ANNOTATIONS TO BOYLE'S *"THE SCEPTICAL CHYMIST"*

by

John S. Davidson

PREFACE TO ANNOTATIONS

When *The Sceptical Chymist* first appeared in Everyman's Library in 1911 it would have been comprehensible to any educated person who had studied chemistry. At that time many of the older chemical names were still mentioned in textbooks. Names such as *aqua fortis, copperas*, and *litharge* were still sometimes used. However as these names now mean nothing to most younger chemists, a modern student could not read 'The Sceptical Chymist' with understanding without some help. It is hoped that the accompanying annotations will provide the assistance required.

Firstly, there is an index of the names of the scientists mentioned by Boyle. As many of the names may not be familiar to the modern reader, there are brief biographical notes and reference is given when possible to English editions of their books.

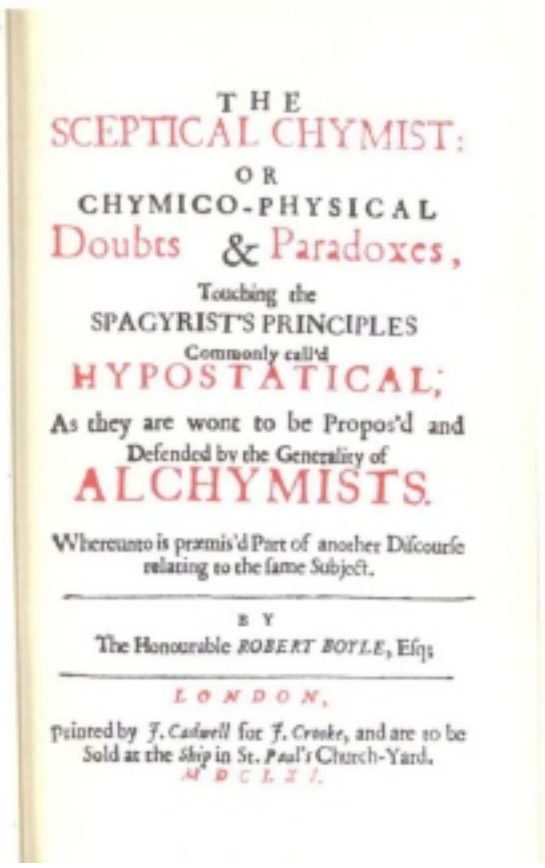
Secondly there is an index of substances giving both the old names which Boyle used and modern chemical names.

Lastly, there are notes, using modern chemical names and formulae, to clarify the experiments which Boyle describes. As a knowledge of Latin is less general than it used to be, translations are given of some of the Latin passages quoted by Boyle. In some cases, use has been made of translations which were published in the 17th century.

The Sceptical Chymist was published, in London, 1661, and in Oxford, 1680. Latin editions were printed at Geneva, 1677, and Rotterdam, 1679. At least seven appeared between 1662 and 1692. The next English edition was the Everyman (No. 559) edition of 1911. An abridged translation of the Everyman edition appeared in German in 1929 as in ***Ostwald's Klassiker der Exacten Wissenschaften*** (No. 229). ***Der Skeptische Chemiker.*** In 1964 Everyman brought out another edition with an introduction by E. A. Moelwyn-Hughes.

John S. Davidson
June, 2001

[A correlation of the page numbers in the Everyman and 1661 editions appears at the end of this document.]



THE
SCEPTICAL CHYMIST:
OR
CHYMICO-PHYSICAL
Doubts & Paradoxes,
Touching the
SPAGYRIST'S PRINCIPLES
Commonly call'd
HYPOSTATICAL;
As they are wont to be Propos'd and
Defended by the Generality of
ALCHYMISTS.
Whereunto is præmis'd Part of another Discourse
relating to the same Subject.
BY
The Honourable ROBERT BOYLE, Esq;
LONDON,
printed by J. Cadwell for J. Crooke, and are to be
Sold at the Ship in St. Paul's Church-Yard.
MDCLXI.

Introduction to "Annotations..."

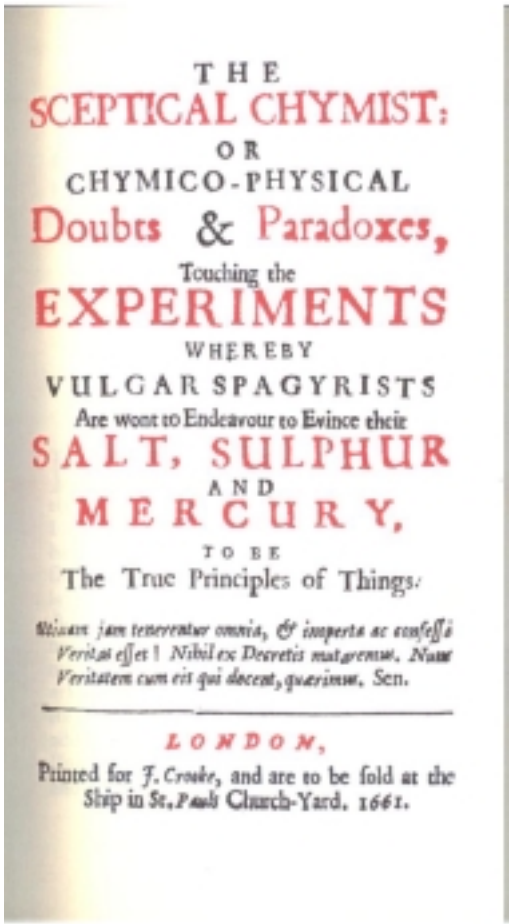
Robert Boyle and his "Sceptical Chymist"

The publication of The Sceptical Chymist, in 1661, was a landmark in the history of chemistry. Its contents can only be understood in the context of the scientific climate of the 17th century. The physicists, Boyle called them "hermetick philosophers", upheld the Peripatetical or Aristotelian doctrine of the four elements – fire, air, earth, and water. The chemists, "vulgar spagyrists", were disciples of Paracelsus who believed in the *tria prima* – salt, sulphur, and mercury. Boyle showed that these theories were totally inadequate to explain chemistry and was the first to give a satisfactory definition of an element. Boyle has been called "The father of chemistry and the brother of the earl of Cork". Several Latin editions of The Sceptical Chymist appeared, and another English edition, in 1680. Although it is found in some 18th century editions of Boyle's works, the next English edition was the Everyman (No. 559) edition of 1911. An abridged German translation of the Everyman edition was published in 1929 in Ostwald's Klassiker der Exacten Wissenschaften (No. 229), entitled Der Skeptische Chemiker. Everyman reprinted the book with an introduction by E.A. Moelwyn-Hughes.

In the first half of the 20th century The Sceptical Chymist would have been comprehensible to anyone who had studied chemistry. Many old names such as *aqua fortis*, *copperas*, and *litharge* were still sometimes used. However, as these names mean nothing to most younger chemists, a modern student would benefit from some help. Therefore, I have prepared some Annotations giving brief biographical notes about some of the scientists mentioned by Boyle, an index giving both the names Boyle used and modern chemical names, and lastly, notes using modern chemical names and formulae to clarify the experiments which Boyle describes. As a knowledge of Latin is less general than it used to be, translations are given of some of the Latin passages quoted by Boyle.

Although the Everyman edition has been out of print for some years, copies are still found in libraries and second hand bookshops. However, a reprint of the 1661 edition is in print, ISBN 0-922802-90-4, by Kessinger Publishing LLC, priced at $36. Although it is described as a facsimile, the page and print size are larger than in the original, and some of the wording is in red in the original 1661 edition.

John S. Davidson, CChem FRSC



THE
SCEPTICAL CHYMIST:
OR
CHYMICO-PHYSICAL
Doubts & Paradoxes,
Touching the
EXPERIMENTS
WHEREBY
VULGAR SPAGYRISTS
Are wont to Endeavour to Evince their
SALT, SULPHUR
AND
MERCURY,
TO BE
The True Principles of Things.
Etiam jam tenerentur omnia, & inperta ac confessa
Veritas esset? Nihil ex Decretis mutaremus. Nunc
Veritatem cum eis qui docent, quærimus. Sen.
LONDON,
Printed for J. Crooke, and are to be sold at the
Ship in St. Pauls Church-Yard. 1661.

ANNOTATED INDEX OF NAMES

Name Page(s)

Acosta, Joseph (c.1539-1600) 198
Spanish author, joined the Jesuits in 1551 and in 1571 was sent out as a missionary to Peru. In 1598 he became rector of the Jesuit College at Salamanca. His *Historia naturel y moral de las Indias*, (Seville 1590) was translated into the main European languages. The English edition appeared in 1604.

Agricola, Georg (1490-1555) 43, 191
Georg Bauer, latinised Agricola, was born at Glauchau in Saxony. He studied medicine, physics, and chemistry at Leipzig, visited Italy, where he took the degree of Doctor of Medicine, and settled at Joachimsthal as physician among the miners. His *De Re Metallica* is of much interest to chemists as it includes assaying and the preparation of chemical (Herbert Hoover translated it into English in 1912). Agricola died at Chemnitz.

Agricola, Johann (b. 1590) 193,209
Johann Agricola was born in the Palatinate, travelled much, was a distinguished surgeon and physician, had a practise at Leipzig and was a strong supporter of Paracelsus and chemical remedies.

Agrippa, Menenius Lanatus 106
Roman consul 503 B.C. He related to the plebeians his fable of the belly and its members to achieve a peaceful termination of the first rupture between the patricians and the plebeians.

Aristotle (384-322 B.C) 18,19,22,27,79,84,194,213
The Greek philosopher, a pupil of Plato. At the Lyceum, in Athens, he delivered his lectures on philosophy while walking about so those who advocated his theory of the four elements (earth, air, fire, and water) became known as “Peripatetics”.

Bacon, Roger (c.1214-1292) 100
An English philosopher and man of science who wrote several alchemical treatises. He was, perhaps, the greatest scientist of his time, the first to use the inductive method, that is reasoning based on observation and experiment. His *Opus Majus* was the Encyclopædia and Organon of the 13th century.

Barthius 181
Jerimias Barth was a pupil at whose instigation Beguin wrote *Tyrocinium Chymicum*. In 1618 Barth published an edition of the *Tyrocinium* under the title *Secreta Spagyrica*. He was a native of Silesia.

Beguinus 127,128,131,146,160,170,181
Jean Beguin (c. 1550-c. 1620), a native of Lorraine, opened a school of chemistry in Paris and gave the first public lectures on the subject. About 50 editions of his book *Tyrocinium Chymicum* were published between 1610 and 1690. The first French edition appeared in 1615. The English edition of the *Tyrocinium Chymicum* was published in London in 1669 (see J. S. Davidson, *J. Chem. Educ.*, 1985, **62**, 751).

Billich 46,170,171

Anton Günther Billichius was a native of East Friesland , born in the latter half of the 16th century. He studied medicine under Arnissaeus at Helmstadt, practised at Jever and was private physician to the court of Oldenburg. He defended his father-in-law, Angelus Sala, from some attacks, and he had a controversy with Peter Lauremberg. He was a good chemist and a clear expounder of facts and principles for which he is recommended. He wrote several books including *Thessalus in Chymicus Redivivis* (1640).

Boccaccio, Giovanni (1313-1375) 192

An Italian author, whose family came from Certaldo in Tuscany, best known for his *Decameron*.

Boyle, Robert (1627-1691) 50, 64, 103, 139, 176

Readers wanting to know more about the author of *The Sceptical Chymist* might read *Robert Boyle Father of Chymistry* by Roger Pilkington (London 1959), which refers to several earlier biographies. (see also Bibliography p. xxii).

Carneades 1, 4-8, 12-19, 24-27, 29, et seq.

Boyle names this character after the sceptic philosopher (b. circa 231 B.C.) who founded the New Academy at Athens. His function in the discussion was not to prove how many elements (or qualities) exist but merely to show that the belief in the four Aristotelian elements, and the three principles of Paracelsus, is not based on experimental evidence.

Cesalpinus (1519-1603) 191

Andreas Caesalpinus was born in Arezzo in Tuscany, studied medicine at Pisa, and became professor of material medica and director of the botanical garden, one of the earliest devoted to the public study of botany. His most famous book *De plantis librisXVI* (Florence 1583) influenced botanical science for over 100 years. Other books included *De Metallicis* (1596).In 1592 he moved to Rome, as physician to Pope Clement VIII, where he died in 1603.

Claveus 39, 149, 150

Gaston Duclo, Latinised to Claveus, was born in the Nivernais (c. 1530). He studied law and was an advocate at Nevers, but seems, from an early age, to have been also interested in chemistry. Having read Erastus' attack on Paracelsus, he wrote the *Apologia* at Nevers in 1590.

Clave, Estienne de

Clave, not to be confused with Claveus, taught chemistry at the Jardin de Roi in Paris. He wrote a textbook *Cours de Chimie* (1646) and also a theoretical treatise *Nouvelle lumiere philosophique des vrais principes et elemens de nature, et qualité d'iceaux. Contre l'opinion commune* (8^o Paris 1641) which is of interest as it gives a definition of an element 20 years before the publication of Boyle's definition. Estienne de Clave's book Ch. vii, p. 39 reads:-"Pour verifer ce que dessus, nous disons avec les Perepateticiens que les elemens sont corps simples, qui entrent premierement en la composition des mixtes, & auquels ces mixtes se resoluent, ou se peuuent resoudre finalement."

Democritus (c. 460 B.C. – 361 B.C.) 71
A Greek philosopher, born at Abdera, in Thrace, about 460 B.C. His knowledge embraced natural sciences, mathematics, grammar, music and philosophy. He developed the atomic theory, which Leucippus had founded.

De Rochas (see Rochas) 72, 188

Diogenes 70
Diogenes Laertius probably lived in the second century. He wrote an uncritical, but valuable, work *Lives of the Philosophers*, which was translated into English by R. D. Hicks.

Eleutherius 1, 12, 13, 15, 17, 21, 26, *et seq.*
A synonym for Zeus, the greatest of the Greek gods (The Roman god Jupiter). Eleutherius acts as the nonpartisan chairman of the discussion in Carneades' Garden. (See *Am. J. Pharm.*, 1932, 104 [12]).

Epicurus (342 B.C.-270 B.C.) 30
A Greek philosopher who founded a philosophical school in Athens. He taught that virtue should be practised because it leads to happiness. In the physical part of his philosophy he followed the atomistic doctrines of Democritus and Diagoras.

Fallopius (1523-1562) 191
Gabriello Fallopio was born at Modena. He studied medicine at Ferrrara. He is best known for his contributions to anatomy.

Galen (130-199) 192
Claudius Galenus was born at Pergamum where he first studied medicine, later he studied at Smyrna, Corinth, and Alexandria. Next to Hyppocrates, he was the most celebrated of the ancient physicians and attended the emperors M. Aurelius and L. Verus. He wrote many works on medical and philosophical subjects. Vegetable remedies are still referred to as galenicals.

Gerhardus 191
Johann Conrad Gerhard was professor at Tübingen and four times rector. He flourished in the earlier part of the 17th century.

Günther (see Billich) 46, 170, 171

Helmont, Johann Baptista van (1577-1644) 5, 42, 68, 72, 79, 100, 104, 118, 125, 126, 140, 144, 162, 181, 184, 186, 189, 202, 207, 213, 214, 220, 226
Johann Baptista van Helmont (1577-1644), born in Brussels, studied at Louvain. He was one of the great experimentalists of the 17th century. Boyle was much influenced by him and constantly quotes him as an authority. Helmont was the first to realise the importance of the production of gas in chemical processes.

Hesiod 71
An early Greek poet who lived around 735 B.C. His *Theogony* gives an account of the origin of the world and the birth of the gods.

Hippocrates (c.460 B.C. – c.357 B.C.) 77
The famous physician was born on the island of Cos. He wrote, taught,and practised his profession there. His best known work is his *Aphorisms*. The first is justly famous, "Life is short and art is long; the occasion fleeting, experience deceitful, and judgement difficult."

Homer 70
The great epic poet of Greece. He probably lived around 850 B.C. and is best known for his *Iliad*, which deals with the siege of Troy, and the *Odyssey*, which tells of Ulysses' return to Greece.

Justin Martyr 70
A Christian writer of the 2nd century who was martyred during the reign of Antoninus Pius.

Laertius Diogenes (see Diogenes) 70

Laurembergius, Petrus 75
Peter Lauremberg (b. c. 1575) and his brother Wilhelm were German naturalists.

Leucippus 13, 71, 120
The Greek philosopher who founded the atomic theory of philosophy which was developed by Democritus. His date is uncertain.

Libavius (1540- 1616) 147
Andreas Libavius was born at Halle, Saxony. He graduated doctor of medicine and in1588 became professor of history and poetry at Jena. In 1591 he was a teacher at Rothenburg-ob-der-Tauber and, in1607, became director of the gymnasium at Colberg where he died, He was an enthusiastic chemist but not a blind follower of Paracelsus, of moderate and independent views. He carried on controversies with both Paracelsists and Galenists. He was among the first to describe chemical actions in plain language and his *Alchymia* (1597) has been regarded as the first real textbook of chemistry. Beguin used parts of it in his *Tyrocinium Chymicum*. Libavius attempted the analysis of mineral waters and discovered several substances. Stannic Chloride, $SnCl_4$, was known as "Libavius's fuming liquor."

Linschoten, Jan Hugo van (1563-1611) 190
Linschoten was a Dutchman who travelled in the East Indies. He published an account of his voyages in Dutch in 1591 (English translation published in 1598).

Lucretius (c.98-55 B.C.) 199
Titus Lucretius Carus, one of the greatest Roman poets. He expounds the doctrine of Epicurus in his book *De Rerum Natura.* See Everyman (no. 750) or *The Nature of the Universe* (Penguin Classics 1951).

Lully, Raymond (c. 1232-1315) 113,129
A native of Palma in Majorca. He founded a monastery of Franciscans. Books on chemistry ascribed to him are probably by other authors.

Moschus 71
Moschus of Syracuse was a poet who lived about 250 B.C.

Moses 71
Boyle refers to Genesis. In the literature of alchemy, medieval writings were often said to have been written by Moses or other Biblical characters.

Muir, M. M. Pattison (1848-1931) xxi
Muir studied at the universities of Glasgow and Tübingen. He taught at Glasgow and Manchester before becoming Praelector in chemistry and a Fellow of Gonville and Caius College, Cambridge. He wrote *The Alchemical Essence and the Chemical Element* (London 1894). For his obituary see ***J. Chem. Soc.,*** 1932, 1330-1334 .

Orpheus 71
A mythical personage regarded by the Greeks as the most celebrated poet before Homer.

Paracelsus (1493-1541) 18, 22, 48, 113, 130, 146, 151, 162, 169, 176, 184, 186, 220
Theophrastus Bombastus Von Hohenheim was born in Switzerland and became a Professor of Medicine at Basle. He founded "Iatrochemistry". Essentially a reformer in medicine, he introduced metallic remedies, mostly compounds of mercury, used to treat syphilis, which had resisted treatment by all the old vegetable remedies. In theory, he believed in the four elements but he thought that they appeared in bodies as the *tria prima* (three principles). Salt was the principle of fixity and incombustibility, mercury of fusibility and volatility, and sulphur of flammability. He died at Salzburg where his tomb can be seen in St. Sebastian's church.

Philiponus 12, 17, 22, 23-25, 93, 154, 173, 227
The "chymist" or follower of Paracelsus argues the case for the *tria prima*.

Platerus (1536-1614) 181
Felix Platter, son of Thomas Platter (the elder), who was a schoolmaster at Basel, studied medicine at Montpellier and then returned to Basel where he became a distinguished physician, professor, and rector of the university. An English translation of his journal *Beloved Son Felix* (London 1961) should be consulted for further information.

Pliny (23-79) 191
C. Plinius Secundus, Pliny the Elder, was born in Northern Italy. He spent much of his time in study and is best known for his *Historia Naturalis.* His interest in the eruption of Vesuvius in 79 A.D. cost him his life.

Plutarch 70
A Greek biographer and philosopher. His *Moralia* is Everyman (no. 565).

Poppius 193
A physician and chemist who flourished at the beginning of the 17th century.

Porta, Giambattista della (1535-1615) 182
Porta, a Neapolitan, acquired a great reputation through his *Natural Magick* (a reprint of the English Edition has been published by Basic Books, New York 1957). He also

wrote a book on distillation and other works, including some plays. He and his associates founded, perhaps, the first modern scientific society.

Quercetanus (c. 1544-1609) 146
Joseph Du Chesne, latinised as Quercetanus, was born in Gascony, graduated at Basel c.1573. In 1593 he went to Paris and became physician in ordinary to Henry IV. As a chemist he was disliked by the Galenic physicians of Paris.

Rochas 72, 188
Henry De Rochas, sieur d'Ayrglun, was the son of a man Henry IV made General of the mines of Provence. He lived in the early part of the 17th century in Paris, was councillor and physician to the king, and wrote some books on medicine and mineral waters.

Rondelatus (1507-1566) 214
Guillaume Rondelet of Montpellier is noted for his painstaking investigation of the fishes of the Mediterranean.

Sala (1576-1637) 101, 153
Angelo Sala was born in Vicenza. Physician to the Duke of Mecklenberg at Güstrow. He advocated chemical remedies and appears to have judged fairly the merits of the chemical and Galenical systems of medicine, then in conflict. He ridiculed transmutation and the universal medicine, objected to the name of oil being given to tartar which had deliquesced, observed that metals have different affinities for acids, that sulphur took something from the air in order to burn, and described new substances and methods of preparation.

Schreterus 192

Sennertus 79, 100, 130, 147, 164, 166, 170, 176, 177
Daniel Sennertus was born at Breslau (Wroclaw) in 1572, graduated at Wittenberg, and became professor of medicine there. He was the first to introduce chemistry as a subject in the medical curriculum and he attempted, unsuccessfully, to harmonise the views of the chemists with those of the Peripateticks and Galenists.

Solomon 227

Strabo (64.B.C.-24 A.D.) 71
Wrote a historical work which is lost. His *Geographia* is extant and has been published in English.

Suchten 150
Alexander von Suchten flourished in the latter half of the 16th century. He lived in Danzig (Gdansk) and was a poet and chemist. An English translation of his book *On the Secrets of Antimony* was published in 1670.

Thales (c.636-546 B.C.) 70, 75
Thales of Miletus was one of the founders of the study of mathematics and philosophy in Greece. He became famous by his prediction of the eclipse of the sun of 28th May,

585 B.C. Thales maintained that water is the origin of all things, meaning that it is out of water that everything arises, and into which everything resolves itself.

Themistius 12, 16, 17, 21-27, 114, 171, 173, 213
Themistius followed the Aristotelian doctrine of the four elements. He would have preferred to argue from logic rather than being held to experimental evidence. Boyle named his character after a philosopher who lived in Constantinople in the 4th century A.D.

Tully (1620-1676) 70
Thomas Tully was a controversial English divine.

Valehius, Johannes 192
Johannes Walch or Walchius of Schorndorff wrote a commentary on the anonymous tract *Der Kleine Bauer* which is ascribed to Johann Grasshoff. Walch may be a pseudonym for Grasshoff, a native of Pomerania, doctor of laws, Syndic of Stralsund, and later councillor of Ernest, archbishop and elector of Cologne. He died in1623.

Van Suchten (see Suchten) 150

Van Helmont (see Helmont)

Vulcan 27
The Roman god of fire

Zeno 71
The founder of the Stoic philosophy.

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More information about early chemists and alchemists can be gleaned from: John Ferguson, *Bibliotheca Chemica*, 2 vols., Glasgow, 1906, which is a catalogue of the Young Collection at Strathclyde University. Kessinger Publishing offer an edition of *Bibliotheca Chemica*, ISBN 1-56459-001-1, $75.00 .

Glasgow University Library has the Ferguson Collection, which includes many of the books by the authors cited by Boyle in ***The Sceptical Chymist***.

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Index of substances

ANNOTATIONS

p. XIX The definition given is not the definition of an element but of a compound. See Pattison Muir, *The Alchemical Essence and the Chemical Element.* (London 1894) p32-33 which is still quite readable.

INTRODUCTORY PREFACE TO THE FOLLOWING TREATISE

p. 1 The Peripatetical or Aristotelian doctrine arose from Greek philosophy. Thales (640-546 B.C.) supposed all things were formed of water (see p 70, 75), Anaximines (560-500 B.C.) of air, Herkleitos (536-470 B.C.) of fire. Empedocles (490-430 B.C.) introduced the idea of four 'roots' of things, fire, air, earth and water, and two forces attraction and repulsion which separated them. Aristotle developed these ideas. His elements are really properties of matter. Thus fire is associated with hotness and dryness, air with hotness and moistness, water with coldness and moistness and earth with coldness and dryness. The properties of any substance were supposed to depend on the quantities of each element which it contained.
The chymical doctrine, was advocated by Paracelsus and the Spagyrists, who believed in *tria prima* (three principles) salt, sulphur and mercury. They were not, however simply the substances which bear these names today. Salt was the principle of fixity and incombustibility (see p. 100, p. 151) , mercury of fusibility and volatility, and sulphur of flammability. So anything that burned was sulphur and different substances afforded different sulphurs, mercuries and salts (see p. 151).
These views may seem strange, even unintelligible to us but, even in the 17th century, they were still believed by some of the best brains of the time. Boyle, in *The Sceptical Chymist (1661, & 1680)* attempted to show that they had become untenable.

p. 3 Ubi palam locuti fumas , ibi nihil diximus.
'Where smoke has spoken openly, there we say nothing'

p. 7 Cicero wrote *De Natura Deorum* in 77 B.C.

p.9 Spagyrist — One who holds the chymical doctrine of the *tria prima*

PHYSIOLOGICAL CONSIDERATIONS

p. 24 In the fire the gold remains unchanged but the lead is oxidised to litharge (PbO) *Lithargyrium auri* — litharge of gold.

p. 27 Venetian talc — mineral magnesium silicate

THE FIRST PART

p. 31 *regulus martis* — metallic iron

aqua Regis — royal water, a mixture of nitric and hydrochloric acids which attacks gold to give a solution of auric chloride ($AuCl_3$)
quicksilver — mercury
menstruum — a solvent
aqua fortis — strong water, nitric acid
The red powder from mercury and nitric acid could be mercuric oxide (HgO), the white powder basic mercurous nitrate ($Hg_2(NO_3)_2,Hg_2O,H_2O$)
Basic mercury (II) sulphate $HgSO_4$,2HgO is a lemon yellow powder.
Cinnabar is mercury (II) sulphide HgS.
Mercury (II) chloride or corrosive sublimate $HgCl_2$.is soluble in water.

p. 32 Regulus — the impure metallic product of smelting various ores which separated by sinking to the bottom of the crucible, originally given to metallic antimony, perhaps because of its readiness to alloy with gold. (Diminutive of *rex* — king).

p.36 Guaiacum or *lignum vitae* is a tree native to the West Indies. It yields a resin which has been used in medicine.
Camphire — this spelling is found in the King James version of the Bible Song of Solomon, **1,** 14; **4,**13**.**

p. 37 Brimstone — sulphur
Caput mortuum — the solid residue left after distillation.
When a mixture of silver and lead is heated, in air, the lead is oxidised to lead oxide (PbO).and silver is left.

p.38 salt of soot — In ancient Egypt the priests at the temple of Amun distilled soot. The 'Salt of Amun' thus obtained was called by the Romans *sal ammoniac* from which is derived the modern name ammonium chloride (NH_4Cl).

p. 39 Spirits of harts-horn — ammonia
Cuncta adeo miris compagibus hærent.
'They stick together joined by a wonderful bond.'

p.42 Cadmia — here means zinc oxide.
Pompholyx — crude zinc oxide.

p. 43 Carbon or sulphur will not burn without oxygen. In air the sulphur burns to sulphur dioxide and some sulphur trioxide, oil of sulphur *per campanam* was dilute sulphuric acid.

p.44 Cinnabar is native mercury sulphide.
Pyrites is iron disulphide (FeS_2 ; Fe^{2+} and S_2^{2-} ions).
Spirit of nitre, *eau de depart* and *aqua fortis* are all names for nitric acid.
Sodium hydroxide or carbonate will readily precipitate copper oxide from a warm solution of blue vitriol ($CuSO_4.5H_2O$), similarly iron oxide could be precipitated from green vitriol ($FeSO_47H_2O$).

p. 45 Antimony when heated with sulphuric acid gives antimony sulphate, sulphur dioxide, and sulphur.

p. 46 The antimony which Boyle distilled with nitric acid (spirits of nitre) may have contained antimony sulphide. Antimony would, with a large excess of concentrated nitric acid form a yellow antimony pentoxide.

p. 47 Salt of tartar, wood ashes, $K_2CO_3+2NH_4Cl = 2KCl+(NH_4)_2CO_3$
Sublimate is $HgCl_2$

p. 48 Tartar is potassium hydrogen tartrate which is obtained by recrystallising the crude deposit (Argol) which forms in wine casks. On heating it gives a smell of burnt sugar. pyruvic acid and acetone (propanone) have been identified among the products.
Sulphur of wine ─ ethanol
Ammonia volatilised from urine.

p.49 The alkahest was supposed to be a universal solvent, possibly aqua regia.
Ignis Gehennae ─ fire of hell.

p. 50 Marchasite (FeS_2).

p. 53 Sulphur of antimony (see p. 45-46)

p. 56 Colcothar is finely divided iron oxide (Fe_2O_3) obtained by heating iron (II) sulphate. When mixed with sal ammoniac (NH_4Cl) and heated it sublimes as iron (III) chloride, which is then converted back into the oxide by ammonia and moisture.
Aqua fortis, HNO_3, dissolves silver.
Aqua Regis, HNO_3 + HCl , dissolves gold

p. 57 *Mercurius dulcis* is mercurous chloride (Hg_2Cl_2) . Vitriol ($FeSO_4$), sea salt (NaCl) and nitre (KNO_3) heated with mercury afford mercuric chloride ($HgCl_2$). This heated with more mercury affords mercurous chloride or calomel.
Alkali, fused with sand, affords fusible silicate (glass).

p. 59 ***The sixth Book of the Archidoxis*** p. 93
Furthermore ‘tis to be known concerning wine, That the *Feces* and *Phlegm* therof in the Mineral as ‘twere, and that the Substance of the Wine is the Body, in which the Essence is Conserved; even as the Essence of Gold lies in Gold: Therefore wee’l set down the *Practise* for a remembrance, that so we may not forget it: and ‘tis thus;
Take the oldest *Wine*, and the best you can get, both to Colour and Taste, what you please; put it in a Glasse Vessel, so that a Third part thereof may be full; and shut it with the Seal of *Hermes*, and keep it in Horse-dung, and in a continued Heat for four months; let it not be defective, viz. your Heat. This being done, then in the Winter-time when the Cold and Frost are extreamly sharp, set it abroad in the cold for a month that it may be Congealed; after this manner, Cold doth thrust the Spirit of the Wine together with its Substance into the Centre of the Wine and separate it from the Phlegm. That which is Congealed or Frozen cast away; but that which is not Congealed, you may

account to be the Spirit with the Substance: Put this into a *Pellican* in a digestion of Sand but not too hot, and there let it abide for some time: Afterwards take forth the *Magistery* of the *Wine*, of which we have now spoken.

Paracelsus his Archidoxes Comprised in Ten Books
Faithfully and plainly Englished and published by J.H. Oxon. London 1661

The seal of *Hermes* ─ sealed by fusion of the glass.
Pellican ─ a glass vessel used for heating liquids under reflux.

p. 59-62 When alcoholic beverages are cooled sufficiently, ice separates, leaving a liquid portion of higher alcoholic strength.

p. 61 Dutch exploration of the Arctic started as early as 1565. They sailed in the Arctic Ocean, North of Russia, in an attempt to discover a North East passage to China. Novaya Zemlya was one of the islands which they discovered.

THE SECOND PART

p. 65 Pompion ─ a pumpkin.

p. 67 Empyreumaticall spirit ─ mostly methanol, acetone, and acetic acid with the smell of burnt organic matter.

p. 68 Although Helmont described 'gas sylvestre' (carbon dioxide) he did not realise the part it plays in plant growth. Cellulose is probably the most abundant organic substance in the world and plants make it from water and carbon dioxide .

p. 74 *Sal tartari* or salt of tartar is potassium carbonate obtained by hearing Argol (crude tartar) and recrystallising the residue. The potassium carbonate would absorb water from aqueous alcohol.

p.75 The insipid menstruum would be *aqua regia*, a mixture of nitric and hydrochloric acids.

p.76 Vitriol ─ iron (II) or zinc sulphate will, if heated , dissolve in its water of crystallisation.

p. 77 If fat or glycerol is heated, it can give off the lachrimator acrolein (CH_2=CH.CHO).
The sal armoniack reacts with the quicklime to afford ammonia thus:
$2NH_4Cl + CaO = CaCl_2 + 2NH_3$
Elaterium is a powerful purgative drug obtained from the juice of the squirting cucumber, *Ecballium elaterium*, which grows in the Mediterranean region.

p. 78 The claim to have obtained water from quicksilver must be erroneous.

p. 83 Quartation, or parting with silver, is used in assaying gold. The silver is added to the gold alloy because, if the gold alloy contains more than about 25%. of gold, nitric acid will not remove all the silver and base metals.

p.86 *Regulus martis* see note p. 32.

p. 88 The copper dissolves in the nitric acid to form copper (II) nitrate, the goodly vitriol.
$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 2NO + 4H_2O$
On heating the hydrated copper nitrate, it loses water and nitrogen dioxide leaving copper oxide: $Cu(NO_3)_2 = CuO + 2NO_2 + {}^1/_2O_2$
Lead oxide dissolves in vinegar (dilute acetic acid) to afford lead acetate, *saccharum saturni*, or sugar of lead.
The alchemists associated the then known metals, with the sun, moon, and planets. Their symbols are featured on the arms of the Royal Society of Chemistry. Chaucer wrote, in the *Canon's Yeoman's Tale:*

> The bodies seven, eek lo here anon.
> Sol gold is, and Luna silver we declare;
> Mars yron, Mercurie is quyksilver;
> Saturnus leed, and Jubitur is tyn,
> And Venus coper, by my father's kyn.

p. 89 The lead acetate on heating gives acetone (propanone)
$Pb(CH_3CO_2)_2 = PbO + CH_3COCH_3 + CO_2$
Some of the lead oxide oxidises some of the acetone and is reduced to lead. This reaction was first described by Jean Beguin in 1612 (see p. 127) who called the product *spiritus ardens e Saturno* or *burning spirit of Saturn*, possibly because he thought it contained lead.
The minium (PbO) reacts with the sal armoniack thus
$PbO + 2NH_4Cl = PbCl_2 + 2NH_3 + H_2O$

p. 99 Osteocolla ─ a deposit of carbonate of lime forming an incrustation on the roots and stems of plants: found in shady ground especially in some parts of Germany.
Silver nitrate and the nitrates of mercury are, of course, salts and not mixtures. The salts are , however, easily reduced to metallic silver or mercury.

THE THIRD PART

p. 100 Bacon, "It is easier to make gold than to destroy it."

Sennertus, "Salt is present in all things (mixtures that is to say) and can be made from them all by chemical separation…….What I said of salt can also be said of sulphur."

Helmont, "I know, that out of sands, flints and rocks that are not limy, sulphur or mercury can never be drawn." See van Helmont's Works (now done in English. London 1664) p.411.

Quercetanus, "Diamond is the densest and hardest of all rocks on account evidently of the closest consolidation and cohesion of the three principles, that by no art can it be separated into its three principles."

p. 101 For seven metals see note p. 88.
Sala, "Although experience often (which we call the master of fools) certainly has fully proved, the mercury of gold is so far fixed, and closely joined with the rest of its bodily substance as in no way can it be recovered."

p.102-3 $HgCl_2 + Cu = CuCl_2 + Hg$
Ammonia, from the sal armoniack , may complex with the cupric ion.

Verdigreas ─ the term has been used for the patina on bronzes, usually basic copper carbonate (similar, in constitution, to malachite), and for the basic acetate, which has been used as a pigment.

p. 104 *Aqua fortis* (HNO_3) dissolves the silver but not the gold (see note p. 83)
Aqua Regis ($HNO_3 + HCl$) dissolves gold forming auric chloride ($AuCl_3$) and leaving the insoluble silver chloride.

Boyle assumes that magnetic and electric forces are due to corpuscles.

p. 106 Boyle quotes St. Paul's words from I Corinthians, **12**, 16-17.

p.107 Heat and light appear on Lavoisier's table of the elements (1789) along with electricity and magnetism. They were regarded as part of chemistry rather than physics until after Joule's work on the mechanical equivalent of heat in the mid 19^{th} century

Nova Zembla (see p. 61) is an island in the Arctic, 70-77^o N, 52-69^o E.

p. 109 The "sowrish spirit" distilled from box wood (pyroligneous acid) contains acetic (ethanoic) acid, methanol, acetone (propanone), and water. The acetic acid reacts with coral (calcium carbonate)to afford calcium acetate.
$CaCO_3 + 2CH_3CO_2 = Ca(CH_3CO_2)_2 + CO_2 + H_2O$

The spirit of a strong smell and of a taste very piercing but without any sourness, is a mixture of methanol and some acetone.
Salt of tartar is potassium carbonate (Obtained by heating cream of tartar). It hisses with acetic acid. Methanol does not react.
The pyrolysis of wood was still (1978) used to manufacture methanol (wood spirit),[see P. E. Childs, *Education in Chemistry*, 1978, **15**(3), 79-83] and could again become profitable.

p. 110 "Blew syrup of violets." Violets are coloured with anthocyanins which turn red in acid solution.
Lignum nephriticum ─ blue sandalwood.
An infusion of *lignum nephriticum* contains 7-hydroxy-2',4',5'-trimethoxyisoflavone (see D. T. Burns, B.G. Dalgarno, P.E.Gargon and J. Grimshaw, *Phytochemistry***,** 1984, **23**(1), 167-169.) which acts as a fluorescent indicator.
Boyle noticed that an infusion of *lignum nephriticum* appeared orange by transmitted light but blue by reflected light, when spirit of salt (HCl) was added only the orange colour was observed. (see Birch's 1744 edition of *Boyle's Works*, Vol. **5**, p 85..R. Boyle (1684/5) *Short memoirs for the Natural History of*

Mineral Waters, p 85-86 . See R. Boyle (1664), *Experiments and considerations Touching Colours*, p. 119-207, 213-216).
Magistry of corals ─ calcium acetate
menstruum ad siccitatem ─ solution to dryness
spirit of urine ── ammonia

p. 111 exantlate ─ to draw out a liquid, pumped out, drained.

THE FOURTH PART

p. 115 Elixir ─ The elixir was another name for the philosophers' stone which was supposed to transmute base metals into gold, the elixir of life was supposed to prolong life indefinitely.

p.118 Distilled olive oil would contain acrolein (CH_2=CH.CHO) which produces an irritant vapour.
The sweet oil is glycerol formed by saponification. *Sal circulatum* may have been alkali.
Dephlegmed aqua vitae ─ alcohol.

p. 119 Boyle held a corpuscular theory of fire.

p. 121 Sublimate ($HgCl_2$) would react with the regulus (Sb) to form butter of antimony ($SbCl_3$). Some auric chloride ($AuCl_3$) could be formed and sublime.
Distillation of vitriol ($FeSO_4.7H_2O$), sal armoniack (NH_4Cl) and saltpetre would afford *aqua regia* ($HCl+HNO_3$).

p. 122 Sulphuric acid could polymerise the turpentine to a flammable resin.

p. 124 Gold dissolves in *aqua regia* to give auric chloride ($AuCl_3$) which can be sublimed.
Butter of antimony ($SbCl_3$) is hydrolysed to the basic chloride (SbOCl).
Flowers of brimstone is, in fact, elementary sulphur.

p. 127 The volatile salt from oil of cinnamon could be cinnamic acid.
Salt of hartshorn is ammonium chloride
Spirit of vinegar ─ acetic (ethanoic) acid.
Beguin's *saccharum saturni* must have been impure. Modern lead acetate gives some moist acetone, a little butanone, and some yellow oily material.
A good account of the action of heat on metal acetates is given by:
Walter Krönig, ***Z. Angew. Chem.,*** 1924, **37**, 667-672.
See note for p 88-89.

p. 128 Saturnine calx ─ lead oxide.

p. 129 Tartar (potassium hydrogen tartrate) is weakly acidic. On heating strongly, it affords potassium carbonate (alkaline).
Amber, on distillation, yields some succinic acid.

p. 134 Spirit of nitre, *aqua fortis* ── nitric acid.

Spirit of salt — hydrochloric acid.
Spirit of allume, spirit of oil of vitriol — sulphuric acid.
Spirit of vinegar — acetic (ethanoic) acid.
Spirit of wine — ethanol.

p.135 Spirit of Hartshorne — ammonia reacts with nitric acid to give ammonium nitrate.

p. 136 Alkali in ashes of plants is mostly potassium carbonate.

p. 137 Small amounts of heavy metals in the ashes can colour the glass.
Fixt salt of urine – microcosmic salt, sodium ammonium hydrogen phosphate, $[Na(NH_4)HPO_4.\ 4H_2O\ ]$.

p.138 Vegetable alkali is potassium carbonate, salt of hartshorn and other animal alkalis are ammonium carbonate.
Shoot – crystallize.
Diaphoretick – medicine promoting perspiration.
Deopilitive – medicine which removes obstructions.

p. 139 Spirit of vitriol (sulphuric acid) reacts with ashes or salt of tartar (potassium carbonate) to give potassium sulphate with evolution of carbon dioxide.

Several salts could be obtained from urine, especially if it is stale, the urea is hydrolysed to ammonia and carbonic acid. Volatile salts could be ammonium carbonate or chloride. Other salts are sodium chloride, and phosphates, such as microcosmic salt so called, because it came from the 'microcosm' i.e. man. Brandt of Hamburg first obtained phosphorus from microcosmic salt in 1674. (See, *The Shocking History of Phosphorus*, by John Emsley. London 2000), which gives a very readable account of the discovery. Boyle, in two of his books, *The Aerial Noctiluca*,1680, and *The Icy Noctiluca*, 1682, describes some early experiments with phosphorus.

p. 140 Venetian sublimate ($HgCl_2$) reacts with a solution of ashes (K_2CO_3) to give basic mercuric carbonate ($HgO,HgCO_3$).
The volatile salt could be ammonia which would give an infusible white precipitate $[Hg(NH_2)Cl]$.

p.141 Essential oils of cloves, cinnamon etc are mostly denser than water whereas the vegetable oils are fats and are less dense than water.
Limbick or alembic — a still
The olive oil would partly decompose to give acrolein (CH_2=CH.CHO)
Distilled liquor of common sope is glycerol which, if distilled with minium (PbO) would give acrolein. Acrolein has been used as a tear gas.

p. 142 Oil of aniseed deposits anethole (p-$CH_3OC_6H_4CH$=$CHCH_3$) when cooled.
The alchemists said "similis similia solvuntur" — like dissolves like.

p. 143 Pyrite (FeS_2) and scrap iron were exposed to rain and air. Copperas, or green vitriol, ($FeSO_4.7H_2O$) was obtained by evaporation of the solution which drained off into pits. (see J. S. Davidson, *Essex Journal*, 1980,**15**(2), 40;

Victoria History of Essex Vol. II, pp. 355-499 describes many chemical manufacturing processes which were at one time worked in Essex).

p. 144 The solution of sulphur in turpentine burns with formation of sulphurous acid
Benzoin is the balsamic resin obtained from *Styrax benzoin* a tree native to Sumatra and Java. Benzoic acid gets its name from the resin from which it was first obtained by Nostradamus in 1556.
Lac is a resin obtained from the insect *Coccus lacca* which infests the trees of the East Indies. Its solution in alcohol is used as a varnish.
Jalap is a purgative drug consisting of the roots of *Ipomaea purga*. The resin contains the glucosides jalapin and convolvulin.

p. 146 The English Edition of the *Tyrocinium Chymicum***,** (1669) p. 20, reads, "Mercury is that Acid, permeable, penetrable, Ætherial, and most pure liquor, whence is all nutrition, sense, motion, and the retardation of over hasty age."

p. 149 *Mercurius corporum* — mercury of the bodies.

p. 150 *Argentum vivum ex stanno prolictum* — quicksilver enticed out of tin.

p. 151 For, "Sulphur (saies he) is different in gold, different in silver, different in iron, different in tin etc., so also it is different in sapphire, different in ruby, chrysolite, amethyst, loadstone etc. It is also different in rocks, flint, salts, springs etc. and in fact there are not only such a number of sulphurs but also such a number of salts. Salt is different in metals, different in gem stones, different in rocks, different in salts, different in vitriol, different in alum; the same is true of mercury. It is different in metals, different in gem stones etc. in such a way that every single species has its own mercury. And yet there are nevertheless three substances; one element is sulphur; one is salt; one is mercury. I add the fact that these individual substances may be divided still more particularly. For gold is not one thing but manifold, just as pear or apple is not one but manifold, there are so many sulphurs of gold, salts of gold, mercuries of gold. The corresponding thing happens in metals and gem stones too, so that there are as many sulphurs of sapphire, salts of sapphire, mercuries of sapphire as there are splendid or poor sapphires etc, the same is also true of turquoises and all other gem stones."

p. 152 Manure or animal refuse is oxidised to saltpetre (KNO_3).
Vinegar, in the presence of air, will gradually react with lead to afford lead acetate (sugar of saturne).

p.153 Colcothar is ferric oxide obtained by heating copperas.

THE FIFTH PART

P. 158 Calx of vitriol would be ferric oxide (see note p. 143).

p. 166-7 "Whenever the same effects and qualities are present in a number of things, they must be present according to some common Principle*, such as they are all heavy due to earth, or hot due to fire. But colours, smells tastes, being

flammable and other such qualities are present in minerals, metals, gem stones, plants and animals. Therefore they are present according to some Principle. For they have no power to produce such qualities. Therefore other Principles from which they derive must be sought."
*Principle as in three Principles.

p. 169 The glow of rotten fish has been said to be due to the oxidation of phosphine.

p. 170 "We begin ,with Beguin, with greenwood, because , if it is burnt up, we will see in the sweat water, in the smoke air, in the flames and live charcoals fire, in the ashes earth: although it pleased Beguin from it to collect water, to hold the oil, and to extract salt from the ashes."
Billichius quoted experiments, described by Beguin (Eng. Edn., p. 22-23) and explained by Beguin in terms of the *tria prima* (salt, sulphur, and mercury). Billichius, however, preferred to give an explanation in terms of the four elements. He then gives similar descriptions of experiments with milk, linseed, cloves, nitre, sea salt, and antimony.

p. 173 Bone ashes — mainly calcium phosphate.

p. 174 Alkali of wood is potassium carbonate.

p.177 $2Hg + O_2 = 2HgO$
The colours formed on iron are due to thin films of oxides.

p.178 Rhubarb rhizomes contain some derivatives of anthraquinone which have a purgative action. At one time, preparations of rhubarb such as Gregory's powder (*Pulv. rhei co.*) were often prescribed for constipation.

p.179 Gumme Arabic — the air dried gummy exudates from *Acacia Senegal* and other species of acacia.
Myrrhe — an oleo-gum-resin from the stem of *Commifora molmol* and other species.

p.181 Helmont, "I believe simples in their simplicity to be sufficient for the healing of all diseases." Simples were vegetable remedies.

Barth, "It is quite absurd to make an extract out of all things, salts, quintessences; especially from substances by themselves either simple or homogeneous, of which kind are pearls, corals,musk, amber etc."

p. 183 Lead , when heated in air, gives oxides.

THE SIXTH PART

p. 187 Although Boyle has often been credited with the first clear definition of an element, Marie Boas in her book, *Robert Boyle and Seventeenth-Century Chemistry* (Cambridge 1958), (p. 85) points out that Estienne de Clave, in 1641, defined elements as "simple bodies, which enter originally into the composition

of mixts, and into which these mixts resolve themselves or may be finally resolved." (See note on Clave.). As Boas points out, Clave and Boyle meant something quite different from what we mean today when they spoke of elements. Over a century later, Lavoisier gave his definition of an element. Advances in chemistry soon followed.

p. 188 The belief in spontaneous generation of animals in putrefying matter was not discredited until after the work of Pasteur in the mid 19th century.

p. 191 Fallopius, "accounts of metal prove that a mine of sulphur which is the nurse of the underground heat that makes or originates springs and minerals is regenerated very quickly below the earth. For there are places from which, if the sulphur is dug this year and the miners return after mining has been suspended for four years, they find everything full of sulphur again as before. Pliny relates that in the Italian island of Elba iron is generated. Strabo says much more expressly that when the metal has been extracted, it is regenerated. For, if the extraction ceased for the space of a hundred years, the miners used to return there again and find an enormous amount of iron regenerated. "

Cesalpinus, "The vein of iron is very plentiful in Italy. Because of it , Elba in the Tyrrhenian Sea, is famous for producing it in incredible quantity even in our times. For the earth that is dug out , as long as the vein is totally evacuated, turns into a vein with the passage of time."

p. 192 Boccacius Certaldus, "For mount Fessulae (Fiesole) in Etruria which overlooks the city of Florence has lead bearing rocks which, if cut out, are in a short space of time, renewed with fresh additions as (annexes my author) Boccacius Certaldus relates, who. writes that this is well proven. This is nothing new; but, on the same subject, Pliny in *Natural Histories* Book 34, chapter 17,has already spoken, saying that, in these lead mines alone, it is strange that when abandoned, they revive even more productively. In lead mines called second stone from the ambergris, the slag piled into heaps for safe keeping, after being exposed to sun and rain, in a few years yield their proper metal with interest."

"In the Joachimica valley Dr Schreterus bears witness that silver grew a finger's length from the rocks of the mine as if from a root in the manner and fashion of grass, he often showed and gave away veins of this kind in his own home, lovely and wonderful to behold. Also a sky-blue water was found at Annenberg where silver was still in its first state, which was solidified and made into pebble of good firm silver."

p. 194 Nitre is formed from decaying organic matter in the earth.

p. 195 See notes (p. 143) marchasite is another form of FeS_2 .

p. 203 Regulus martis stellatus — iron .

p. 203 Clay heated with salt would give hydrogen chloride which would react with spirit of urine (ammonia) to form ammonium chloride.

p. 208 Mercury readily forms an amalgam with gold.

p.209 Vinegar (say 3% acetic acid) is neutralised by coral (calcium carbonate) forming calcium acetate.
Mercurius dulcis is calomel or mercurous chloride $HgCl_2 + Hg = Hg_2Cl_2$ If blue vitriol (copper sulphate) is heated, it first loses its water of crystallisation to give white anhydrous copper sulphate which, on heating to a higher temperature, then loses sulphur trioxide. The caput mortuum would be mostly black copper oxide.

p. 210 If Poppius made his oyle of sulphur from distilled blue vitriol, heating the residue with linseed oil would cause reduction to copper.
Verdigrease — see note p. 102 .

p.216 Until about 1870, the usual method of making oleum (fuming sulphuric acid, $H_2S_2O_7$) was by heating ferrous sulphate. First the water of crystallisation was driven off and then the residue was heated to a bright red heat to drive off sulphur trioxide and sulphur dioxide.

$$2FeSO_4 = Fe_2O_3 + SO_3 + SO_2$$

p. 219 Vinegar is formed by the oxidation of the alcohol in the wine by *Acetobacter*. It contains about 3% acetic (ethanoic) acid which reacts with salt of tartar (potassium carbonate) with evolution of carbon dioxide. Vinegar eels are small worm like organisms which are sometimes found in vinegar.

p.220-2 The *sal tartari fugitavus* could be ammonium carbonate formed from impurities in Boyle's chemicals.

p.222 On heating verdigrease (copper acetate) glacial acetic acid is obtained

$$2Cu(CH_3CO_2)_2 = 2Cu + 3CH_3CO_2H + CO_2 + C$$

W. Krönig, *Z. Angew. Chem*.,1924, **37**, 670 . For a full account, giving references to many earlier papers (1773-1892) see, Andrea Angel and A. Vernon Harcourt, *J. Chem. Soc*., 1902, **81**, 1385-1402 . Andrea Angel perished in 1917 when a factory, purifying TNT, at Silvertown, blew up. His name heads the list on the R.S.C. war memorial at Burlington house.

p.223 On heating lead acetate acetone is obtained (see notes p. 89, 127).

p.227 Solomon's Tarshish fleet is mentioned in **I Kings,10**, 22 .

(end of annotations)

The Sceptical Chymist

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Page 107 is not found in the 1661 edition, but is pages 191-194 in the 1680 edition.

* Page 142 should be page 342.