SIR THOMAS BROWNE'S CHEMISTRY

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SIR Thomas Browne was born in 1605 and died in 1682, and he saw in his lifetime the first stage of the Scientific Revolution in Europe. It is always difficult to assign a date to the beginning of any revolution, because it may begin long before the first full-scale battle and continue in many ways after the victory or defeat of the revolutionary forces. In the case of Science, the situation was more complex because the various branches of it did not all experience their revolutions during the same period. For example, although William Harvey's discovery of the circulation of the blood at the beginning of the century marked a great advance towards the new understanding of Anatomy, there is no doubt that in many ways he was a mediaeval scholar, and his Physiology and Chemistry were largely those of the Middle Ages. At the end of the sixteenth century, Van Helmont and Glauber, the last of the true Alchemists, were still living, and their kind of Chemistry continued until the middle of the seventeenth century. Boyle, through his book *The Sceptical Chymist* (1661) is regarded as the 'father' of English Chemistry, but the science as we know it dates from the middle of the eighteenth century. In spite of these considerations, the seventeenth century is generally regarded as the source-period of modern science, if only perhaps because Newton and Descartes, Galileo and Francis Bacon, Huygens and Leibnitz, Kepler and Leeuwenhoek, Boyle and Ray lived during that momentous period.

Saint Thomas says that 'In Natural Science, the argument from Authority is the weakest', and during the period 1600-1700 the force of his remark was being increasingly realised. This was certainly due to a renewed interest in what could be observed, to a growth of societies, like the Royal Society, whose aim was to foster scientific investigations especially by experiment, and to the growing ability of technologists to construct apparatus and measuring devices. The use of the astronomical telescope, the development of the microscope and the micrometer, and the invention of the air pump, all date from this century. Men of Science began to appeal more and more to the results of practical investigation and observation, and less and less to the unsupported testimony of the scholars of antiquity. The change was noticeable even in the lifetime of one man; Harvey seems to have moved steadily in the direction of the newer methods.[1]

[1] *The Scientific Revolution* A. R. Hall (Longmans) pp. 148, 154 et seq.

Sir Thomas Browne, who lived through the most exciting part of the century, showed less progress of this kind, but nevertheless adopted a dual approach to science. He combined a critical consideration of ancient and mediaeval authorities with practical investigation, in numerous branches of Physics, Medicine, Biology and Chemistry.

Browne is often criticised adversely on the grounds of his 'unreasonable' reverence for the beliefs of the past. It has been claimed that he was not original, and that his ideas were an undigested blend of incompatibles culled from Aristotle, Galen and others. There is an element of truth in this charge, and we may look for the reason for it in his early training for the profession of Medicine. This began at Oxford, where the Medical course seems to have consisted of a close study of the works of Aristotle, Galen and Hippocrates. After a short time in general practice, he went in 1630 to Montpellier, where the School of Medicine flourished.

It was at Montpellier that he came into contact with a vigorous school of Botany, and this became one of his lifelong interests. Chemically, Montpellier was backward.[2] The 'Vital Force' theory that there existed a special 'spirit' or 'force', present in substances produced by plants and animals and preventing their artificial preparation, was strongly held, and the liberalising views of Paracelsus on chemically-produced medicinals and the treatment of disease by chemical methods were not admitted. Browne learned no Chemistry or Physics there, nor did he encounter either of these at Padua, where he went in 1632 to study Medicine under Sanctorio and Surgery under Marchetti. At Leyden in 1633 he encountered for the first time the Paracelsian doctrines, and theories of the chemical nature of disease. It is conjectured that, while in Leyden, he met Descartes, and possibly also Van Helmont, although the latter was then living in virtually monastic seclusion. Certainly he could not have attended any lectures by Van Helmont at that time.

As a consequence of these latter experiences Browne became a desciple of Paracelsus, interested in the products of plants and convinced of the value of weight and measurement in chemical studies. The latter conviction seems to have been due to Van Helmont's influence at Leyden.

Sir Thomas was by no means intellectually narrow. At the age of thirty, when he wrote the famous *Religio Medici,* he was fluent in French, Italian Spanish, German, Dutch, Danish, Latin, Greek, Hebrew and Arabic, as well as being acquainted with some dialects. A voracious reader, he immersed himself in the available writings, in all these languages, of a scientific and philosophical nature. His return to England, to the quiet-

[2]No lectures or demonstrations in Chemistry were available until after Browne had left.

ness of Norwich, gave him the opportunity to practise medicine in a manner sufficiently leisurely to permit an acute and active interest in all scientific matters. He died at the age of seventy-seven years, having fathered ten children, of whom four survived, one becoming eminent in the medical profession.[3]

Of Sir Thomas Browne's writings, the most famous and the most widely read and valued are of the least scientific interest. *Urne Buriall* and *Religio Medici* chiefly throw light on his mental outlook, which oscillated between the sanguine and practical and the melancholic. The inclination of Browne towards matters curious and metaphysical is revealed in the fantastic *Garden of Cyprus,* in which the properties of the number five and the arrangement of five points in the manner called a 'quincunx' are discussed. There is more scientific interest in his *Pseudodoxia Epidemica* or *Vulgar Errors.* This informative, learned and entertaining work is a mine of information and speculation on an enormous variety of subjects. It discusses, for example, the blackness of the skin of negroes, whether or not badgers have two of their legs longer than the other two, and whether a drowned woman floats face downward, for reasons of modesty! It is probably this work that has given rise to Browne's reputation for being too much inclined to follow the old authorities, but this is a superficial view. Certainly he appears to deny such a charge when he writes '... the mortallest enemy unto knowledge, and that which hath done the greatest execution upon truth, hath been a peremptory adhesion unto authority; and more especially the establishing of our belief upon the dictates of antiquity'.[4] An inspection of each topic discussed reveals that he takes a thoroughly modern view of the problem. First are considered, often at some length, it must be admitted, the views of scholars of antiquity and the claims of popular belief. A logical dissection of these views, usually very penetrating, follows, and finally in many cases the decision is made after appeal to experiment. Research workers in science today would at once recognise this as the pattern of many a modern scientific paper. One often reflects that a great deal of time would have been saved by a simple experiment carried out at the very beginning, but his method shows him to be genuinely representative of the seventeenth century scientific revolution.

One of the specific problems brought into prominence in the middle of

[3] Edward Browne.

[4] *Pseudodoxia Epidemica* Chap: VI, Bk. 1. The fullest edition of Browne's works is that of *Keynes* (1931), and this edition is used except where stated otherwise. The above reference is in *Keynes* edition Volume II page 42. Such references will be given henceforth in the form (K II 42).

the seventeenth century was that of the nature of matter. What were Sir Thomas Browne's views about it?

It is difficult to be very sure, so far as his surviving writings are concemed. His reverence for antiquity might have led him to hold to the four-element, or earth-air-fire-water doctrine, and he certainly uses it in explaining some phenomena. For example:

> ... That which is concreted by exsiccation or expression of humidity will be resolved by humectation [such] as Earth, dirt and clay; that which is coagulated by a fiery siccicity, will suffer colliquation from an aqueous humidity...[5]

These views appear again when he writes:

> ... The Earth will not be at an end but rather a beginning. For at present it is not earth, but a composition of fire, water, earth, and air; but at that time, spoiled of these ingredients, it shall appear in a substance more like itself, its ashes...[6]

and again:

> ... the number four stands much admired... in the quaternity of the Elements, which are the principles of bodies.[7]

Nevertheless, Sir Thomas is apparently prepared to give equal weight to other theories. Mercury, sulphur and salt, for instance, seem to him equally acceptable as 'elements' of matter:

> The Chymists have laudibly reduced their Causes into Sal, Sulphur and Mercury... besides the fixed and terrestrious salt, there is in natural bodies a *Sal niter* referring to sulphur; there is also a volatile or Armoniak Salt, retaining unto Mercury...[8]

Some of his statements are reminiscent of the theories of Becher, that matter contains a *terra pinguis* (or fatty material) and a *terra mercurialis* (or liquefying principle). Thus, he writes of smoke that it is '...proceeding from the sulphur of bodies torrified, that is the oylie fat...[9]

The apparent confusion of Sir Thomas's views on the nature of matter

[5] Enquiries into *Vulgar and Common Errors* Bk. II Chap. I (K II, 90). This work will now be referred to as *Vulgar Errors.*
[6] *Religio Medici* Part I Section 50 (K I, 62).
[7] *Vulgar Errors* Bk. VI Chap. 12 (K I, 254).
[8] *Vulgar Errors* Bk. VI Ch. 10 (K III, 231).
[9] *Vulgar Errors* Bk. VI Ch. 12 (K III, 249).

is illusory. The quotations referring to the four-element theory are found in his earliest writings, the *Religio Medici* having been written and published in manuscript in 1635, and the *Vulgar Errors* written in 1645. The latter work was continually edited and added to until 1672, and it will be observed that the quoted references to newer theories of matter are found in the later books of that work. We may conclude, therefore, that the records show a gradual change of Browne's own views as he leaves behind him the views of the classical writers and encounters scientific men who are in touch with the European developments of the time. Certainly his views were in process of change in 1646, because after first adding, he later removed the words:

> ... So Iron ... consisting of impure Mercury and combust sulphur ...[10]

– in preparing a second edition of the *Vulgar Errors*.

If the nature of matter were a chief interest of late mediaeval renaissance thinkers, so were the problems of combustion and respiration. Indeed, some of the critical issues in both studies were investigated by Robert Boyle and John Mayow in the early years of the Royal Society. Sir Thomas Browne again shows in his works a gradual change of views. Possibly this was due to the influence of these two scientists and to the Society itself, whose transactions Sir Thomas received, at any rate for many years.[11] In 1946, when the *Vulgar Errors* appeared, he regarded combustion as the breaking loose from bodies of the 'sulphurous' principle. Air functioned merely to absorb the resulting fumes:

> For that which substantially maintaineth the fire is the combustible matter in the kindled body, and not the ambient air, which affordeth exhalation to its fuliginous atoms ...[12]

When the flame, in an enclosed volume of air, died down and went out, it was due to the fact that:

> The fuliginous exhalations ... recoil upon the flame and choak it.[13]

Respiration, for Sir Thomas, was not combustion, or anything like it, but rather a refrigerating, or ventilating process, as was believed by Galen. Thus:

> The use of air ... is not the nutrition of parts, but the contemperation

[10] *Additional passages* (K III, 335).
[11] Letter to Edward Browne 1668 (12th December) (K VI, 43).
[12] *Vulgar Errors* Bk. III Chap. 21 (K II, 263).
[13] Ibid.
[14] Ibid (K II, 262).

and ventilation of that fire always maintained in the forge of life...[14]

In 1668, in a letter to his son,[15] Sir Thomas refers to having seen Mayow's book *De Respiratione*... and Boyle's *New Experiments Concerning the Spring and Weight of the Air.* These publications evidently caused him to revise, though somewhat cautiously, his former theories, for in the 1672 edition of *Vulgar Errors* the following words are inserted:

> And though the air... by its *nitrous spirit,* doeth affect the heart, and several ways qualify the blood...[16]

He is clearly beginning to accept the idea that air is not merely an inert solvent for the 'volatile sulphur' of bodies but that it contains a vital ingredient. Nevertheless, the theory is not completely accepted. Although as Merton[17] points out, Sir Thomas conceives of the solution of iron in 'aqua fortis' as the combination of the Sulphur of the element with the nitrous spirits in the aqua fortis,[18] yet the increase in weight of antimony on burning, in the famous experiment of Hamerus Poppius, is explained in terms of the 'imbibing of the humidity' of the air, which more than makes up for the 'expected' (!) loss in weight of the metal.[19] This statement is allowed to remain in all subsequent editions, in spite of its obvious incompatibility with the then established mechanism of combustion.

It is curious that though Sir Thomas is prepared to continue in ignorance of the fact that metals gain in weight on burning, he stresses the use of the balance in chemical operations. In his general note-book we find in one place this reminder:

> ... Take a strict account by wayght in Chymicall operations...[20]

and elsewhere he notes:

> ... nor is it to be taken strictly which is delivered by the learned Lord Verulam ... that a dissolution of iron in aqua fortis, will bear as good weight as their bodies did before, notwithstanding a great deal of wast by the thick vapour that issueth ... for we cannot find it to hold neither in Iron nor Copper ... and hereof we made trial in Scales of good exactness...[21]

[15] K VI, 43.
[16] *Vulgar Errors* Bk, III Chap. 21 (K II, pp, 262, 313) Italics mine.
[17] *Osiris* 10, p. 206 (1952).
[18] Vulgar Errors Bk. II Chap. 5 (K II, 152).
[19] Ibid. Bk. IV Chap. 7 (K III, 37).
[20] Misc. Writings (K V, 333).
[21] Vulgar Errors Bk. IV Chap. 7 (K II, 36).

It was during the course of the seventeenth century that the old 'science' of Alchemy virtually disappeared. Individual alchemists could be found, it is true, during the eighteenth and even the nineteenth centuries, but they had no longer any 'raison d'etre', as a result of the work of men like Boyle, and had not realised that the game was lost long before they began to play. There is no doubt that Sir Thomas Browne was both interested in, and credulous of, Alchemy. When writing to his son Edward, on tour in Europe, he enquired after:

> ... Dr. Helvetius, who writ *Vitulus Aureus* and saw projection made and had pieces of gold to showe of it...[22]

and informed his son, while the latter was in Vienna, that

> ... among the Emperours Rarities, severall conversions there are of basser metall into gold.[23]

Among his acquaintances Sir Thomas numbered Dr. Arthur Dee, son of the famous Dr. John Dee, who claimed to have been helped to escape from prison by Queen Elizabeth I on account of his reputed ability to transmute base metals into gold.[23] Another friend of alchemical persuasion was Sir Robert Paston, who consulted Sir Thomas on matters relating to the subject in a series of letters.[24] In spite of these things, and the fact that Sir Thomas himself owned a small collection[25] of alchemical books and pamphlets, there is not the slightest evidence in any of his surviving books or papers that he ever tried the 'great experiment' of transmutation himself, or had seen it done. It seems likely that he was so interested in the chemical aspects of disease and of medical treatment that he would prefer to be classed with the iatro-chemists rather than the alchemists. Indeed, in a letter of advice to Dr. Henry Power he writes:

> ... Be not a stranger to the *useful* part of chymistry. See what chymistators *do* in their officines. See chymical operations *in hospitals* and in private houses.[26]

This view is supported by the correspondence with Sir Robert Paston[24]

[22] Letter to Edward Browne at Frankfurt 1668 (K VI, 34).
Projection was the term given to the final stage of transmutation of base metals into gold.
[23] Letters to Mr. Elias Ashmole (K VI, 321-326).
[24] Letters from Sir Robert Paston. These are not included in the Keynes edition but are found in Volume III of the earlier Wilkin edition.
[25] Letters (K VI, 322-323).
[26] Letter to Dr. Henry Power (K VI, 277) Italics mine.

in which the chief matter concerns the preparation of the medicinal 'aurum potabile', the iatrochemists' 'philosophers stone'. Paston, unlike Sir Thomas, seems to be interested in the 'aurum potabile' mainly as a stepping stone to transmutation, for he quotes Sendivogius:

> That which will dissolve gold as water does ice ... is that out of which gold was first made in the earth.[24]

The extraordinary variety of Sir Thomas Browne's experimental work, especially in connection with the products of plants and the preparation of medicines, is seen in his general note books. The more formal works, like the *Pseudodoxia* and *Religio Medici,* and even his correspondence, do not lead one to believe that he troubled unduly about experimental chemistry. The miscellaneous writings and the commonplace books tell an entirely different story. Between his settling in Norwich and his death in 1682 there was clearly a great deal of experimental investigation, the reports of which were never published in his lifetime.

The preparation of lunar caustic (silver nitrate)[27] and of infusion of vitrum Antimonii (antimony oxide and sulphide)[28] are described with rather careful detail. These would, of course, be standard methods of preparation, but it is of interest that the details which he gives are so very clear and uncluttered with imagery and mythology. It is evident that the methods described have really been used by the author himself. The same can be said of all other references to experimental work in Browne's notebooks. He was a careful and discriminating experimentalist, ready to turn his abilities towards anything new or interesting.

Tobacco had been brought to England in 1586 by Sir Walter Raleigh, and, although it was still something of a curiosity even in Browne's time, he carried out a chemical investigation of it.[29] He correctly identified the presence in the smoke of a narcotic principle (to be identified much later as an alkaloid, nicotine), and comments as follows:

> ... [tobacco] containeth 3 eminent qualities, sudorific, narcotick and purgative. The narcotick depends on 'humorum impurum', for the vapour thereof contains it and the burnt part looseth it, as in opium.

Another example of Sir Thomas Browne's chemical opportunism was the investigation of the properties of spermaceti in the early 1640's. It happened that a large dead whale, some sixty feet long, was cast upon the coast of Norfolk, near Wells. As the whale putrified, the oil and sper-

[27] Misc. Writings (K V, 234).
[28] Ibid. (K V, 332).
[29] Ibid (K V, 356).

maceti were liberated, and were collected for examination by Sir Thomas.[30] He was able to free some specimens from the whale-oil with which they were contaminated, and to examine them in his laboratory. The expressed whale oil clearly had dissolved some of the spermaceti, for he writes:

> ... it seems different from the oyle of any other animal, and very much frustrated the expectation of our soap boylers, as not incorporating or mixing with their lyes. But it mixeth well with painting colours, though hardly drieth at all. It may prove of good medical use ... in compounded oyls and Balsam ...[31]

His further enquiries into the anatomy of the creature, and the possible occurrence of ambergris in its stomach, were frustrated by the rapid decomposition of the flesh. 'Insufferable fetour' discouraged the enquiry.

Many of Browne's chemical investigations were suggested by his less scientific interests. For example, he undertook to consider, in one of the chapters of the *Pseudodoxia,* the causes of the blackness of the skin of negroes. From this he was led into a very careful investigation of the nature of ink. Blackness, he considered, might be derived from

> ... an atramentous condition ... that is a vitriolate or copperose quality conjoining with a terrestrious and astringent humidity; for so is 'Atramentum Scriptorium', or writing Ink commonly made by copperose cast upon a decoction or infusion of galls.[32]

The investigation throws interesting light on the methods used then in ink manufacture. Neither alum, nor nitre [potassium nitrate] nor ammoniak [ammonium chloride] had the same effect as copperas, but Browne strangely seems to conclude that it is the vitriolate part of the copperas rather than the iron, which gives rise to the black coloration. Even the description of the process given, that the 'artificial copperose' (which must have contained copper as well as iron, and therefore to have been made from crude pyrites) is first treated with pieces of iron for better effect, does not seem to Browne to be significant. We would nowadays explain the effect of adding iron as the conversion of the (ineffective) copper sulphate into the useful iron sulphate, with the precipitation of copper, an experiment that most schoolboys have frequently performed on copper

[30] Vulgar Errors Bk. III, Chap. 26 (K II, 228).

[31] Ibid., p. 289. The oil of the whale would itself mix with the caustic lyes of the soap boilers, but the dissolved spermaceti would be left uncombined. Whale oil is not a 'drying oil' and would not harden on exposure to air.

[32] Vulgar Errors, Bk. VI, Chap. 12 (K III, 254). Copperas is ferrous sulphate, which gives a black ink with the extract of galls. Ferrous sulphate is a combination of iron with sulphuric acid (vitriol).

sulphate with the blade of pocket knife.

Nevertheless, Sir Thomas carried out various experiments which showed that the iron of copperas certainly communicated 'something' to the vitriol, because the oil of vitriol distilled from copperas, leaving the iron behind, gave no black colour when treated with galls. What is fascinating is the way in which, armed with a considerable body of useful and accurate practical data, Sir Thomas goes completely astray in his theorising, concluding that the colours of negroes, as well as that of cuttlefish ink,[33] arise from 'vitriolic' qualities present in the earth, in plants and in animals. His errors are not chemical, but logical, ones and it is gratifying to read at the end of his account that

> ... although in this long journey we miss the intended end, yet are there many things of truth disclosed by the way.[34]

One aspect of Sir Thomas Browne's scientific thought has not been mentioned. He did not clearly distinguish in his mind the organic from the inorganic, the animate from the inanimate. The distinction was to be made by others later on, far too sharply, as in the theories of Stahl, but one might have expected Browne to anticipate Stahl. The point of view of Sir Thomas is best seen in some of his writings dealing with crystallisation and with water. Crystallisation is seen by him as a growing process, like that of plants, and his ideas are admirably illustrated by the following:

> ... make a ... solution of sal ammoniak and let it exhale ... at the bottom will remain woods and rows of filicular shaped plants ...[35]

Again, when speaking of the regularity and pattern to be seen in the structure of flowers, he adds:

> from the like disposure of the subtle veynes... of stones arise these various lineare figures as in lapis cruciger...

In this treatise on coagulation, he writes even more fully of a supposed analogy or correspondence between crystalline bodies and plants. Thus:

> ... most congelations ... carry in theire surface a leaf of one figure, which somewhat representeth the leaf of a ferne or brake, from a middle and long rib spreading forth jagged leaves. Soe a lixivium of nett-

[33] Ibid., p. 253.
[34] Ibid., p. 255.
[35] Miscellaneous Writings (K V, 353).
[36] Ibid., p. 353.

> les ... will shoot in the same shapes. ... The shootings in the gellies of flesh carry smaller branches and twiggs without that exact distinction of leaves.[37]

Sometimes indeed, the solids formed by evaporation of liquids are in the shape of 'corralline mosses of the sea, arising from a root.[37]

It seems likely that this attitude towards inorganic, inanimate, crystals is prompted by Sir Thomas's very clear notion that the water from which they are crystallised contains 'a seminall principle' which permits it to generate living organisms on storage. He seems to hold that the 'spirits' of plants and animals which die pass into the earth, are extracted upwards from it by the sun, and then fall in the rain, so that seeds can be animated by these 'spiritual principles' and a new cycle of life begin. In this belief he seems close to Paracelsus and to Van Helmont. For instance, he writes, in his *Notes on Natural History,* as follows:

> ... That water is the principle of all things, some conceave; that all things are convertible unto water, others probablie argue; that many things which seeme of earthly principles were made out of water the Scripture testifieth in the genealogy of the foules of the ayre. Most insects owe their originall thereto, most being made of dewes, froaths or water. Even rayne water which seemeth simple, contains the seminalls of animals ...[38]

and in his *Notes on Coagulation:*

> Rayne water wh[ich] containeth seminall atoms elevated by exhalations, making the earth fruitfull where it falleth ... snow water will also doe it as containing these seeds and salt nitrous coagulum ...[39]

Belief in 'spontaneous generation' of animals and plants from water alone persisted down to the early years of the eighteenth century, and this is not surprising when one reflects how short a time the microscope had been known. Without it, the world of bacteria and moulds, and the nature of fertilisation processes had to remain unknown. In such a situation it seems reasonable enough that Sir Thomas Browne should see in the ability of water to 'generate' animals and plants and to produce, through what we call crystallisation, the plant-forms of salts, evidence of a ubiquitous generative spirit.

What must our judgement of this man be? It is true that he was steeped in knowledge of the ancients; to study his books is to wonder at the

[37] Miscellaneous Writings, (K V, 427-428).
[38] Miscellaneous Writings (K V, 334).
[39] Miscellaneous Writings (K V, 427).

breadth of his reading. It is equally true that he was independent of them, thinking his own thoughts and ever ready, if need be, to disagree with his authorities. He was no bigot, being prepared to consider and reconsider his views as time passed, an attitude evidenced by the frequent corrections and amendments of his more famous works, as they passed from one edition to another. So, in one place he writes:

> ... I could never divide myself from any man upon the difference of an opinion, or be angry with his judgement for not agreeing with me in that from which perhaps in a few days I should dissent myself ...[40]

One may speculate about the reason why he never became a member of the Royal Society, for his work was of a standard well capable of justifying his election. Possibly, had he exerted himself in the matter, or made more public his experimental work, it would have made some difference. As it turned out, he saw his son Edward become a member of that august Society while he himself remained outside of it, an interested spectator of its affairs, but never a participant. There is no indication that he ever complained of this, or felt himself slighted, for he was a modest man, seeking neither public recognition in his lifetime nor a memorial after it, and being as 'content with six foot as the Moles of Adrianus'.

[40] Religi Medici (K I, 9).