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Chemical Collections

Christoph Meinel

Chemical collections do not seem to exist. This is in brief what I am going to argue in this chapter. Of course, chemists – like most ordinary people – collect all kinds of items, including chemicals. But if one asks scientists in a chemistry laboratory for the department's chemical collection, they are likely to shrug their shoulders. Chemistry textbooks and dictionaries, ancient and modern ones, speak of the tools of chemical teaching or research, but never refer to the use of chemical collections. The iconographic tradition of chemistry abounds with pictures of laboratories and apparatus, but views of collections are strikingly absent. There are no references in the museographical literature of the past, nor are they listed in present-day guidebooks to museums and collections. Even a random *Google* search leads to nothing but a couple of companies specialised in the disposal of household chemicals and other hazardous substances.

To prove absence is usually more difficult than to prove the contrary. Therefore, the object in question needs to be clearly defined. The notion of a 'chemical collection' can in fact have various meanings. For the purpose of this paper, I use it in a rather specific sense, viz. as a collection of chemical elements or compounds, properly arranged to represent the inherent order of nature, just as mineralogical collections or collections of butterflies do. Natural history collections are an obvious way to display order within the diversity and variety of natural objects. The idea of representing an existing natural pattern by means of material exemplars is crucial for this type of collection. Their use in research and teaching is part of a practice of comparing and referencing. In this manner mineralogists collect 'typical' specimens, and botanists keep herbaria and preserve a 'type specimen' whenever a new species is described for the first time.

In this natural history sense, I argue, chemical collections don't exist and have never existed. At first glance, this is a somewhat surprising claim. For, through much of its history, chemistry was an integral part of natural history, and much of its teaching and methodology followed that same approach.[1] Well into the nineteenth century it was seen as one of the organising principles of any chemical system to arrange and re-arrange compounds according to their elemental composition. 'To put things in order' is still very much the way Justus Liebig would have defined the task of an organic chemist in the 1840s, and the periodic system of the 1860s is still part of this natural history tradition. Beautiful mahogany cabinets, however, and the impressive displays that we immediately associate with contemporary natural history museums, would not have been found in a nineteenth-century chemical laboratory. Chemical collections do not seem to have normally been part of the practice of teaching and research of that science.

This negative finding may be explained in the following ways: first, by examining the status of chemical substances as natural objects;[2] second, by looking more closely into the hierarchy of institutional spaces where chemical knowledge was produced and communicated; and finally, by looking at topological representations of chemical knowledge similar to, but at the same time different from, material collections. In this chapter, these three aspects will be combined.

Spaces of knowledge production

When dealing with spaces in chemistry, the obvious space to begin with is the laboratory; and when dealing with laboratories, the obvious point of departure is Andreas Libavius' *De sceuastica artis* of 1606,[3] a 110-page textbook of chemical equipment and instruments, of furnaces and vessels of all kinds, each of which refers to a specific type of operation. Published as an appendix to the second edition of Libavius' famous *Alchemia* of 1597, *De sceuastica artis* is an attempt at classifying and systematising the various operations performed in the laboratory.

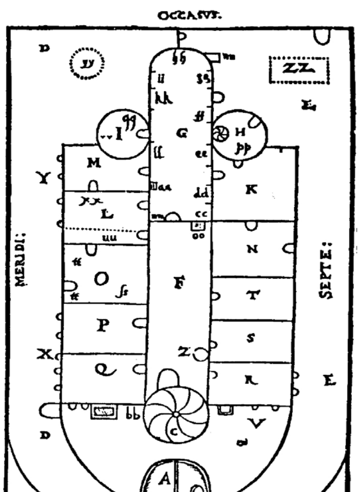


Figure 1. Floor plan of Libavius' idealised chemical laboratory (A. Libavius, *De sceuastica artis*, in: *Alchymia Andreae Libavii recognita*, Frankfurt, 1606, 95).

A rigorous concept of order was at the core of Libavius' effort to turn chemistry into a teachable science – as opposed to the idiosyncrasies of Paracelsian mysticism.[4] For Libavius, disciplines were created by disciplining words and practices. He insisted that the logic of words must correspond to the properly arranged toolkit of procedures, methods and apparatus, and this order must in turn correspond to the moral conduct of the chemist. Accordingly, Libavius proposed the blueprint of a prototypical laboratory.

In the idealised ground plan, the *laboratorium* or χυμειον (G in Figure 1) occupies the central space. Next to it, we find the dormitory of the amanuenses (M), a small cabinet for metallurgical essaying (I), a large storage room for solid materials and solutions (K, *apotheca materiarum et essentiarum artis*) and another one for moveable apparatus and vessels (N, *armarium et loculamenta vasorum chymicae mobilium*). The heavier equipment, and in particular the furnaces, remained in the laboratory. None of these storage rooms are described as a collection for display or instruction. Instead, they were dump rooms to stock the supply of materials and tools, similar in function to the rooms for keeping the fire-wood. As the building was meant to be a private home and a laboratory at once, it also had spacious rooms for the chemist's family and a large wine cellar, but there was no library – perhaps a subtle indication of an aversion to the tradition of speculative and bookish learning as opposed to the operative and solid knowledge of the practical chemist.

The chemical laboratory was a space in which a kind of knowledge was produced that was impossible to acquire by listening, reading and observing alone. A sort of 'thing knowledge'[5] related to the tools and apparatus, and in addition a knowledge of materials and substances acquired by the very process of making them. As a consequence, typical laboratory chemicals were produced on the spot. In that regard, they have little in common with the items in a natural history collection. Collections contain samples from the outside world, exemplars to represent the underlying order of nature. Chemical laboratories were workshops in which nature was transformed into new natures, guided by operative knowledge. Accordingly, chemicals kept in the laboratory or in the storage room next to it did not 'represent' anything besides being the products of purposeful operations. The *locus classicus* for this operative view of chemistry is Hermann Boerhaave's *Elementa chemiae* of 1732, a textbook that stemmed from his 1718 lecture course at the University of Leiden and served as a model for the teaching of chemistry for more than three generations.[6] In it, Boerhaave presents chemistry as a body of operations and recipes. The first volume is entitled 'theory of the art', but in fact more than 90% of it is devoted to the tools of the chemist (*de instrumentis chemicorum*): first of all the fire as the chief instrument of separation and fusion, followed by the solvents, apparatus, furnaces and vessels. The second volume, entitled *Operationes chemicae*, presents 227 individual processes, each of which is divided into 'preparation' (*apparatus*) and 'use' (*usus*). According to Boerhaave, chemistry is the purposeful application of procedures to the making of products for a specific use, a 'technoscience avant la lettre'.[7] The model for this presentation was the pharmacist's pharmacopoeia; its underlying didactic scheme is not the order of nature, but the order of uses and the sequence of operations. The best depiction of the operational notion of chemistry is the famous plate *Laboratoire et table des Raports* from the great French *Encyclopédie*.[8]

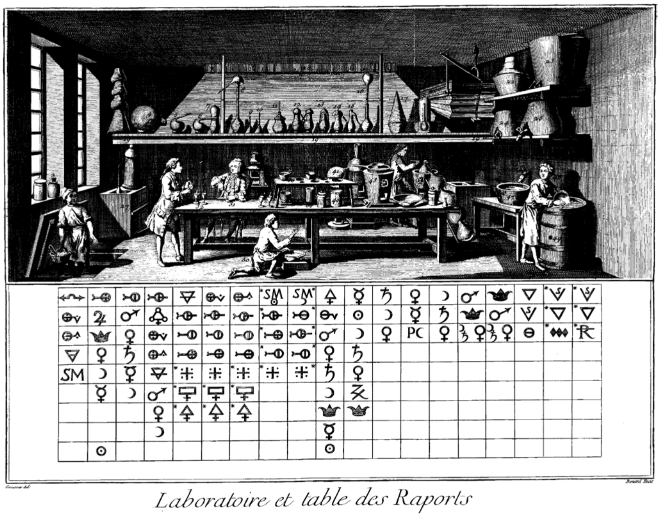


FIGURE 2. *Laboratoire et table des Raports* (*Recueil des planches sur les sciences, les arts libéraux, et les arts méchaniques*, vol. 2/2, Paris, 1768, s.v. 'Chimie').

The top part of the engraving shows a large room with five different furnaces, a huge hood with bellows, a couple of washing basins, and a bewildering variety of flasks, vessels and crucibles for specific purposes explained in the legend. Strangely enough, chemicals are not mentioned at all, nor do we see any shelves or cupboards with reagents. Two fashionably dressed gentlemen, a *physicien* and a *chimiste*, are shown at the work bench conversing about the dissolution, while another *chimiste* in the back monitors a descending distillation, and three *garçons de laboratoire* perform ancillary services such as cleaning and getting fresh coal from the basement. The *laboratoire* of the *Encyclopédie* is of course not a real one. It is an idealised workshop, and chemistry is presented as the art of performing operations by means of specific apparatus, properly arranged according to size, weight and use. The idea of order is conveyed by the topology of tools and operations. This is an operational, not an ontological notion of order, also symbolised by the affinity table in the lower part of the engraving, which again represents operations and types of reactions.

Topology and order

As an operational art, chemistry stands in stark contrast to natural history. Mineralogists arranged their collections according to external qualities (if they adhered to the Wernerian system) or internal ones such as elemental composition (if they adopted the chemical classification). In both cases, the topology of the collection was meant to represent the order of nature; for minerals are natural objects and are collected as exemplars to represent natural genera, classes and species. Typical chemicals, on the other hand, are artificial objects, purposefully prepared in the laboratory. They are not normally made to represent anything outside the laboratory, and they are by no means unique, as individual crystals or pieces of rocks are. On the contrary, chemicals can be reproduced *ad libitum*, once the procedures are established and if the means and apparatus are available. As a consequence, there is little point in keeping chemicals the way minerals are collected, except if they are needed as starting materials for new preparations. This accounts for the habitual lack of proper 'collections' in chemical laboratories, unless the stock of reagents and solvents on the laboratory shelves or in a dump room nearby can be called a 'collection'.

In practice, the distinction between collections of the natural history type and storages of chemicals was not always maintained. Particularly in institutions that provided a common space for mineralogy and chemistry, hybrid forms can be found. But to the best of my knowledge, attempts at presenting chemicals in the form of a systematic collection of a natural history type failed or remained restricted to very specific purposes.

In 1815, August Wilhelm Lampadius, Professor of Chemistry and Mineralogy at the Mining Academy of Freiberg in Saxony, the leading school of mines at the time, drew up a plan for a teaching museum attached to the amalgamation plant in the village of Halsbrücke near Freiberg. For this museum, he drafted a 'chemical system according to classes and genera',[9] obviously meant to provide the principles according to which a teaching collection should be built up. Lampadius' introductory remarks prove that he realised the intrinsic ambiguity of a 'natural system', the building blocks of which, viz. the chemical elements and pure substances, do not occur in nature as such but have to be artificially prepared by the chemist. A 'chemical collection', which according to Lampadius' plan comprises both natural substances and artificial products, including those produced in metallurgical and other industrial processes, would consequently display 'either formations of nature or the results of chemical operations.'[10] Whether or not this plan was realised, we do not know. It is more likely that Lampadius confined himself to publishing a revised version of his *System* in the form of a 430-page textbook,[11] and collecting mechanical models, technical drafts and metallurgical specimens in the *Hütten-Museum* in Halsbrücke.

An early example of a real 'chemical collection' was published by Adolph Martin Pleischl, Professor of General and Pharmaceutical Chemistry at the University of Prague, in 1820. In a volume on the university's chemical laboratory, its organisation and the research carried out there, Pleischl gave an overview on the available apparatus for mechanical and chemical (i.e. caloric, electrical and pneumatical) operations. Furthermore, he added a systematic register of 'preparations' (*Präparate*) kept in the laboratory.[12] This list is worth examining more closely. The classification corresponds to the French system: it lists the chemical elements according to non-metals and metals, followed by 'primary' (i.e. binary) and secondary compounds, divided into inorganic and organic ones. This is neither new nor remarkable. The unusual feature of this 15-page list is the fact that it was intended as an inventory of a real collection, or, to be more precise, of two collections devoted to different purposes. The first one, called *Präparate*, was a collection for teaching demonstrations and explicitly meant not, and under no condition, to be used up in the laboratory. The exemplars for this collection were selected according to purity, beauty and ideal crystallisation, and displayed in uniform show glasses: They were representations of a natural system of chemical elements and compounds. In this regard, the *Präparate* collection follows the pattern and fashion of collecting in natural history – up to the inclusion of a few *mirabilia* such as a piece of lead gilt by a strong electrical discharge. The second of Pleischl's collections, named 'reagents' (*Reagentien*), served a completely different purpose. It contained the chemicals to be used in the laboratory, was kept in supply and, when necessary, remade in the quantities needed. The *Reagentien* were meant to be used up in everyday work. They were not meant to 'represent' or to 'stand for' any system. In this regard, the *Reagentien* collection is more of a warehouse attached to a workshop, and less of a museum collection. According to Pleischl, there was a clear functional difference between the two types of 'collections'. However, it is unclear whether or not the *Präparate* collection was in fact used in the way it was conceived. Although it was designed to represent a natural system, it was never displayed accordingly. For practical reasons and 'in order to find the individual items more quickly' on the shelves, both collections were kept in alphabetic order. Eventually, to grasp the underlying system, one had to turn from the material specimens to the printed list.

Conflicting spaces of knowledge

During the nineteenth century, the number of known chemical substances increased at an unprecedented rate. From the 1840s onwards, the rise of chemical synthesis undermined the 'natural' or 'ontological' status of chemical substances even further by reducing them to mere outcomes of operations that could be produced and reproduced *ad libitum*. The realm of chemistry was no longer confined to the traditional three realms of nature. Scientists were beginning to create a new world out of new materials. Yet, from archives, descriptions of laboratories, textbooks and teaching manuals, there is little evidence that collecting chemicals played any significant role in their teaching and research practice.

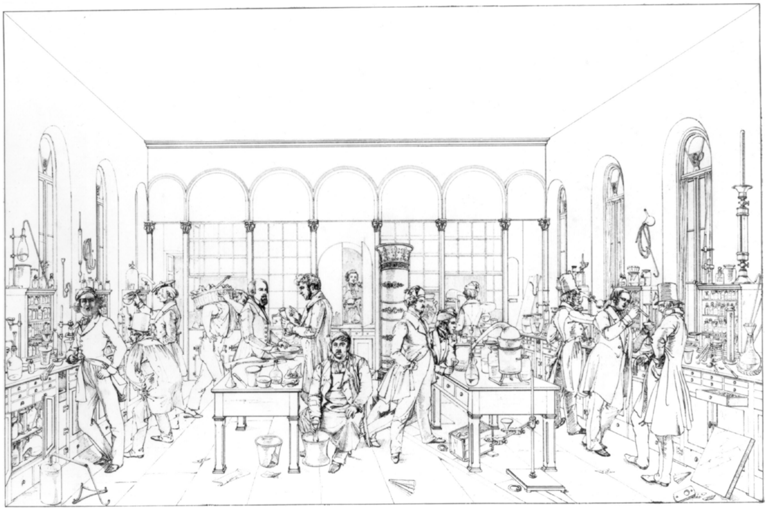


FIGURE 3. Liebig's Analytical Laboratory in Giessen, 1842; drawn by F. Trautschold and engraved by H. v. Ritgen (J.P. Hofmann, *Das chemische Laboratorium der Ludwigs-Universität Gießen*, Heidelberg, 1842).

Liebig's famous laboratory in Giessen (Figure 3) does not even seem to have had a special room for storing chemical substances. The very idea of collecting would have been alien to Liebig. In his view, order in chemistry was the order achieved by the arranging and re-arranging of the data obtained by elemental analysis. His new apparatus supplied such data at an ever increasing speed. 'In this way,' Liebig wrote in 1840, 'it is possible make the boldest discoveries in a factory-like manner.'[13]

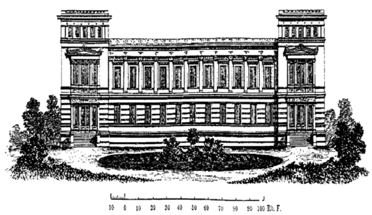
From his point of view, individual samples were meaningless unless they were used as part of an argument. The more than 1,800 letters Liebig exchanged with his friend and colleague Friedrich Wöhler in Göttingen were only rarely used to send new compounds back and forth for cross-examination. Instead, they discussed procedures and the analytical data obtained. The identity of substances was established on the basis of elemental analysis and by matching procedures in their preparation. It was not before the twentieth century that physical data, such as melting point, refraction or spectroscopic properties, played a more significant role in chemistry as they required comparison with known substances. In the case of Liebig and Wöhler, the exchange of materials was primarily in the form of large quantities of cigars and barrels of Bavarian beer.

The space of knowledge created by the chemical laboratory operates on exactly the opposite premise to the space of knowledge created by the natural history collection.[14] The latter represents knowledge by means of bodily exemplars in a topological grid. The laboratory creates knowledge by producing materials. Within the restricted space of a given institution, the two models compete for material and moral resources. As a consequence of the transition of the university, earlier devoted to teaching, towards the research-oriented university, this competition gained momentum. In the mid-nineteenth century, the budget of the chemical laboratory was sometimes the largest single expense in the total budget of a university, besides salaries. For obvious reasons this became a bone of contention between the disciplines. In 1863, Hermann Kolbe, professor of chemistry in Marburg, wrote to the Senate of his university:[15]

> One often hears it said that a university profits much more from those disciplines which bring together and maintain beautiful collections, than from a chemical laboratory the budget of which goes up in smoke and disappears through the chimney. Yet universities are not supposed to have nice collections meant to please the eye. For the mineralogist, zoologist, botanist, anatomist, etc., collections are but means to an end, i.e. to provide science education to students. The same applies for sulphuric acid, soda, spirit, etc., for the chemists, even though these materials are being used up and don't leave things behind to please the eye. […] The production of moral capital in the form of scientific knowledge is to be valued much more highly than the material capital a university can accumulate by creating beautiful collections.

Competing for moral and material resources, the collection lost status and the laboratory gained recognition. Laboratories became *temples de l'avenir* (Louis Pasteur), collections but shrines of the past. Representational ideals of knowledge gave way to an idea of a knowledge that could be used to transform the natural world. Within the economy of space in buildings devoted to chemistry, rooms reserved for the display of collections were consequently marginalised. During the second half of the nineteenth century, laboratory design shows two related trends: (i) a marginalisation and eventual disappearance of museum-like collections in chemical institutes, and (ii) an ever increasing functional division of spaces according to special types of operations.[16]

The first generation of new chemical laboratories erected in Prussia in the 1860s was a public demonstration of the increasing importance of science. The much-admired prototype was Bonn's Chemical Institute, erected for August Wilhelm Hofmann on his return from London.



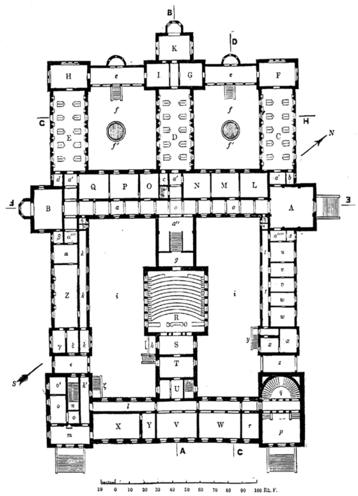


FIGURE 4. Chemical Laboratory, University of Bonn, 1866 (A.W. Hofmann, *The Chemical Laboratories in the Course of Erection in the Universities of Bonn and Berlin*, London, 1866, 16, 34).

Besides luxurious apartments for the director and his family, the palace-like building even boasted a ballroom to satisfy the social ambitions of a chemistry professor. Within this framework of representation, the display of collections came to be seen as appropriate: two great halls on the front side, profusely lighted by six windows, were provided by the architect to house a 'Mineralogical Museum' and a 'Chemical Museum' (V and W in FIGURE 4). Hofmann's report, however, admits an intrinsic opposition between the contemplative atmosphere of a museum and the busy space of the laboratory: 'experience […] has taught that the love of research and zeal for discovery in young chemists, however praiseworthy in themselves, are at times anything but conducive to the increase of scientific collections.'[17] If and how these museums were actually used, is not known; the Chemical Museum seems at least to have been equipped with industrial samples from the 1867 World Exhibition in Paris.

Subsequent laboratory buildings testify to an ever increasing degree of specialised spaces and division of labour. The Chemical Institute of the University of Berlin, for instance, in 1869 the largest chemical institute in the world, had dozens of rooms for specific purposes such as qualitative analysis, quantitative analysis, volumetric elemental analysis, weighting and titration, spectroscopy and photometry, gas analysis, operations with hydrogen sulphide, combustions, distillations, metallurgical and forensic tasks, the handling of strong-smelling or poisonous substances, and so on. In addition, there were storage rooms for coal, dry and liquid reagents, glass and porcelain vessels, apparatus and instruments. The building also contained a hall of 60 by 25 feet with an arched roof supported by iron columns, to house the scientific collections of the Institute. From Hofmann's description, we learn that these collections were divided into three parts: minerals, rocks and metallurgical products in the first section; chemicals in the second and largest one; and models, drawings, diagrams etc. in the third.[18] However, this 'Museum' was neither a space for display nor was it open to students or the public. Primarily it was meant as a storage room for the objects required in teaching. By means of a wheeled table of the same height as the lecture table, the respective specimens could be carried to the laboratory for the preparation of lecture demonstrations and from there to the adjacent lecture theatre.

The very idea of a traditional collection, viz. to display a system in its entirety and to represent, by topological means, coherence, order and relation within the individual species of nature, had thus been replaced by a mere storage space from which the required items could be fetched. Within the heterogeneous farrago of teaching aids ranging from minerals and models to wall-charts, the collection of chemical substances was not given any peculiar status. In chemistry, the collection was not seen as a way of representing system and order. This task had long been taken over by another, merely symbolic, topology: the table of chemical elements. In the second half of the nineteenth century, this table was usually placed on the wall of the lecture theatre – a space later to be occupied by the periodic system.

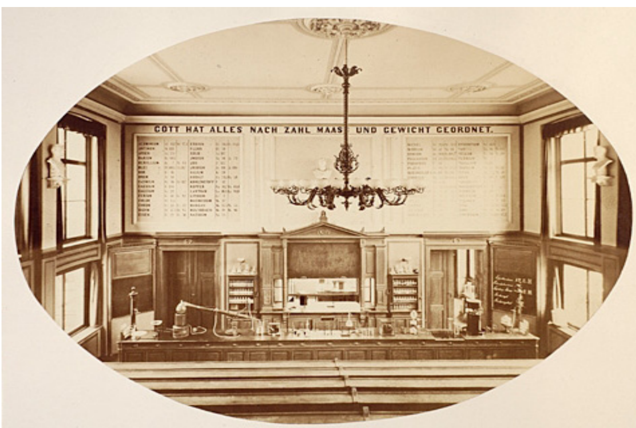


FIGURE 5. Chemistry Lecture Theatre, University of Leipzig, albumine photograph by A. Stecher, 1872, from *Photographische Ansichten von Laboratorium der Universität Leipzig*, Braunschweig, 1872. The inscription quotes from Wisdom 11:20: 'God has arranged all things by measure and number and weight.'

Collections of chemical substances did of course not disappear altogether.[19] For instance, some of them were sample collections of industrial or commercial products. Among the better known examples of this kind are the collection of furnaces, technological models and mining products of the Harz mountains established in the chemical laboratory of the University of Göttingen in 1791;[20] the Playfair Collection at the University of Edinburgh built up as an 'Industrial Museum' for intermediate stages and final products in the 1850s;[21] the Dyestuffs Collection of the Technical University of Dresden, begun in 1852 as a collection of natural dyes and grown to some

10,000 samples to date;[22] and the chemical collection of ETH Zurich which holds the complete dyestuffs collection of the CIBA Company. But all these collections belong to a different tradition: that of collecting technological artefacts, models, tools, and commercial products not dealt with in this paper.

Conclusion

Collections, in the specific sense of collections of chemicals presented in a systematic way to create order in the bewildering variety of natural substances, are rather exceptional tools in chemistry. Their status and use is entirely different from the status and use of collections in other branches of natural history – despite the fact that chemistry, for much of its history, was considered a part of natural history. However, it is no exaggeration to say that in a natural history sense of the word, chemical collections have never existed. Chemical knowledge is operative knowledge. From the very beginning, chemists realised that typical chemical substances are artificially produced in the laboratory or in the factory. Since chemicals did not fall under the notion of natural species, there was little point in presenting them in order to 'represent' anything – except as results of purposeful operations.

As a consequence, there is an intrinsic opposition between the collection and the laboratory as competing spaces for the production of scientific knowledge. In laboratory design, this resulted in an ever increasing functional division of spaces devoted to specific operations on the one hand, and in a marginalisation of spaces reserved for collections on the other.

Collections of minerals, plants or insects represent the existing order of nature. The underlying order of chemistry, however, is more adequately presented in the order and sequence of laboratory operations, in the symbolic topology of affinity tables, or in the combinatorial building blocks arranged in the list of elements or the periodic system.

Notes

1. U. Klein, 'Shifting ontologies, changing classifications: plant materials from 1700 to 1830', *Studies in History and Philosophy of Science* (2005), **36**, 261-329; U. Klein and W. Lefèvre, *Materials in Eighteenth-Century Science: A Historical Ontology*, MIT-Press, Cambridge/Mass., 2007; M. Beretta, *The Enlightenment of Matter: The Definition of Chemistry from Agricola to Lavoisier*, Science History Publications, Canton/Mass., 1993.
2. Cf. the contributions by B. Bensaude-Vincent and U. Klein to this volume.
3. A. Libavius, *De sceuastica artis*, in *Alchymia Andreae Libavii recognita*, Frankfurt, 1606, 95; cf. B. Meitzner, *Die Gerätschaft der chymischen Kunst: Der Traktat 'De sceuastica artis' des Andreas Libavius von 1606*, Steiner, Stuttgart, 1995.
4. O. Hannaway, 'Laboratory Design and the Aim of Science: Andreas Libavius versus Tycho Brahe', *Isis* (1986), **77**, 585-610.
5. D. Baird, *Thing Knowledge: A Philosophy of Scientific Instrument,* Univ. of California Press, Berkeley, 2004.
6. H. Boerhaave, *Elementa Chemiae, quae anniversario labore docuit in publicis, privatisque scholis*, 2 vols, Leyden, 1732. There was an earlier pirated edition (Paris, 1724) and a number of translations.
7. U. Klein, 'Technoscience avant la lettre', *Perspectives on Science* (2005), **13**, 226-266.

8. ‘Laboratoire et table des Raports’, in *Recueil des planches sur les sciences, les arts libéraux, et les arts méchaniques*, vol. 2/2, Paris, 1768 (*Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers, Planches*, vol. 3 (Reprint Stuttgart-Bad Cannstadt, 1967, vol. 24), s.v. ‘Chimie’.
9. W. A. Lampadius, ‘Chemisches System nach Klassen und Ordnungen entworfen … für das Museum an der Halsbrücke’ (pres. 15 August 1815), manuscript, 19 fols., Universitätsbibliothek der TU Bergakademie Freiberg, sig. 07.918 4.
10. ‘ entweder Gebilde der Natur oder Resultate chemischer Arbeiten’. *Ibid.*
11. W. A. Lampadius, *Grundriss des Systems der Chemie, oder klassische Aufstellung der einfachen und gemischten Körper*, Freiberg, 1822.
12. A. M. Pleischl, *Das chemische Laboratorium an der k.k. Universität zu Prag*, Prague, 1820.
13. ‘Mit ihrer Hilfe lassen sich die kühnsten Entdeckungen fabrikmäßig machen’, Liebig to Wöhler, 12 July 1840, Bayerische Staatsbibliothek Munich, Liebigiana.
14. C. Meinel, ‘Chemische Laboratorien: Funktion und Disposition’, *Berichte zur Wissenschaftsgeschichte* (2000), **23**, 287-302.
15 H. Kolbe to the Senate of the University of Marburg (8 October 1863), see C. Meinel, *Die Chemie an der Universität Marburg: Ein Beitrag zu ihrer Entwicklung als Hochschulfach*, Elwert, Marburg, 1978, 85-86.
16. Two official surveys on chemical laboratories were published for Germany: A. Wurtz, *Les hautes études pratiques dans les universités allemandes*, Paris, 1870; G. Roster, *Delle scienze sperimentali e in particolare della chimica in Germania*, Milano, 1872.
17. A. W. Hofmann, *The Chemical Laboratories in the Course of Erection in the Universities of Bonn and Berlin*, London, 1866, 23.
18. *Ibid.*, pp. 58-59.
19. E.g. the ‘Chemical Museum’ at the University of Leeds consists of roughly 3000 samples in standardised glass-stoppered jars. It was founded as a teaching collection for Yorkshire College in 1874.
20. F. C. G. Hirsching, ed., *Nachrichten von sehenswürdigen Gemälde-und Kupfersichsammlungen*, vol. 6, Erlangen, 1792, 167-168.
21. R. G. W. Anderson, *The Playfair Collection and the Teaching of Chemistry at the University of Edinburgh, 1713-1858*, Royal Scottish Museum, Edinburgh, 1978.
22. B. Werner, ‘Wie die Welt farbiger wurde: Ein Rundgang durch die Farbstoffsammlung der TU Dresden’, *Wissenschaftliche Zeitschrift der Technischen Universität Dresden* (2000), **49**, 4/5, 35-40.