratory was created for practical teaching but only the professor was permitted to carry out the chemical manipulations.[10] In Strasbourg, chemical courses were given in the medical faculty during the first third of the century by Gabriel Marie Masuyer (1761–1849), who wrote a *Précis d'un cours de chimie philosophique et médicale* which was published in 1815. As in other medical faculties, during the late 1830s a school of practical chemistry was established in order to train medical students in chemical manipulations under the guidance of a 'chef de laboratoire'.[11]

In many French cities, special medical schools intended for officiers de santé were created with the name of 'écoles secondaires de médecine'. Chemistry was taught in some of these schools, especially after the changes promoted by Orfila who introduced compulsory chemistry and pharmaceutical courses.[12] In 1840, these schools became 'écoles préparatoires de médecine et pharmacie', with chemistry courses in the first year of the studies.[13]

Ecoles de Pharmacie

Students of pharmacy were another intended audience for Orfila's textbook. Their importance was, however, minor compared to students of medicine since they could obtain their title without attending lessons in the 'écoles de pharmacie'. In accordance with the *Loi 21 germinal an XI* (11 April 1803), aspirants to the title of pharmacist could choose between traditional training, a long period of 'compagnonnage' (apprenticeship) with a pharmacist, or an

academic education in a school of pharmacy for three years plus a shorter period of apprenticeship (three years). Both types of candidates then had to pass an examination.[14] Three schools of pharmacy were established in Paris, Montpellier and Strasbourg but they did not become integrated into the university system until 1840.[15]

After their creation, the schools of pharmacy included theoretical chemical courses in their curricula. Practical courses were not introduced until some years after, following the labours of Alexandre Bussy (1794–1877) in Paris. Bussy collaborated in the translation of Faraday's book on chemical manipulations, probably with the purpose of using it in his practical classes.[16] In 1844, a new regulation compelled schools of pharmacy to establish 'écoles pratiques', in which students could be trained in practical chemical operations related to their future work.[17] As a result, by the middle of the nineteenth century, both medical faculties and schools of pharmacy offered practical and theoretical courses of chemistry, although the conditions of these courses in different centres varied considerably.

Several features clearly differentiated the courses followed by students of medicine and by students of pharmacy. For example, students of medicine had to have a 'baccalauréat-ès-lettres' and, from 1823, also a 'baccalauréat-ès-sciences physiques' in order to enrol in the medical faculties, while only the baccalauréat-ès-lettres was compulsory for the students of the schools of pharmacy, and then only after 1840.[18] Furthermore, the number of doctors was larger than the number of pharmacists during the first half of nineteenth century. Moreover, the number of pharmacists received by the 'jurys médicaux' was much greater than the number of students in the schools of pharmacy.[19] By contrast, medical doctors received an academic education in medical faculties and comprised a larger group than officiers de santé.[20]

Private Chemistry Courses

Besides the courses offered in the faculties of medicine and the pharmacy and veterinary schools, there were a great number of private and public chemistry courses for students of medicine and pharmacy. In 1818, an unofficial guide for students at the Paris Medical Faculty recommended the courses of institutions such as the Ecole de Pharmacie, the Collège de France, where Louis Jacques Thenard (1777–1857) was teaching chemistry, and the Museum d'Histoire Naturelle, where firstly, Nicolas Louis Vauquelin (1763–1829), and afterwards, André Laugier (1770–1832) were in charge of chemistry courses. Jacques Maygrier (1771–1834), a physician and author of this guide, strongly recommended that medical students attend lectures on general chemistry at the Muséum d 'Histoire Naturelle in order to be able to make the most of the chemistry courses taught in the faculty of medicine.[21]

Medical students also acquired an important part of their chemical knowledge in various private courses. Apart from his own courses, Jacques Maygrier suggested in the guide of 1818 that medical students follow private

courses of anatomy, physiology, medicine, surgery, etc. which were taught by teachers such as Jean Marjolin (1780–1850), Nicolas Adelon (1782–1862) and François Magendie (1783–1857), and also chemistry courses taught by Nicolas Vauquelin, Mateu Orfila and Laurent Salle.[22] In the *Almanac général de médecine* of 1827, a great number of private courses were reported, including courses on medical chemistry by Marie Guillaume Devergie (1798–1879), chemistry applied to the arts by Henry Gaultier de Claubry (1792–1878) and general chemistry by George Sérullas (1774–1832).[23] New courses appeared during the 1830s as a result of the rules making it obligatory for students to pass baccalauréat-ès-sciences exams before being admitted to medical faculties. Two of the teachers of these courses–J. Tyrat (*fl.* 1838) and Edouard Robin (b. 1808)–published chemistry textbooks for their students and, in publicity brochures, affirmed that, in addition to the theoretical lectures, their students had the use of a physical and chemical laboratory in order to practice chemical manipulations.[24]

These private courses were encouraged by the members of the Paris Medical Faculty and part of the faculty building was reserved for them. According to Mateu Orfila, this system literally accommodated pedagogical innovation:

> [For my part] I strongly support this system, the main advantages of which are that they complement the syllabus to be taught by the Faculty during the year and stimulate a useful competitive spirit among teachers who will always be wary of allowing themselves to be overshadowed by young rivals; in short honour, within the bounds of reason, the principle of academic freedom so often insisted upon.[25]

Orfila's support for these private courses is not surprising. After studying in Valencia and Barcelona, Orfila moved to Paris thanks to the financial support given by the Junta de Comerç de Barcelona, where he had studied chemistry under Francesc Carbonell i Bravo (1768–1837). In Paris, Orfila attended several science courses at the Muséum d'Histoire Naturelle, including one on chemistry by Vauquelin, who admitted him to his laboratory. During the winter of 1807–1808, at the same time as he registered as student at the Paris Medical Faculty, Orfila started teaching physics and chemistry in a laboratory equipped by a wealthy friend, Auguste César Barrat.[26] The war between France and Spain deprived Orfila of his grant and compelled him to keep organising private courses which became some years later his main source of income.[27] Between May and August of 1811, he passed the required exams in order to obtain his M.D. and in December he defended a medical thesis entitled *Nouvelles recherches sur l'urine des ictériques*.[28] During the winter of 1812, Orfila taught chemistry to a group of forty students. The following year he moved to a new laboratory where he kept lecturing on chemistry and other subjects such as legal medicine, botany and anatomy for more than three years.[29] He also applied for a post as a teacher of physics and chemistry in one of the Lycées created in Paris but, despite being supported by Vauquelin, Haüy and

Thenard, he was not accepted.[30] In 1817, he replaced Jacques Thenard in the chemistry courses at the Athénée of Paris and published his *Elémens de chimie médicale* aimed at the 'medical and pharmaceutical students' attending private lectures on chemistry.[31]

At the beginning of 1819, Orfila was appointed professor of legal medicine in the Medical Faculty of Paris and he began an ascending career within this institution.[32] After the dismissal of several professors for suspected liberal opinions, Orfila became in 1823 a professor of medical chemistry there replacing his master and protector Nicolas Vauquelin. His career culminated with his appointment as dean from 1831 to 1848. The great success of his chemistry textbook was partially due to his advantageous institutional position as well as the increasing number of medical and pharmaceutical students who were obliged to study chemistry during these years.[33]

2. The Debate About Medical Applications of Chemistry

The publication of Orfila's textbook took place at a time of great controversy over the applications of chemistry in medicine. In the first edition, Orfila remarked:

> Nobody dares to dispute the utility of chemistry in the arts; but the same is not true of its application to medicine; it is regarded by some doctors not only as useless, but even as dangerous.[34]

Who were these doctors and why did they consider the medical applications of chemistry 'dangerous'? In order to answer this question, we must take into account some changes in the relationships between chemistry and medicine which occurred during the later eighteenth century. Several chemical advances had generated new expectations.[35] On the one hand, the new method of analysis by solvent extraction enabled chemists to isolate numerous new vegetable and animal substances.[36] On the other hand, the development of pneumatic chemistry furnished new mineral products which were used by physicians for different purposes. In France, Antoine Fourcroy considered that the application of the new chemistry to medicine would engender a 'révolution médicale'. Fourcroy analysed various human fluids and solids, which were obtained from sick or healthy individuals in order to determine the characteristics of different diseases and suggest possible treatments. For example together with Vauquelin, he analysed numerous urinary calculi which led him to isolate urea and study its chemical properties. He also penned several studies on the therapeutic properties of oxygen and he taught chemistry courses on this topic, especially after the French Revolution, when he was appointed chemistry professor at the newly created École de Santé of Paris.[37] Moreover, Fourcroy was during these years the editor of the journal *La médecine éclairée par les sciences physiques.* Among the objectives of the journal he aimed 'to show the immediate utility of all the physical sciences in medicine' and 'to demonstrate that the art of healing cannot make real progress [. . .] without the help of all the sciences together.'[38]

Other authors in different countries published texts with similar purposes during the late eighteenth century. In France, Pierre-Philippe Alyon (1758–1816) published an *Essai sur les propriétés médicinales de l'oxygène* in which, following Fourcroy, he proposed new treatments for syphilis using 'oxygenous substances.'[39] Alyon also wrote a chemistry textbook and translated into French a book on *diabetes mellitus* by John Rollo (d. 1809), which was published with notes by Fourcroy.[40] The recently discovered 'oxymuriatic acid' was proposed by Guyton de Morveau (1737–1816) and Fourcroy to be used for the destruction of putrid miasmata which were supposed to be a cause of transmission of some diseases. Jean-Baptiste-Thimothée Baumès (1756–1828), professor of the Faculty of Medicine of Montpellier, proposed a nosological system based on the new chemistry. His five main classes of diseases were: 'calorinèses', 'oxigenèses', 'hydrogenèses', 'azotenèses' and 'phosphorenèses'.[41]

The reactions of doctors to these new contributions varied. In 1797, Fourcroy described the two principal extreme tendencies. On the one hand, there were the doctors who denied any value in such studies, and whose attitudes ranged between cool immovability and demonstrable regret.[42] On the other hand, another group, like Foucroy's young students in the medical faculty, enthusiastically embraced new medical applications of chemistry. Fourcroy thought that this fervent acceptance could be as dangerous as the conservative doctors' denial and he attempted to rein back student enthusiasm.[43] Fourcroy also warned against such dangerous excesses in his memoirs on the applications of pneumatic chemistry to the art of healing. He criticised some recent works such as those by Alexander von Humboldt (1769–1859) on muscle irritability, which were published in *Annales de chimie*, and, especially, Baumès' nosological system because of its chemical basis.[44]

Fourcroy's ideas would have been familiar to the young Orfila, not only because of his studies in the Paris Medical Faculty but also because of his prior relationship with Francesc Carbonell i Bravo in Barcelona. Carbonell had translated Fourcroy's *Discours sur l'union de la Chimie et de la Pharmacie* into Spanish and developed some of Fourcroy's views in his own pharmaceutical textbook, which was itself translated into French and reprinted several times.[45] After studying in the Montpellier Faculty of Medicine, where he attended Chaptal's chemistry courses, Carbonell had written a doctoral dissertation about the uses and abuses of chemistry in medicine, in which he defended the difference between 'inorganic' and 'organic' bodies both in reactions studied in the chemical laboratory and those taking place inside human body under the influence of the vital force. A large part of his dissertation focused on a critical discussion of Baumès' nosological ideas and their therapeutic consequences. Carbonell argued that all chemical nosology was 'defective' (*improvida*) and all chemical therapeutics was 'vicious' (*vitiosa*), but he praised chemical applications to hygiene (analysis of air, water or food, for instance) and *materia medica*, the part of the art of healing where chemical applications were more fruitful according to Carbonell. As far as physiology was concerned,

Carbonell thought that chemistry–as well as physics and mechanics–should focus on studying the 'perfection of the instruments' (substances) which participated in life functions but not on explaining the causes of such processes that were under the influence of vital forces. Finally, Carbonell concluded that 'valid applications of chemistry to medicine' were very useful but their abuse could be pernicious.[46]

During Orfila's early years in Paris, an important dissertation about the application of chemistry to the different branches of life was published byAdrien Jacques de Lens (1786–1846). Lens had studied with Fourcroy in the Ecole Polytechnique and had written his medical thesis under the guidance of Jacques Thenard. His work was diffused broadly; its structure and main conclusions were reproduced in the chapter 'chemistry' of several medical dictionaries, one of them written by Orfila.[47] Lens discussed the medical applications of chemistry in several sections dealing with the 'art of the anatomist', physiology, hygiene, pathology, pharmacy, *materia medica* and therapeutics, legal medicine and practical medicine. While describing a great number of recent medical applications of chemistry, Lens argued that these applications had some limitations due to the subordination of chemical and physical laws to economy of life ('économie vivante'), as far as the explanation of physiological and pathological phenomena was concerned. Moreover, Lens thought that much research was required before reaching any conclusions on these subjects and, accordingly, he suggested several lines of future work. Lens claimed that his purpose was neither to yield medicine to chemistry nor to be ignorant of its applications in 'a great number of circumstances'.[48]

Another important work was published during these years by Godefroy Barthélemy Coutanceau (1775–1831), a military physician who had obtained his M.D. in the Paris Medical Faculty in 1800.[49] Coutanceau was critical of the reform of medical studies which he considered to have been done under the influence of the 'universal enthusiasm' produced by the 'pneumatic discoveries'. This enthusiasm was one of the causes of the creation of new 'doctrines chimicophysiologiques' that Coutanceau criticised. He objected to several chemical explanations of the digestion, 'hémastose',[50] secretion and nutrition, including Lavoisier's theory of respiration and Fourcroy's ideas about the function of bile. On the one hand, he considered that chemical laws were not applicable to the study of the transformations that happen in living organisms because all these phenomena took place according to particular laws which could not be determined by general chemical laws. In other words, these phenomena were produced under the influence of a 'force vitale'.[51] On the other hand, he regarded chemical analysis as a worthless tool for investigating physiological processes, not only because chemists were unable to synthesise organic products but also because there was no evidence of a relationship between chemical composition and physiological activity. Accordingly, Coutanceau concluded that chemistry played a very insignificant role in physiological theory and argued that 'chemistry should offer to physiology its facts not its theories'.[52]

Some years later, Coutanceau wrote an article for the *Dictionnaire des Sciences médicales* with the title 'chimisme', a term he defined as the abuse of the application of chemical theories in medicine. After a short history of chemistry, especially the iatrochemistry of the sixteenth and seventeenth centuries, he discussed Fourcroy's research on animal chemistry. Coutanceau considered Fourcroy to be the 'true author' of modern 'chimisme' but he praised his prudence when dealing with these subjects. By contrast, he angrily criticised 'chimico-physiologiques' theories of 'more imprudent' authors such as Girtanner, Beddoes and Baumes, which he regarded as 'folies'.[53]

The points of view of Couteanceau and Lens show that a range of intermediate positions lay between 'chimisme' and 'vitalisme' in the early nineteenth centuly. In those years, the pharmacist Julien Joseph Virey (1775–1846) wrote a paper in the *Journal de pharmacie*, outlining the history of the relationship between chemistry and medicine. At the beginning of his paper, Virey described contradictory views about this question:

> [There is much debate about this subject] some 'savans' insist on explaining the whole of physiology and pathology by the laws of physics (mechanics, hydraulics, etc.) and chemistry; others exclude absolutely everything which is not vital force, soul, action of the senses and of excitability, or contraction of animal fibre, control of organisation etc.[54]

Ridiculing these views, Virey tried to differentiate his ideas from both extreme positions. He acknowledged the importance of chemistry, for activities such as analysing mineral waters, identifying or neutralising different poisonous substances, destroying 'putrid miasmas' with oxymuriatic acid and finding out the composition of animal and vegetable substances. However, Virey stressed that chemistry should only be used in medicine within its proper limits and he criticised Girtanner's and Baumés' works because they established 'doctrines médicales toutes chimiques'. Finally, Virey concluded with the following sentence: 'si la nature y fait de la chimie proprement dite, elle l'exécute à sa maniére'.[55]

Another illustrative example of the range of opinions concerning medical applications of chemistry was given by the young François Magendie (1783–1855) in a review of Alexander Marcet's work on 'calculous disorders' published in 1817. There were: those doctors who completely rejected physical sciences; and those who 'made an effort in order to adapt the principles of physics and chemistry to health and illness phenomena'. Within this group, Magendie distinguished between authors who 'wanted to explain everything by means of the science, and those who 'accepted that the laws of inanimate bodies were not enough to explain a great number of the phenomena of life' but, at the same time, were not afraid of regarding other characteristics of life as 'completely ruled by these laws'. Magendie considered that rejecting the physical sciences in medicine was as meaningless as exaggerating its real uses and aligned himself with the latter group.[56]

The preceding analysis shows some features of the important debate on the medical applications of chemistry in early nineteenth century France. This debate was carried on by some of Orfila's masters as well as by some of his contemporaries, a group of pharmacists and physicians trained in the new educational institutions which emerged after the French Revolution. Disregarding the extreme positions, we can see that there was a group of influential physicians and pharmacists who promoted certain uses of chemistry in medicine whilst criticising its pernicious abuses. For some of them, the boundaries between uses and abuses were not clearly defined. It was rather a matter of deciding how to treat recent empirical evidence about the differences in chemical properties of organic and inorganic substances in relation to their ideas concerning the influence of vital forces in physiological processes. It is therefore not surprising that different authors adopted different views about the exact and correct limits of such applications. Moreover, it should also be borne in mind that the terms of this controversy changed during Orfila's life, as chemical research on animal substances developed and new applications of chemistry were incorporated into the practice and theory of medicine, among them a revived field–toxicology–which was specially cultivated and promoted by Orfila.

3. Orfila's Ideas on Chemistry Applied to Medicine

Mateu Orfila's work shows the influence of various authors who tried to place themselves between the extreme positions that we could label 'vitalisme' and 'chimisme'. His first chemical paper, concerning the analysis of urine and of biliary calculi, fitted within the research program initiated by Fourcroy and Vauquelin during the late eighteenth century.[57] Some of his earliest references to the debate appeared in the first edition of his famous *Traité de Toxicologie*, published between 1814 and 1815. In the chapter dedicated to potash, Orfila argued from the evidence of several experiments carried out in the laboratory that one of the characteristics of this substance was the inhibition of the spontaneous coagulation of the blood. Contradicting these results, Orfila also presented his own experiments with dogs, into whose veins he injected a calculated amount of potash with the effect, he concluded, of provoking the coagulation of their blood and causing the dogs' deaths. Orfila reckoned that no satisfactory explanation existed for this evident contradiction but, in a footnote, he suggested that the reason for such contradictory results could be the differences between the phenomena of vital and inanimate realms 'in certain circumstances'. Hence, he concluded that physicians must be watchful against 'excessive use of chemistry in physiology'.[58]

Orfila stated similar views in his chemistry textbook. Remarking that some people thought that chemistry was unrelated to medicine, he aimed to correct them by showing the numerous connections between those disciplines. According to Orfila, it was difficult to deny the utility of chemistry in determining the characteristics of drugs or in medico-legal research concern-

ing cases of poisoning. He accepted however that other applications were the subject of debate among physicians:

> But what can be the danger of excessive application of this science to medicine? Medical chemists, it will be said, paying no attention to the vital forces, only see in the exercise of the various functions of the animal organisation, phenomena which are analogous to those they observe in their laboratories; they heedlessly compare the properties of inanimate bodies with those of living bodies and establish theories in physiology which are purely chemical and false, and which the slightest observation is sufficient to overturn.[59]

Orfila argued that these criticisms should be directed only at 'unattentive and little-enlightened observers' and not to the 'savans' who 'incessantly interrogate nature' through 'experiments and observations' and who preferred 'news and well-established facts' to 'premature and unfounded explanations'. According to Orfila, such research should result in 'the future perfection of physiology'. Like his teachers Fourcroy and Carbonell, Orfila was not against chemical research in physiology but he opposed hurried and careless conclusions. However, recognising the existence of the controversy, Orfila announced in the introduction that his book offered only medical applications of chemistry whose benefits were not contested, such as those related to therapeutics and legal medicine. Regarding 'physiological applications', he declared that his book included only the results of chemical experiments related to physiology because this part of science was not advanced enough to enable it to be 'reduced to general principles.[60] Here again the influence of some of the texts discussed before is evident.

Orfila's response to a critical review of his book provides further insight. An article published in the *Gazette de Santé*, criticising Orfila's *Treatise on Toxicology*, referred to his textbook as 'new elements of pretended medical chemistry.'[61] Orfila replied with a paper in the *Nouveau Journal de Médecine, Chirurgie et Pharmacie*. He explained that he had tried to describe in his textbook questions such as the action of several substances on the 'économie animale', their employment in the treatment of diseases and their appropriate doses, the substances which could not be mixed without decomposition or the chemical manipulations employed to discover various poisons and their antidotes. Orfila maintained, however, that the term 'chimie médicale' was understood by other authors–including his critic–in a very different way, *i.e.*, 'the science that aims to understand what happens during the transformation of chyle into blood, the secretion of urine, sperm, tears and so on'. Orfila claimed that he had avoided considering the human body as a chemical laboratory and 'building up theories even when facts were lacking'.[62]

Orfila did not deal with this type of issue in his textbook partly because he thought that data were scarce, but also because he considered the chemical analysis of inanimate materials to be worthless in answering some questions related to physiological processes. He restated this some years later in his chapter 'chimie' published in the *Dictionnaire de Médecine*. Following the

structure of Adrien Lens' thesis, Orfila wrote on the relationship between chemistry and anatomy, physiology, hygiene, pathology, pharmacy and medical jurisprudence. As far as physiology was concerned, Orfila remarked that chemistry would produce valuable results in the future since it was the only discipline which was able to offer accurate knowledge of the 'principal operations and material results' of physiological processes. However, Orfila thought that this science was incapable of dealing with all the 'mutations matérielles' which take place inside live organisms, despite important contemporary advances in organic chemistry. According to Orfila, the main reason was that chemical analysis was applied to inanimate fluids and solids, whose composition could have been altered. In reference to Coutanceau's book, Orfila concluded with the advice: 'avoid making a too exclusive use of chemical laws when explaining phenomena of life'.[63] In the second edition of the *Dictionary*, Orfila introduced few changes except in the part related to physiology. After quoting Berzelius on difficulties relating to the chemistry of organic bodies, Orfila claimed that–apart from future development in this area–it would not be possible to understand such substances fully by means of chemical analysis of non-living bodies:

> Nevertheless one cannot overlook the fact that in presuming that the chemistry of organic bodies will provide more accurate results than it has done up to now, one can scarcely hope to reveal the material changes which take place in the inner parts of living beings, since analysis can only act on dead tissues and fluids, whose chemical composition has then perhaps changed.[64]

Would it be accurate to characterise Orfila's ideas as vitalism? In an article dedicated to this question, John H. Brooke warned about problems of using this word when describing the views of some nineteenth-century chemists.[65] The word 'vitalism' has been used to describe a large diversity of opinions, including different attitudes to chemistry in medicine.[66] Orfila disapproved of specific uses of chemistry in physiology but, at the same time, he contributed substantially to establishing relationships between chemistry and medicine with his toxicological research and his teaching in the Paris Medical Faculty.

In addition to criticising the extreme positions that could be labelled 'vitalisme' and 'chimisme', Orfila and others also used the term 'medicin-chimiste' rather pejoratively to refer to physicians who overstepped the appropriate limits of applicability of chemistry in medicine.[67] However, participants in the debate used no specific term to refer to authors who shared Orfila's ideas. Alan Rocke has recently employed the term 'vital materialist' in order to characterise Berzelius' ideas on animal chemistry.[68] Even if such a term could represent the ideas of some of the authors quoted before, no correct understanding could be reached without taking into account the diversity of positions held in this debate.

4. The Reception of Orfila's Elémens de Chimie

Rather than labelling Orfila's position, it is more useful to approach this diversity by analysing the different reactions to the publication of Orfila's textbook. Shortly after its publication in September 1817, Orfila wrote a letter to an old friend describing the favourable reception of his work. Orfila was afraid of possible competition from other chemistry books, such as Thenard's *Traité*, of which a second edition was published at the same time. In this private document, Orfila acknowledged that he had 'conceived, written, printed and revised' his textbook very quickly. Hence, he was surprised by its success.[69]

Orfila also mentioned that several favourable reviews had appeared in medical and scientific journals. An anonymous reviewer in the September-October 1817 edition of the *Journal de médecine, chirurgie et pharmacie*, edited by Jean Jacques le Roux de Tillets (1749–1832), dean of the Paris Medical Faculty, began with a defence of the utility of chemistry in medicine and a harsh criticism of the 'médecins routiniers', regarded as unable to follow the progress of science. Following Orfila, and quoting mainly the foreword to his textbook, the reviewer highlighted the importance of chemistry in problems related to legal medicine. In these cases, forensic expertise might be a matter of life or death for those accused of poisoning. 'How could physicians make these crucial decisions without knowing chemistry?', asked the reviewer, who concluded that recent research, 'and the excellent Orfila's *Treatise on Toxicology*', should contribute to eradicate old disdain for chemistry. After warning against some applications of chemistry to physiology, the reviewer illustrated the structure of Orfila's textbook by using mercury and related compounds as examples. The review concluded by recommending the book to all people dealing with chemical and medical sciences, especially medical students who could use it as a textbook.[70]

That Orfila's textbook was well received by the Paris medical community is also indicated by the fact that it was quickly recommended in Maygrier's guide of 1818 for students of medicine. Jacques Pierre Maygrier (1771–1834), was a former naval surgeon who had become a Paris medical doctor, author of several textbooks on anatomy and editor of the *Annuaire médical*, as well as several guides for medical students. He was a good example of a physician whose work was not immediately related directly to chemistry. Arguing that books such as those by Chaptal, Fourcroy and Lavoisier were outdated due to the rapid advancement of chemistry, he recommended texts published more recently by Thenard and Orfila, although he himself still quoted the *Philosophie chimique* by Fourcroy and the *Manuel de chimie* of Bouillon-Lagrange. According to Maygrier, Orfila's textbook was especially appropriate because the author had focused on the medical applications of chemistry with due caution:

> Orfila satisfies every condition required by the subject that he has handled. When determining the laws according to which bodies are composed and act among themselves, he never forgets that other laws, different from those of chemistry, govern physiological and patho-

> logical phenomena; in short, he always keeps chemistry within the limits that the science can never transcend.[71]

Some reviewers were not as favourable as Maygrier. Henry Gaultier de Claubry (1792–1878), a young physician who became professor of chemistry and toxicology, published a review in the *Journal de physique* in 1817. He reported diverse shortcomings, from ambiguous definitions to orthographic mistakes and confusions in the names of foreign authors. Gaultier de Claubry criticised a lack of accurate descriptions of the techniques of proximate analysis of vegetable and animal substances. Nevertheless, he conceded, as Orfila did in his textbook, that these techniques were not as developed as mineral analysis in spite of the research of 'MM. Vauquelin, Berzelius, *etc.*, and above all, by Chevreul'.[72] This criticism illustrates the importance that certain authors ascribed to proximate analysis of vegetable and animal substances due to its use in isolating diverse products employed for therapeutic purposes. In spite of these reproaches, Gaultier de Claubry valued Orfila's introduction of the latest developments of chemistry in his textbook as well as its structure which the reviewer considered to be 'simple and susceptible of useful applications'.[73]

Far less in agreement however was Jean F. Delpit (d. 1830), a Montpellier medical doctor who published several papers on mineral waters as a member of the French Mineral Waters Committee. His review in the *Journal universel des sciences médicales* soon after the publication of Orfila's textbook began by asserting that 'a work on medical chemistry could breed ... fear'. Delpit recalled the nosological system based on chemical substances by a renowned 'practitioner'–an obvious reference to Baumès–as one of the examples which justified these fears. Delpit believed that chemical laws should be clearly differentiated from those which governed physiological and pathological phenomena. After criticising some of Orfila's points concerning the therapeutic uses of chemicals, he also alerted readers to abuses of chemistry in medical diagnosis by recalling former abuses of uroscopy, whose followers had built therapeutics on 'the misleading sediments of a secretion'.[74]

Orfila held a similar view of 'the secte des Ouroscopes' but he supported modern chemical analysis of urine in medical research in order to determine how this liquid varied in different diseases. Following the work of his masters Fourcroy, Vauquelin and Thenard, Orfila employed urinary analysis in his Paris medical thesis of 1811. The thesis began with the results of chemical analyses of healthy human urine and bile, followed by the conclusions of similar analyses but using urine from icteritious individuals.[75] The analysis of fluids and solids from healthy or ailing human bodies was, in fact, the most important part of Orfila's chapters on animal chemistry.

Delpit also emphasized the problems of arranging vegetable and animal substances according to chemical criteria. He criticised the fact that in the group 'other particular materials of certain animals,' Orfila had assembled products so medically distinct from each other as, for example, musk or cantharides (Spanish flies)–which were part of traditional *materia medica*–

biliary calculi–a morbid concretion–and birds eggs and sponges. Delpit felt that, although these categorizations could be justified chemically, they were not adequate for medicine.[76] In fact, Delpit alluded to substances that were not classified chemically by Orfila but grouped in a rather miscellaneous chapter about the 'solid parts of the animals', placed at the end of the section on animal chemistry. However, the problems arising from differences between chemical and medical classification criteria may have been one the reasons which constrained Orfila to adopt the traditional arrangement of three kingdoms of natural history instead of an arrangement based on new organic chemistry theories.[77]

Another review of Orfila's textbook, written by the pharmacist Julien J. Virey and published in *Journal de Pharmacie*, began with a short history of chemistry, followed by brief description of the book's contents. He remarked that Orfila had incorporated the most recent discoveries, among them modern knowledge about the 'immediate principles of vegetables', such as morphine, meconic acid, emetine and picrotoxin. Virey, who published during these years an important work on the relationships between medicine and chemistry, also claimed that physiological processes could not be explained by chemical laws:

> The title *chimie médicale* seems to indicate that the author suggests chemical explanations of the physiology of the living body. M. Orfila has been very careful and he was quite right. It was also difficult for him to reconcile the explanations of many chemists on scientific points which have not yet been clarified.[78]

Orfila abandoned the title of his first edition *Elémens de chimie médicale* for the perhaps less controversial *Elémens de chimie appliquée a la médecine et aux arts* for subsequent editions. But the new title was not the only way in which the controversy about the medical applications of chemistry shaped chemistry textbooks such as Orfila's. The preceding discussion suggests that both the contents and structure of certain chapters were affected in several ways. At the same time, chemistry textbooks themselves helped to change the characteristics of the controversy by introducing new chemical theories and data which contributed to gaining recognition for chemistry as a discipline within the medical community. In order to address this complex process, the remaining sections will be devoted to the analysis of a particular but crucial concept in Orfila's textbook concerning the debate about the medical applications of chemistry.

5. The Concept of 'Principe Immédiat' and the Structure of Orfila's Book

One of the questions directly related to supposed differences between physiological transformations and chemical processes was the impossibility of

synthesising organic substances in the chemical laboratory. This limitation appeared in the introduction to vegetable and animal chemistry in Orfila's book, where he argued that new plants could be created only through the process of germination. However, Orfila reported that several 'principes immédiats' (malic, oxalic and acetic acids) had been obtained in the laboratories and he predicted that new ones would be synthesized in the near future.[79] He considered that the impossibility of artificial synthesis of some 'immediate principles' was the consequence merely of some technical limitations which should be overcome in the future, *i.e.,* he was employing this expression with a descriptive meaning, in Brooke's terms.[80]

The concept of 'immediate principle' had been introduced into chemistry during the eighteenth century after the development of new methods of separation and analysis of vegetable and animal substances usually called 'proximate analysis'.[81] At the beginning of the nineteenth century, several authors highlighted the importance of this new type of analysis in the advancement of animal and vegetable chemistry and its applications to medicine.[82] For example, in his *Système des connaissances chimiques* of 1800, Fourcroy included a historical introduction to plant chemistry in which he described changes in analytical methods. According to him, at the beginning of the eighteenth century, both mechanical methods and analysis by fire ('la distillation à la retorte') were employed. Their limitations were evident in the attempts made by savans of the Paris Academy of Sciences to identify the 'active principles' of some plants used in therapeutics. Fourcroy referred to a new method of analysis introduced during the eighteenth century–'celle des réactifs'–based on the use of cold and hot water and alcohol. Other advances in vegetable chemistry had been the isolation of new acids by Scheele, the development of pneumatic chemistry and the elementary analysis of Lavoisier.[83] At the end of the eighteenth century, Fourcroy employed the concept of 'principes inmédiats ou prochains' when referring to diverse vegetable and animal substances obtained through proximate analysis, such as mechanical analyses or the application of water, alcohol, oils, without the use of high heat or long heating. Fourcroy believed that other methods of plant analysis–*i.e.*, by fire, hot water, acids, alkalis, combustion or fermentation–altered and decomposed the vegetable substances and could be employed in order to find out the composition of the 'materiaux immédiats'.[84] Such analyses had shown that vegetable substances all contained carbon, hydrogen and oxygen. Because of this particular ternary composition of vegetable substances, Fourcroy considered that 'chemical art' was incapable of producing vegetable matter (matières végétales') due to the overly violent methods involved:

> the methods and instruments of chemistry are too vigorous, too penetrating, too rapid, and up to now Nature has reserved for herself the power of creating, reproducing and forming vegetable compounds from fundamental elements or simple substances.[85]

Here Fourcroy merely described limitations of vegetable chemistry during these years rather than any belief in the impossibility of producing artificial vegetable substances.[86] According to Fourcroy, germination consisted of a sequence of chemical phenomena or forces which produced characteristic ternary combinations of vegetable substances. Some years later, in the third edition of his *Philosophie Chimique*, Fourcroy reaffirmed his view that the difference between mineral and vegetable substances was that the latter were more complicated from the point of view of composition. While all vegetable substances were susceptible to decomposition and analysis, their artificial synthesis was not always possible.[87]

The concept of 'principe immédiat' was adopted in several French chemistry textbooks published at the beginning of nineteenth century.[88] One of the most influential was the *Traité de chimie* by Jacques Thenard. Like other authors, Orfila followed Thenard's ideas on classification, leading the American translator of Orfila's textbook to say that it 'may be considered as an abridgement of the larger work published by Thenard'.[89] Thenard began his chapter on plant chemistry with an anecdote by the philosopher Jean Jacques Rousseau, who, while attending Rouelle's chemistry lessons, was reported to have said that 'he would never believe in a chemical analysis of flour until he saw chemists recompose it'. Thenard considered that it was no longer possible to make similar statements and, with arguments which recalled Fourcroy's, he explained that such a synthesis was not possible due to the properties of the elements which formed vegetable substances: two (hydrogen and oxygen) were gases whilst carbon was a solid. Insofar as the synthesis of a vegetable compound required the elasticity of the first and the cohesion of the second to be overcome, prolonged heat was indispensable in order to produce the reaction and this heat destroyed the organic substances. Accordingly, Thenard thought that only 'vegetation' was able to create this kind of substance but not the chemical laboratory.[90] He defined several groups of substances that could be obtained by analysing vegetable materials. Thenard differentiated between those which were anatomically distinct–such as epidermis or parenchyma–and those substances obtained by using chemical procedures These last substances were also made up of 'several principles'.[91] In accordance with these groups, he described the realm of vegetable chemistry thus:

> To discover what these principles are, to study how they are assembled to form the various vegetable substances, to describe each one of them, to determine those which enter into the composition of all parts of plants, and to study all these parts successively; that is what constitutes that branch of chemistry called *chimie végétale*.[92]

Thenard adopted the same arrangement when dealing with animal chemistry and he offered a similar description of its limits and purpose. Although he included some sections on animal respiration and blood circulation, he did not go into these subjects in depth because he considered them to belong almost completely to the physiological realm.[93] In the last

edition, published in 1835, Thenard attempted a joint presentation of animal and vegetable chemistry. The paragraph which described the purpose and realm of vegetable and animal chemistry was slightly but meaningfully changed. Thenard included then not only the idea of the study of nutritional processes in living organisms but also the possibility of artificial synthesis of some of these substances. This artificial synthesis was, however, confined to one of the three groups of substances, the 'immediate substances', in a similar manner to that of Orfila in his early editions.[94] While adopting Thenard's arrangement, Orfila had introduced a sharper distinction between the three groups of substances which could be obtained by analysing vegetable compounds, *i.e.*, 'ultimate principles', 'immediate principles' and 'matter made up of several immediate principles':

1. Simple substances (ultimate principles) the combination of which forms the vegetable molecule: such as oxygen, hydrogen, carbon and sometimes nitrogen.
2. Substances composed of these elements to which we have given the name immediate principles: like rubber, sugar, starch, lignin, oils, etc.; substances supplied directly by the plants and formed from hydrogen, carbon and oxygen are immediate principles.
3. Substances composed of a more or less large number of immediate principles: such as juices, stalks, leaves, flowers, roots, *etc.*, products in which one sometimes finds three or four immediate principles.[95]

Like Thenard, Orfila structured his vegetable chemistry chapters into three main parts dedicated to each group of substances. The number of pages devoted to the groups was, however, unequal. He scarcely dealt with the ultimate principles because data about these were given in the chapters on inorganic chemistry. The most important part was a description of immediate principles, whose therapeutic and toxicological properties were often described. Orfila arranged these substances following several, mainly chemical, criteria such as Thenard's and Gay-Lussac's classification based on different proportions of oxygen.[96] By contrast, the chapters about the third group of substances dealt with the most important part of animal chemistry. In this part Orfila offered mainly results of chemical analyses of some solids and fluids which were obtained from healthy or sick individuals. These substances were presented in a physiological sequence which began with substances related to digestive processes, followed by blood and 'chemical phenomena of respiration' and ended with 'the solids of animals', including cerebral matter, skin, muscles, bones and calculi. Thus, two main divisions were established in both vegetable and animal chemistry with very different approaches, arrangements and contents.

In subsequent editions of this work, Orfila altered the number of groups of substances obtained from animals and plants. These changes reveal the strong influence of Eugène Chevreul's (1786–1889) researches on fats and organic

analysis. In the fourth edition, published in 1828, Orfila offered, for first time, a definition of immediate principle similar to Chevreul's:

> substances composed of these elements (ultimate principles) which always show the same properties, whatever the plant or part of the plant from which they are derived, and from which one cannot separate any heterogeneous body without obviously changing their nature: such as rubber, sugar, starch, lignin, quinine.[97]

In the sixth edition published between 1835 and 1836, Orfila established a new subgroup by dividing the group of 'produits des végétaux' into two parts. The first subgroup–'produits immédiats'–included materials such as 'oily, resinous or sugary juices' which consisted of three or four immediate principles; while in the second subgroup he gathered vegetable organs and tissues, leaves, flowers, roots, *etc.*, also formed by several 'immediate principles'.[98] In 1843, Orfila combined animal and vegetable chemistry in a chapter on organic chemistry but no important changes were introduced concerning the groups of substances. Finally, in the last edition published in 1851, Orfila came back to the traditional division into vegetable and animal chemistry, but delimited a new group of substances, in this case by distinguishing two groups of substances formed by several immediate principles. The three initial groups increased to five: 'matières simples', 'principes immédiats', 'les composés à proportions définies des principes immédiats', 'les mélanges des plusieurs principes immédiats' and 'les organes' of vegetables and animals.[99] For the first time, a chapter was especially dedicated to a discussion of the concept of 'espèce organique' which included the 'principes immédiats' and the 'composés définis de ces principes immédiats'.[100] In order to establish the characteristics of an 'espèce organique', Orfila followed Chèvreul's criteria: crystallisation, volatilisation and constant values of boiling and solidification points.[101]

An adequate interpretation of Orfila's passage quoted at the beginning of this section should take into account these arrangements and groups of organic substances. In this passage, which was retained in the eighth edition without significant changes, Orfila reaffirmed that the possibility of chemical synthesis was limited to some of the groups of materials studied in the chapters on vegetable and animal chemistry:

> However valuable the instruments that chemistry acquires daily, it is impossible for us to create plants except by germination; this is not the case of certain immediate principles of plants that we can produce; thus, malic, oxalic and acetic acids and the grape sugar can be obtained in the same form as supplied by nature; and we expect that thanks to the progress of chemistry, we will be able to imitate a larger number of them in the future.[102]

Insofar as the definitions changed during the period, the organic materials which Orfila considered susceptible to laboratory synthesis were not a clearly

delimited group but a rather changeable repertoire enabling him to avoid disputes about this question.

Thus, as much as a decade before Wöhler's synthesis of urea, Orfila's popular textbook included a discussion of the possibility of synthesis of organic compounds. Moreover, this idea was also implicit in some of the classifications he used. For example, in the first editions, Orfila followed Thenard's classification of vegetable acids in three groups: (1) those produced both by art and nature, (2) those produced by nature and (3) the artificial ones.[103] In the last edition, published in 1851, Orfila dealt with this question in a section on the immediate principles and the characteristics of the 'espèce organique'. He remarked that some immediate principles were present already formed in vegetables and animals, while others were produced artificially. He also reaffirmed that some of the former could be made completely in chemical laboratories by combining specific bodies with chemical agents. As examples, Orfila described the syntheses of glucose, urea and lactic, oxalic, formic and butyric acids, which could be obtained by the chemical combination of several mineral substances or by processes such as fermentation.[104] This last sentence indicates that while considering whether Orfila regarded 'organic substances' as susceptible to synthesis by chemical means one should take into account not only Orfila's understanding of 'organic substances' but also that he considered processes such as fermentation to be a 'chemical means'.

As these examples show, an accurate discussion of ideas on the artificial synthesis of organic substances during the first half of the nineteenth century should take into account what authors generally understood by 'chemical synthesis' as well as the distinct groups of organic substances which were generally adopted when authors dealt with animal or vegetable chemistry. An analysis of nineteenth century chemistry textbooks can shed light on these questions because the concept of immediate principle was a central element in the organisation of vegetable and animal chemistry.

Conclusion

The several groups of vegetable and animal materials distinguished by Orfila in his *Elémens de chimie* were directly related to the debate about the medical applications of chemistry which took place in France during the early nineteenth century. One of the chief points of discussion was the possibility of studying physiological transformations by means of laboratory research. This question appeared in several writings by Orfila's teachers, in publications consulted by Orfila during his early years in Paris and in some reviews of the ealry editions of his chemistry textbook. Orfila's references to this question in early chemical papers provide evidence of such influences on his work.

One of the consequences of this debate for the contents of Orfila's textbook was the exclusion of matters related to chemical interpretations of physiological transformations. Very few pages of the part on vegetable and animal chemistry contain discussion of these questions. Most of his vegetable

chemistry was devoted to the description of different immediate principles, many of which had been isolated during the early nineteenth century. In many cases these immediate principles were obtained by proximate analysis of diverse parts of vegetables which had been employed in therapeutics. The number of immediate principles which had been isolated from animal products and employed in medicine were few. Orfila's chapters on animal chemistry were mainly devoted to the analysis of solids and fluids from the human body. A good example is in the long sections dedicated to the analysis of urine or urinary and biliary calculi. When presenting these substances, Orfila did not adopt the same kind of chemical criteria he used when dealing with immediate principles, but rather a sequence based on physiological processes. In both animal and vegetable chemistry, the approach was based on the distinction between 'principes immédiats' and 'produits immédiats'. We have already described how these distinctions became more precise in successive editions of Orfila's book until the concept of 'espèce chimique organique' was formulated in the final edition.

These groups, which changed over the period, made it possible to establish certain limits concerning the possibility of chemically synthesising vegetable and animal materials. While not clearly defined, the concept of immediate principle helped establish boundaries between the chemical and physiological realms at a time of considerable controversy focused on the chemical interpretations of physiological processes. In this sense, the debate about the medical applications of chemistry contributed to shaping the structure and contents of Orfila's chemistry textbook and consolidated the concept of immediate principle as an organising element.

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11. Charles A. Wurtz (1817–1884) and Paul Schützenberger (1829–1897) were among the students of this school. See J. Hoeffel, *Aperçu historique sur l'ancienne faculté de médecine de Strasbourg* (Strasbourg: Treuttel et Wurtz, 1872), pp. 121–24.
12. See Beauchamps, *op. cit.* (3), vol. I, 771: *Arrêté qui établit des chaires de chimie et pharmacie, et d'histoire naturelle, dans les Ecoles secondaires de médecine*, 15 September 1837. and *ibid.* (1891), vol. XL, pp. 498–500, *Nouvelles dispositions réglementaires concernant les études dans les écoles secondaires de médecine*, 26 September 1837.
13. Beauchamps, *op. cit.* (3), vol. I, pp. 884–88: *Rapport et ordonnance concernant l'organisation des écoles préparatoires de médecine et de pharmacie, 13 octobre 1840.* See also *ibid.*, vol.. XL, pp. 510–28:

Rapport et ordonnance concernant l'organisation des écoles préparatoires de médecine et de pharmacie, 13 October 1840: 'chimie et pharmacie'. Every school was required to appoint 'un chef de travaux anatomiques, un prosecteur et un préparateur de chimie et d'histoire naturelle'. *ibid.*, pp. 522–28. *Règlement concernant les écoles préparatoires de médecine et de pharmacie,* 12 Mars 1841.

14. Beauchamps, *op. cit.* (3), vol. XXVIII, 600–606. *Loi contenant organisation des écoles de pharmacie, 21 germinal de l'an XI* (11 April 1803). On Orfila and medical teaching see L. Auquier, "Orfila et l'organisation des études médicales," *Bull. Acad. Méd.*, **171** (1987), 477–83.
15. Beauchamps, *op. cit.* (3), vol. XL, p. 500 *Rapport et ordonnance portant organisation des écoles de pharmacie* (27 September 1840). For a general framework of French pharmacy see F. Prévet, *Histoire de l'organisation sociale en pharmacie* (Paris: Recueil Sirey, 1940). For a recent discussion of chemistry and pharmacy in revolutionary France, see J. Simon, *The Alchemy of Identity: Pharmacy and the Chemical Revolution, 1777–1809* (University of Pittsburgh, Ph.D., 1997) and J. Simon, "The Chemical Revolution in Pharmacy: A Disciplinary Perspective," *Ambix,* **45** (1998), 1–13.
16. M. Faraday, *Manipulations chimiques, par ... Traduit de l'anglais, par M. Maiseau... et revu pour la partie technique par M. Bussy* (París: A. Sautelet, 1827), 2 vols.
17. Beauchamps *op. cit.* (3), vol. I, pp. 892–96. *Règlement pour les écoles de pharmacie,* 5 février 1841. On chemistry courses in these institutions see Arnaud *op. cit.* (3).
18. Beauchamps, *op. cit.* (3), vol. XXXVII, p. 48, *Décret portant organisation de l'université,* 17 Mars 1808; *ibid.*, pp. 244–50, *Ordonnance portant réorganisation de la Faculté de médecine,* 2 February 1823. and, vol. XL, 500: *Rapport et ordonnance portant organisation des écoles de pharmacie* (27 September 1840). See M. Piobetta, *Le baccalauréat* (Paris, 1937), on p. 72.
19. G. Dillemann and M. E. Michel, "La réception des pharmaciens en France de la Révolution à l'application de la loi du 21 germinal an XI (1791-1813)," *Revue d'Historie de la Pharmacie,* **260** (1984), 42–69, offers valuable quantitative data.
20. According to Beauchamps *op. cit.* (3), in France between 1803 and 1854 there were 20,260 physicians and 13,650 officers de santé while of 10,672 pharmacists, 4581 obtained the title in an *Ecole de Pharmacy* and the others in a *Jury Médical.* Orfila's textbook was also probably used by the students who attended the practical courses of chemistry established in several 'Hôpitaux militaires d'instruction' or in the veterinary schools created in Alfort and in Lyon. Professors of these institutions published diverse chemistry textbooks, among them the "Abrégé de chimie" by Jean Louis Lassaigne (1800–1859), professor of physics and chemistry in the Ecole vétérinaire d'Alfort, which was reprinted on four occasions. On Alfort see R. Taton, *Enseignement et diffusion des sciences en France au dix-huitième siècle* (Paris: Hermann, 1986) and M. Villemin, *Les vétérinaires français au XIX siècle* (Alfort: Editions du point vétérinaire, 1982).
21. J. P. Maygrier, *Guide de l'étudiant en médecine...* (Paris: Gabon, 1818), pp. 41–42: 'Il ne se fait point de chimie à la faculté pendant l'été, ni de cours d'opértions: c'est donc dans les écoles particulières que l'élève doit chercher ce genre d'instruction. Quelles que soient celles auxquelles il donne la préférence, nous nous faisons un devoir de l'avertir que le Muséum d'Histoire Naturelle (Jardin du Roi), lui offre, pour la chimie, les plus précieuses ressources. Le cours de chimie générale qui s'y fait tous les ans, est precisément celui qui convient le plus aux élèves qui ne sont point encore initiés dans les secrets de cette belle science: munis des connaissances générales qu'ils puiseront dans ce cours, ils pourront alors retirer le plus grand fruit de celui de l'Ecole, qui est aussi plus directement applicable à l'art de guérir, et qui, sous ce rapport, convient davantage à l'étudiant en médecine'.
22. Maygrier, *op. cit.* (21), p. 197.
23. Hubert, *op. cit.* (7), pp. 144–46.
24. "Cours préparatoires aux grades de bachelier-ès-sciences physiques et mathématiques et de bachelier-ès-lettres par M. Tyrat" in J. Tyrat" *Nouveau manuel complet et méthodique des aspirants au baccalauréat ès sciences, d'après le nouveau programme, rédigé spécialement pour l'usage des jeunes gens qui se destinent à l'étude de la médecine* (Paris: J. Delalaine, 1837); "Prospectus ... cours speciaux et permanents de chimie, de physique ... par E. Robin" in E. Robin, *Philosophie chimique ou chimie expérimentale et raisonnée... Tome Premier* (Paris: chez l'auteur, 1842–1843, fourth edition). Robin's textbook was published for the first time in 1834.
25. *Cf. Rapport de M. Orfila sur l'état de l'enseignement médical en France,* 10 September 1837 in Beauchamps, *op. cit.* (3), vol. III, pp. 612–52.
26. M. G. Chapel d'Espinasoux, "La Jeunesse d'Orfila. Fragment d'une autobiographie inédite publié par ...," *Revue Hebdomadaire,* **22–3** (1914), 615–34; 86–113.

27. Letter from Mateu Orfila to his mother, Paris, 16 February 1812. Printed in M. C. Bosch, "Contribució a l'epistolari d'Orfila," *Randa*, **30** (1988), 133–76.
28. Orfila registered for the first time at the Paris Medical Faculty in the 1807–1808 course and he registered for the 15th time in 1811. He passed exams in physiology (11 May 1811), pathology and nosology (29 May 1811), materia medica, chemistry and pharmacy (18 June 1811), hygiene and legal medicine (20 July 1811) and on 'clinique interne et externe' (9 August 1811). *Cf.* ANF, AJ 16, 6422–6423, *Registre d'inscriptions de la Faculté de Médecine de Paris*, années 1807–1811 and ANF, F 17, 6097, *Certificats d'aptitude aux grades universitaires. Docteur en médecine.*
29. Orfila's autobiography reproduced by M. G. Chapel d'Espinasoux, *op. cit.* (26). See also Orfila's letter to *Junta de Comerç* of Barcelona, Paris, 29 November 1814 in *Arxiu de la Biblioteca de Catalunya (Barcelona, Spain), Junta de Comerç*, 21 bis 366.
30. The letters were printed by P. Lemay, "Contribution à la biographie d'Orfila," *Bull. Soc. Franç. Hist. Med.*, **25** (1931), 516–22.
31. Orfila (1817), vol. I, p. II. Orfila's autobiography in Chapel d'Espinasoux, *op. cit.* (26). This institution replaced the Musée created by Jean-François Pilâtre of Rozier (1757–1785) in Paris, where some of the important chemists of this period such as Lavoisier, Fourcroy, Brogniart, Thenard, Chevreul, etc. gave classes. By the middle of the century, when Orfila wrote his autobiography, the institution no longer had the prestige it had enjoyed in the years when he gave his first chemistry courses. See C. Dejob, *De l'établissement connu sous le nom de Lycée et d'Athénée et de quelques établissements analogues* (Paris: Colin, 1889) and W. A. Smeaton, "The early years of the Lycée and the Lycée des Arts," *Annals of Science*, **11** (1955), 309–19; 349–55.
32. ANF, AJ 16, 6357, *Registre des procès verbaux des séances de la Faculté, 1818-1822, f. 98, Séance du 18mars 1819.*
33. For more biographical information see books quoted in note 1.
34. Orfila, *op. cit.* (1) (1817), vol. I, p. VII.
35. F. L. Holmes, "The chemical revolution and the art of healing," *Caduceus*, **11** (2) (1995), 103–26.
36. F. L. Holmes, "Elementary Analysis and the Origins of Physiological Chemistry," *Isis*, **54** (1963), 50–81 and "Analysis by Fire and Solvent Extractions: The Metamorphosis of a tradition," *Isis*, **62** (1971), 129–48.
37. W. A. Smeaton (1962), *Fourcroy, chemist and revolutionay* (Cambridge: Heffers, 1962), pp. 136–72. See also N. G. Coley, *From animal chemistry to biochemistry* (Amersham, Bucks: Hulton Educational Publications, 1973), pp. 32–37.
38. A. Fourcroy, "Introduction," *La médecine éclairée par les sciences physiques*, 1 (1–2) (1790), 3–47.
39. See Holmes, *op. cit.* (35), pp. 116–17.
40. *Cours élémentaire de chimie théorique et pratique* ... (Paris: 1787), reprinted in 1798. *Traité du diabète sucré, des affections gastriques et des maladies qui en dépendent. . . par J. Rollo* (Paris, an 6 [1798]).
41. J. B. T. Baumès, *Fondemens de la science méthodique des maladies, pour servir de suite à l'Essai d'un système chimique de la science de l'homme...* (Montpellier: 1801–1802) vol. I, pp. 174–80. On Baumès, see Dulieu, *op. cit.* (8), vol. iii, pp. 739–41 and Holmes, *op. cit.* (35), pp. 118–20.
42. A. Fourcroy, "Sur l'application de la chimie pneumatique à l'art de guérir, et sur les propriétés médicamenteuses des substances oxigénées," *Annales de Chimie*, **28** (1799), p. 279. Fourcroy used the expressions 'froide immobilité' and 'mépris prononcé' to characterize the groups.
43. A. Fourcroy, "Extrait d'une lettre du citoyen Fourcroy, au citoyen Van Mons, au sujet de celle de M. Humboldt," *Annales de Chimie*, **22** (1797), 77-80: 'Les jeunes gens suivent avec ardeur mon cours sur la chimie animale à l'école de medecine. Rien n'égale leur envie d'apprendre; les vingt lecons que je fais sur cette partie si neuve de la chimie, donnent, je le vois, un grand mouvement à cette branche de l'étude de la nature; mais je le modère le plus que je le puis; je ne veux pas trop l'accélérer, de crainte de briser cette belle machine entre mes mains'.
44. *Cf.* A. Fourcroy, "Réponse du citoyen Fourcroy à M. Fréderic Humbolt," *Annales de Chimie*, **27** (1798), 67–71, on p. 70 and Fourcroy, *op. cit.* (42), pp. 277–78.
45. Francesc Carbonell i Bravo, *Pharmaciae elementa chemiae recentioris fundamentis innixa...* (Barcelona: Joanes Franciscus Piferrer, 1796), 4th ed. 1824. French translations: Paris, Méquignon l'aîné, 1803; 3rd ed. 1821. Carbonell's translation of Fourcroy's Discourse was published in Madrid by Repullés in 1804.

46. F. Carbonell i Bravo, *De Chemiae ad Medicinam applicationis usu et abusu* (Monspelii: Apud G. Izar et A. Ricard, *an IX*). On Carbonell, see A. Nieto Galán, *Ciència a Catalunya a l'inici del segle XIX: teoria i aplicacions tècniques a l'escola de Química de Barcelona sota la direcció de Francesc Carbonell i Bravo (1805-1822),* (Barcelona, PhD, 1994).
47. Lens' conclusions were more widely diffused among French physicians. In 1813, Cadet de Cassicourt summed up Lens' conclusions in the *Dictionnaire Dictionnarie des Sciences Médicales, par une société de Médecins et de Chirurgiens* (Paris: C. L. F. Panckoucke éditeur, 1813), vol. V, 45–60. In 1822, the author of the chapter "chimie" in the *Dictionnaire* was Orfila. See Adelon *et al.*, *Dictionnaire de Médecine* (Paris, Chez Béchez Jeune, 1821-1828), vol. V, 127-133. A thesis published in Paris in 1829, L. S. B. Izarie, *Essai sur les services rendus par la chimie aux diverses branches de la médecine*', used the same arrangement.
48. A. Lens, *Considérations générales sur l'application de la chimie aux diverses branches de la médecine; Thèse présenté et soutenue à la Faculté de Médecine de Paris, le 18 avril 1811 par ..., de Paris, elève de l'Ecole pratique et membre émérité de la Société d'Instruction médicale* (Paris: Didot Jeune, 1811), p. V: mon dessein n'est pas plus de soumettre, avec quelques modernes, la médecine au joug de la chimie, que de méconnaître, comme on le fait trop généralement, les services que celle-ci peut lu rendre dans un grand nombre de circonstances'. On Lens, see A. Dechambre, *Dictionnaire Encyclopédique des Sciences Médicales* (Paris: Masson, 1864-1889), vol. II, *deuxième série,* 1876, pp. 154–55. Lens described his chemical studies in his thesis, *op. cit.* (48), p. VIII.
49. G. Coutanceau, *Révision des nouvelles doctrines chimico-physiologiques, suivie d'expériences relatives à la respiration* (Paris: Maradan, 1814). It was reprinted in 1821 (Paris: J. B. Baillière, 1821). Reviews of Coutanceau's book were published by N. Adelon in *Bibliothèque médicale,* **45**, September 1814, 289–310 and by E. Gaulthier de Claubry in *Journal de médecine, chirurgie, pharmacie,* **XXXVI** (1816), 71–80. Orfila quoted Coutanceau's book in his chapter *Chimie* in the *Dictionnaire de Médecine, op. cit.* (46) and also in the second edition, (Paris: Béchet, 1832–46), t. VII, p. 310. On Coutanceau's publications see A. Dechambre (dir.), *op. cit.* (48), vol. XXII, p. 84.
50. By this term, Coutenceau meant the transformation of chyle into blood and the venous blood into arterial blood.
51. Coutanceau, *op. cit.* (49), p. 6. See also, the chapter on nutrition, for example, p. 174. 54. Coutanceau affirmed that no chemist had created nor would be able to create in the future 'une goutte de sang, une goute de lait' or 'un atome de gélatine animale'. *Cf. op. cit.* (49), pp. 250–1 .
52. *Cf. op. cit.* (49), pp. 178, 248, 255–57 and 266. Adrien Lens defended similar views in his chapter on physiology, *op. cit.* (48), p. 20–27: 'Les aplications de la chimie à la physiologie doivent donc être bornées encore une fois à l'explication des résultats, et non des causes des phénomènes de l'organisme animal'.
53. Adelon *et al.*, *Dictionnaire de médecine* (Paris: Béchet Jeune, 1821–1828), 21 vols. on vol. V (1822), pp. 133–141. Reprinted in the second edition: *Dictionnaire de médecine ...* (Paris: Béchet Jeune, 1832–46), on vol. VII, 313–20. On Fourcroy, Coutanceau, *op. cit.* (49) (1822) p. 140.
54. J. J. Virey, "Recherches historiques sur l'origine et les applications de la chimie à la médecine, et considérations sur son emploi dans la thérapeutique", *Journal de pharmacie,* **4** (1818), 74–84, on pp. 74–5.
55. *Ibid.*, p. 84
56. F. M.[agendie], "An essay on chymical history and medical treatment of calculous disorders, etc.; ... par A. Marcet...," *Nouveau Journal de Médecine,* vol. I (1818), 260–70; 363–7, on pp. 260–61. On Magendie's ideas about this question, see J. M. D. Olmsted, *François Magendie, Pioneer in Experimental Physiology and Scientific Medicine in XIX Century France* (New York: Schumans, 1944), pp. 27–34 and L. Deloyers, *François Magendie, 1783–1855. Précurseur de la médecine expérimentale* (Bruxelles: Presses Universitaires, 1970), pp. 98–119.
57. M. Orfila, "Analyse d'une nouvelle espèce de calcul biliaire," *Ann. de Chimie,* **LXXXIV** (1812), 34–40. See N. G. Coley, "Animal Chemists and Urinary Stone," *Ambix,* **18** (1971), 68–93 and G. Richet, "The chemistry of urinary stones around 1800: a first in clinical chemistry," *Kidney international,* **48** (3) (1995), 876–86.
58. M. Orfila, *Traité des poisons tirés des règnes minerál, végétal et animal, ou, Toxicologie générale, consideré sous les rapports de la Physiologie, de la Pathologie et de la Médicine Legale par M. P. Orfila,..* (Paris: Crochard, 1814–1815), on vol. II, pp. 153–154.65. Orfila, *op. cit.* (1), (1817), vol. I, p. ii.

59. Orfila, *op. cit.* (1), (1817), vol. I, p. ii.
60. *Ibid.*, *Introduction*: 'cette partie de la science nous ayant paru trop peu avancée pour pouvoir la réduire à des principes généraux'.
61. H. M., "Mort occassioné par un bain de drêche," *Gazette de Santé*, 21 de janvier de 1819, 300–302: 'nouveaux élémens de chimie prétendue médicale'.
62. *Nouveau journal de médecine, chirurgie, pharmacie*, **4** (1819), 93–98.
63. M. Orfila, "Chimie", in Adelon *et al. Dictionnaire de Médecine* (Paris: Chez Béchez Jeune, 18211828), vol. V (1822), 127–33. This last sentence was also in the second edition, Paris, 1832–1846, t. VII, p. 310.
64. *Ibid.*, p. 310.
65. J. H. Brooke, "Wöhler's Urea, and Its Vital Force? A verdict from the Chemists," *Ambix*, **15** (1968), 84–114. About chemistry and vitalism during these years see also B. S. Jorgensen, "Berzelius und die Lebenskraft," *Centaurus*, **10** (1965), 258–81; T. O. Lipman, "Vitalism and Reductionism in Liebig's Physiological Thought," *Isis*, **58** (1967), 167–85 and J. Jacques, "Le vitalisme et la chimie organique pendant la première moitié du XIXe siècle," *Revue d'histoire des sciences*, **3** (1950), 32–66. A recent discussion of some literature relating to this question is N. G. Coley, "Studies in the History of Animal Chemistry and its Relation to Physiology," *Ambix*, **43** (1996), 164–87.
66. On French vitalism see R. Rey (1987), *Naissance et dévelopment du vitalisme en France de la deuxième moitié du XVIIIè siècle à la fin du premier empire* (Paris: Thèse, Univ. Paris I, 3 vols). A collective book on this subject has been recently published by G. Cimino and F. Duchesneau (eds.), *Vitalisms from Haller to the Chell Theory* (Firenze: Leo S. Olschki Editore, 1997).
67. Other authors used the term 'médecin chimiste' with a similar pejorative meaning. See Lens, *op. cit.* (48), p. 34.
68. A. Rocke, "Berzelius's Animal Chemistry: From Physiology to Organic Chemistry (1805–1814)," in: E. M. Melhado and T. Frängsmyr (eds.), *Enlightenment Science in the Romantic Era* (Cambridge: University Press, 1992), pp. 107–31. The term 'vital materialism' had been used by other authors such as O. Temkin "Materialism in French and German Physiology in the Early Nineteenth Century," *Bull. Hist Med.*, **20** (1946), 323–27 and T. Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth Century German Biology* (Dordrecht: Reidel, 1982), especially in chapter I. There are some interesting similarities between Orfila's and Bernard's points of view. See F. L. Holmes, "Claude Bemard and the Vitalism of his Time" in G. Cimino and F. Duchesneau *op. cit.* (65), pp. 281–95.
69. Orfila's letter to Mr. Llambías, Paris, 24 september 1817. *Cf.* Hemández Mora *op. cit.* (1), pp. 163–4. See Bertomeu Sánchez *op. cit.* (1).
70. *Journal de médecine, chirurgie, pharmacie, etc*, **XL**, 161–70, on p. 162: '...grâce aux lumières répandues sur la science chimique par les travaux des modernes, et à l'excellent Traité de M. Orfila sur la Toxicologie, on ne verra plus, il faut l'espérer, de semblables méprises".
71. Maygrier, *op. cit.* (21), pp. 160–63. The first edition was published in Paris, 1807; second edition, Paris, 1816. On his biography and publications, see A. Dechambre, *op. cit.* (45), vol. 5, pp. 548–9.
72. H. Gaultier de Claubry, "'Elémens de chimie...' de M. Orfila, 1 ed., Paris, 1817," *Journal de Physique*, **42** (85) (1817), 263–65; 315–20; on p. 319. In the first edition, Orfila established two kinds of problems concerning vegetable analysis: proximate and elementary analysis. However, he stated that he would deal only with the second. The 'progress of chemistry' was not enough to reduce proximate analysis to 'general rules'. (*Cf.* Orfila, *op. cit.* (1) (1817), vol. II, p. 553 and Orfila, *op. cit.* (1) (1828), vol. II, p. 650).
73. Gaulthier de Claubry, *op. cit.* (72), pp. 319–20.
74. Delpit, "'Elémens de chimie...' de M. Orfila, 1 ed., Paris, 1817," *Journal universal des Sciences médicales*, **6-7** (18–19) (1817), 337–52; 61–75; on p. 338 and 64–65. On his biography, see Dechambres *op. cit.* (49), vol. 26, p. 545.
75. Orfila, *Nouvelles recherches sur l'urine des ictériques* (Paris: Didot jeune, 1811). Icterus or jaundice is a morbid condition marked by yellowness of some fluids and tissues.
76. Delpit, *op. cit.* (74), pp. 70-71.
77. Orfila unified animal and vegetable chemistry in a joint chapter in the seventh (1843) edition of his textbook but came back to the traditional three kingdoms arrangement in the last edition of 1851.
78. J. J. Virey, "'Elémens de chimie médicale', par M. P. Orfila, médecin par quartier de S. M. Louis XVIII, membre correspondant de l'Institut de France... (Analyse par M....)," *Journal de pharmacie*, **III** (1817), pp. 427–31; on pp. 430–31.

79. Orfila, *op. cit.* (1), (1817), vol. II, p. 3.
80. Brooke, *op. cit.* (65), p. 87
81. Holmes, *op. cit.* (36), (1963), p. 57. See also J. R. Partington, *A Histoy of Chemisty* (London: Macmillan, 1961–70), vol. IV, p. 233 and M. Florkin, "A History of Biochemistry" in *Comprenshive Biochemisty* (Amsterdam: Elsevier Publishing, 1972), vol. 30, p. 114.
82. See J. J. Virey, "Recherches historiques sur l'origine et les applications de la chimie à la médecine, et considérations sur son emploi dans la thérapeutique," *Journal de pharmacie*, **4** (1818), pp. 74–84.
83. A. Fourcroy *Système des connaisances chimiques et de leurs applications aux phénomènes de la nature et de l'art, par...* (Paris: Baudouin, 1800), vol. IV, pp. 31–37. See also Virey, *op. cit.* (82), pp. 82–83 and J. J. Virey, "Discours sur l'histoire et les progrès des sciences pharmaceutiques ou naturelles et chimiques jusqu'aux temps actuels," *Mémoires de l'Académie de Médecine, Paris*, **1** (1828), pp. 323–39; on p. 329. Johann Friedrich John's (1782–1847) book was used by Orfila as a source book for this kind of analysis, probably his French translation published in 1816, *Tableaux chimiques du règne animal, ou Aperçu des résultats de toutes les analyses faites jusqu'à ce jour sur les animaux* (Paris: L. Colas, 1816), 92. Fourcroy, *op. cit.* (83), p. 44.
84. Fourcroy, *op. cit.* (83), p. 44.
85. *Ibid.*, vol. IV, p. 48
86. *Ibid.*, vol. VI, p. 49: 'Ce que j'ai dit d-dessus sur l'impossibilité où l'on est encore en chimie de fabriquer une matière végétale, quoiqu'il ne soit pas défendu d'espérer qu'on pourra y parvenir, et quoiqu'on l'ait peut-être fait même déjà sans s'en douter, surtout relativement au mucilage, le plus simple peut-être des matériaux produits par les corps organisés, ce que j'ai dit se rapportait nécessairement à la puissance créatrice ou formatrice dont jouissent les végétaux pendant leur vie'.
87. A. Fourcroy, *Philosophie chimique, ou Vérités fondamentales de la chimie moderne, disposées dans un nouvel ordre, par...* (Paris: Levrault, 1806), p. 303.
88. See, for instance, E. J. B. Bouillon-Lagrange, *Manuel d'un cours de chimie, ou principes élémentaires théoriques et pratiques de cette science, 4e édition* (Paris: Bernard, 1808), vol. III, pp. 10–11.
89. J. Coxe, "Introduction", *Practical chemistry... Tr. from the French. . .by John Redman Coxe...* (Philadelphia: Thomas Dobson and Son, 1818) . See Bertomeu Sánchez *op. cit.* (1).
90. J. L. Thenard, *Traité de chimie élémentaire, théorique et pratique, par...*, 1st edition (Paris, Crochard, 1813–1816) vol. III; pp. 3–4. Id. in the 5th ed., Paris, 1827, vol. III, 544–45. About this question see Brooke, *op. cit.* (65), p. 89 and Jacques, *op. cit.* (65), pp. 42–45.
91. Thenard, *op. cit.* (90), (1813–16), vol. III, 1; id. in 5th ed (1827), vol. III, 543.
92. *Ibid.*, vol. III, p. 2. id. in 5th ed. Thenard, 1827, vol. III, p. 543.
93. *Ibid.*, vol . III, 518. id . in 5th ed. Thenard, 1827, vol . IV, 555.
94. L. J. Thenard, *Traité de chimie élémentaire, théorique et pratique, suivi d'un essai sur la philosophie chimique et d'un précis sur l'anayse, par...*, 6th ed. (Paris–Bruxelles, Crochard, 1834–1836), vol. IV, p. 1. During these years, Thenard was appointed Chairman of the Gelatin Commission. See F. L. Holmes, *Claude Bernard and Animal Chemistry* (Cambridge, MA: Harvard University Press, 1974), pp. 8–13.
95. Orfila, *op. cit.* (1), (1817), vol. II, p. 1; (1819), vol. I, p. 1–2; (1824), vol. II, p. 1–2.
96. J. L. Gay-Lussac et J. Thenard, "Extrait d'un mémoire sur l'analyse végétale et animale," *Annales de chimie*, **LXXIV** (1810), 47–64. On classifications of vegetable immediate principles see R Löw, *Pflanzenchemie zwischen Lavoisier und Liebig* (Straubing/München: Donau Verlag, 1977) and R. Löw, "The progress of organic chemistry during the period of German romantic Naturphilosophie (1795–1825)," *Ambix*, **27** (1980), 1–10.
97. Orfila, *op. cit.* (1), (1828), vol. II, p. 2. This definition shows many similarities to Chevreul's in *Recherches chimiques sur les corps gras* (Paris, 1823), p. 4. On Chevreul, see A. B. Costa, *Michel Eugène Chevreul, pioneer of organic chemistry* (Madison, WI: State Historical Soc., 1962), on 47–63. Costa does not emphasize this aspect of Chevreul's work enough. Neither is his discussion of Chevreul and vitalism satisfatory. *Cf ibid.* p. 23–26.
98. Orfila, *op. cit.* (1) (1835–36), vol . II, pp. 305–306.
99. Orfila, *op. cit.* (1) (1851), vol . II, pp. 1–2.
100. *Ibid.*, vol. II, p. 15.
101. *Ibid.*, vol. II, p. 15. On Chevreul's criteria see *Considérations générales sur l'anayse organique et sur ses applications*, Paris, 1824, p. 31–50. Chevreul, *ibid.* p. 22, had differentiated between 'des composés dont on ne peut séparer plusieurs sortes de matières sans en altérer évidemment la nature' (principes immédiats); 'des composés de deux ou plusieurs principes immédiats

unis en proportions définies'; and 'des composés formés par la réunion en proportion indéfinie, soit de principes immédiats, soit des combinaisons définies de ces mêmes principes'. Chevreul considered that the concept of 'espèce dans les composés organiques' could be only used to designate the first two groups, as Orfila argued in the final edition. On this question see also Florkin, *op. cit.* (81), p. 115.

102. Orfila, *op. cit.* (I), (1817), vol. II, p. 3. Small variations in subsequent editions suggest that Orfila revised the text but he decided to maintain the quoted sentence.
103. *Ibid.*, vol. II, pp. 11–54 and 4th ed., 1828, vol. II, pp. 52–127. On this question, see Brooke, *op. cit.* (65).
104. Orfila, *op. cit.* (I) (1851), vol. II, p. 15.