ESSAYS

PHYSICAL AND CHEMICAL,

BY

Olof
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TRANSLATED

FROM THE ORIGINAL LATIN.

TO WHICH ARE ADDED

NOTES AND ILLUSTRATIONS,

BY THE TRANSLATOR.

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PREFACE

BY THE

TRANSLATOR.

NO name is more illuſtrious in the annals of Chemiſtry than BERGMAN:—none has contributed more than he, to the rapid advancement which this ſcience has made in the preſent century.—Nor has any other philoſopher applied the principles of Lord BACON with greater ſkill or attention, in the inveſtigation of nature. Ardent enthuſiaſm, and patient aſſiduity in the purſuits of ſcience, candour, modeſty, clearneſs of judgement, and comprehenſion of mind, qualities the union of which conſtitutes the true philoſopher, appear to have been happily conjoined in this great man. The number and the accuracy of his experiments, the ſimplicity and ingenuity of his proceſſes, the beauty and plauſibility of his theories, command the admiration and reſpect of every intelligent reader of his works.

His writings are already very generally known through Europe. They have moſt of them been tranſlated into various languages. An Engliſh tranſlation of two volumes of his Eſſays was, ſome years ſince, publiſhed. They met with the favourable reception which they deſerved:

 and

and there is reafon to think that they have been of great utility.

The pieces which compofe this volume are not inferior in value to thofe already before the Englifh reader: The Hiftory of Chemiftry is no where traced with greater erudition and good fenfe, than in the two firft of thefe Effays. The Arrangement of Foffils, the Combination of certain Metals, the Analyfis of fome Swedifh mineral Waters, with a few other matters, perhaps of ftill higher importance than any of thefe, are the fubjects which occupy the reft of the volume.

Whether confidered as original records of a number of chemical facts, communicated upon the very beft authority, or viewed as models of philofophical inveftigation, the reafonings and proceffes of which may be imitated with advantage in either of thefe lights,—the contents of this volume will be acknowledged to have been worthy of the tranflator's pains. Their utility may perhaps be the greater, becaufe the propagation of a new theory, formed to pervade the whole fcience of Chemiftry, renders it of confequence for the ftudent to examine that which has fo long prevailed, in all its parts, and to view it in connection with every fact which has been difcovered; in order that he may determine whether to adhere to the doctrine of STAHL, or to adopt the opinions of LAVOISIER,

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OF

OF THE

ORIGIN

OF

CHEMISTRY.*

In artibus et ſcientiis, tanquam in metalli ſodinis, omnia novis operibus et ulterioribus progreſſibus circumſtrepere debent.

BACO DE VERULAMIO.

§. I. *Of the Slow Progreſs of Natural Philoſophy.*

AS the qualities of bodies can never be known by reaſoning *a priori*, it is not to be wondered, that the progreſs of Natural Philoſophy unto its preſent height ſhould have been ſo ſlow, when we conſider, that every thing muſt be attentively obſerved, compared, and put to the teſt of experiment. The fallibility of our ſenſes, too, is one great cauſe of delay: For, whenever

A ſubſtances

* This diſſertation was publicly read at Upſal, in the Guſtavian Hall, 4th June 1779.

ſubſtances below a certain ſize are to be examined, they are either ſeen confuſedly, or vaniſh from the ſight; and things that are in themſelves ſufficiently obvious are often repreſented very obſcurely. The great number and variety of characters likewiſe of the productions of nature is ſo great, that I will venture to ſay, not only the ſagacity of Newton, employed during the age of Methuſalem, had failed in aſcertaining but ſlightly the qualities of a ſingle object; but that the united induſtry of many, employed during a long ſeries of ages, had not been more ſucceſsful.

Nature may be compared not improperly to an immenſe book, written in an unknown language. In order to underſtand the text of which, it is neceſſary that the letters ſhould be known, ſo that by attentively obſerving the reſemblance and diſparity of bodies, their diſtinguiſhing characters, and natural qualities, may be diſcovered.—This conſtitutes *Natural Hiſtory*. Then the ſyllables are to be formed:—And this allegorical language points out general properties to be determined by proper experiments.——And, as in ſociety, the genius and ſecret diſpoſition of the mind and affections are rendered more conſpicuous in ſituations of difficulty and diſtreſs; ſo, in the ſame manner, the ſecrets of nature are more unfolded by the moleſtations of art than when they are ſuffered to remain undiſturbed.—From hence *Phyſics* ariſe.

Next,

Next, the ſenſe and connection is to be gathered from the words, as to the proportion and various modifications:—Which conſtitutes *Chemiſtry*.

If then we conſider theſe three vaſt fields of phenomena and experiment, and the ſmall number of thoſe who have attended to their cultivation; and if we contemplate the neceſſary ſupply of ſelect apparatus, the ſingular ſagacity requiſite for inſtituting proper trials—and view the unwearied patience, dexterity, and exquiſite attention, in carrying on, repeating, and varying the ſeveral proceſſes; and finally, the mature and penetrating judgement required to form a true reſult, we ſhall ceaſe to wonder at the ſlow advances of Natural Philoſophy.

Lord Verulam juſtly remarks, that the human underſtanding is not a mere faculty of apprehenſion, but is affected more or leſs by the will and the paſſions. What man wiſhes to be true, that he eaſily believes to be ſo. From impatience he rejects every difficult enquiry;—from pride and arrogance, he diſdains the light of experience, leſt he ſhould appear to be wholly abſorbed in particulars ſubject to the ſenſes.—He deſpiſes moderate purſuits, becauſe they limit his hope;—avoids paradoxes, on account of the opinion of the vulgar;—and ſlights the beautiful diſcoveries of others, from envy.

The hiſtory of Natural Philoſophy muſt therefore in a great meaſure conſiſt of errors, falſehoods, and conjectures: For in all crofs ways we feldom arrive at the truth by the fhorteft path; nor do we reach it at laft but by many circuitous wanderings, and after every other road has been tried unfuccefsfully. But, neverthelefs, the view of the errors of the human underftanding is exceedingly ufeful, and the caufes of them being laid open in the examples of others, the mind is improved;—like a failor, who, from different charts, learns to navigate through dangerous feas, and from the track of former voyagers, to efcape the rocks and fhoals around him. Hence then it appears, in what manner the underftanding, refcued from darknefs, reflects the light of truth, and refumes its true direction.

The hiftory of chemiftry is properly divided into the mythologic, the obfcure, and the certain. The firft period exhibits it from its infancy, deformed by fictions, until the deftruction of the library of Alexandria by the Arabs.—The fecond, though freed in fome meafure from thefe abfurdities, yet is ftill clothed in numberlefs enigmas and allegorical expreffions.—The third period commences at the middle of the feventeenth century, with the firft eftablifhment of focieties and academies of fcience; of which the wife affociates, in many places uniting their efforts, determined to purfue the ftudy of Natural Philofophy by obfervation and experiments, and candidly to publifh their attempts in a general account of their tranfactions.

tions. In the following pages, we ſhall give a ſlight ſketch of the firſt period,—truſting to the mild criticiſm of our gentle readers.—To treat of every part at large would exceed the limits of one volume.

§ II. *Origin of Chemical Arts.*

THE concatenated ſeries of truths on which ſcience depends, ariſes from a more frequent and accurate compariſon of many phenomena.—In order to acquire this knowledge, it is neceſſary to prepare a number of experiments and obſervations with judgement and attention. The properties of ſome bodies, perhaps, were known immediately; but neceſſity, or the love of gain and convenience, the moſt powerful incitement to genius, taught their uſe and application.—Hence ſprung arts and artificers; but, as yet, there appeared no veſtige of true ſcience. Sagacity and ſedulous inveſtigation were required to perceive the relation of various phenomena, and to reduce them, in ſome meaſure unfolded, to a neceſſary arrangement.

We are, however, ſo far from wiſhing to detract from the merit of the firſt diſcoverers, that we contend, they were men of the greateſt ingenuity; for who will not allow, that in order to judge truely of their claim to honour, both the times in which they lived, and their ſituations, muſt be taken into the account.—If Newton, the great Newton, the glory and ornament of the human underſtanding; he who determined ſo wonderfully the laws of motion of the planetary ſyſtem; who, to the aſtoniſhment of all mankind, divided a ray of light, and reduced almoſt infinity itſelf to calculation;—if this hero of philoſophers had lived among the Laplanders, he would ſcarce have been the inventor of decimal arithmetic.—Or had the ſublime Stahl exiſted before the flood, he had, perhaps, not ſurpaſſed Tubalcain in dexterity,

Hence it may, in ſome meaſure, be conjectured, why, in remote times, divine honours were paid to the firſt diſcoverers of the works of nature; and why to thoſe who had deſerved well in civil affairs, the dignity of heroes only was granted.—The benefits of the firſt affect all the human race, and extend their happy influences through every age; while the operations of the latter is confined to certain ſituations, and limited to a few years.——Beſides, it rarely happens that any improvement takes place in ſociety, without ſome violence or commotion; but the noble diſcoveries in the great book of nature bleſs wherever they proceed, and bear their ſalutary fruits without ſorrow or diſturbance *.

The truths of every part of philoſophy, whether they are worthy of admiration, and extol the wiſdom of the ſupreme authority of nature, or

* Lord Bacon.

or whether they are actually beneficial to the purpoſes of a ſtate, do ſtill intitle it to the ſame degree of eſtimation.—But, nevertheleſs, there are not wanting many cultivators of ſcience who, not content with this ſhare of commendation, ſeek in the duſt of antiquity for traces of inventions they conceive to have been meritorious, or to have been more amply diſcuſſed.——And I am forced to acknowledge, that many among the earlier chemiſts eſpecially, have attended too much to this ſtudy, labouring to reduce to their favourite ſyſtem the ſublimeſt arts almoſt coeval with our own globe. In this view ancient monuments are ranſacked, and diligent ſearch is every where made for the veſtiges of their beloved age; and if, in the teſtimonies they are able to produce, any thing ſhould be deficient, they are at no loſs to ſupply the vacancy with reaſoning and conjecture.——Let us attend a little to theſe patrons of ſuch high antiquity.—Surely they apprehend, that from this enquiry into the character and hiſtory of mankind, it will appear, that the firſt intimations of arts and ſciences were received partly by divine, and partly by diabolic inſpiration. The holy writings make mention of ſeveral interviews with God and angels; nay, even in expreſs words, it is ſaid, that Bezaleel, the ſon of Uri, was endued with the ſpirit of the Lord, and with ſkill to work in gold, ſilver, braſs, marble, in precious ſtones, and ſeveral kinds of wood *. They adduce Enoch the patriarch, as a firſt evidence, who relates that the Egregori (Εγρηγορυς) adminiſtred antidotes againſt poiſons to men and women, and verſes that ſhould preſerve them from diſeaſes. And they quote Hexaele the tenth prince of the Egregori, who taught the art of making ſwords, breaſt-plates, and all warlike inſtruments, and the methods of working gold and ſilver, to make them appear beautiful to the women; and inſtructed them in painting their faces, and in wearing precious ſtones †.

The ſame thing almoſt is advanced upon the faith of ancient monuments by Clemens Alexandrinus ‡, Tertullian §, and Euſebius ‖. Eupolemus in Euſebius relates of Enoch himſelf, that he was taught by angels, and tranſmitted the ſcience of aſtrology, through Methuſalem and his poſterity, down to Abraham. Zoſimus of Panopolita aſſerts, that the works of nature were revealed by demons unto the daughters of men, in return for their love; and he adds, that the firſt account of theſe arts was called χημα, as well as the book itſelf; and hence the art

* Exod. xxxi. 3.

† Fragmen apud Syncellum.

‡ Strom. 5.

§ De idolatria de virgin. veland. et cultu fæminarum.

‖ Præp. evang. lib. 9. cap 17, 18.

art came to be diſtinguiſhed by the name χημια*.

By angels or demons, and Egregori, as they are called by ſome, many underſtand, with Borrichius, the poſterity of Seth and Tubalcain, (the children of God) the wicked offspring of righteous parents, who being initiated by their fathers in the ſecret myſteries of nature, profaned the majeſty of their truſt, by an ill-timed loquacity with the daughters of Cain, with whoſe charms they were captivated.—By this and other crimes they drew upon themſelves the anger of the Deity †. Who could believe that moroſe philoſophers, ſhut up, for the greateſt part of their lives amidſt the coals and furnaces of their laboratories would ſeriouſly ſeek the origin of their ſcience in the tender paſſion? But they did not ſtop here. Almoſt every where in their writings they allude to love ſports; one while to the nuptials of a philoſophic king, then to the net of Vulcan, and many other ſtories of a ſimilar nature; which, as they ſay, are all to receive a myſtic interpretation. Wherever Homer ſtudiouſly

* Φασκυσιν αἱ ἱεραι γραφαι, η τοι βιβλοι, ὦ γυναι, ὁτι εςι τι δαιμονων γενος, ὁ χρηται γυναιξιν. Εμνημονευσε και Ἑρμης εν τοις φυσικοις, και σχεδον ἁπας λογος φανερος και ἀποκρυφος τυτο ημνημονευσεν. Τουτο ουν εφασαν αι αρχαιαι και θειαι γραφαι, ὁτι Αγγελοι επεθυμησαν των γυναικων, και κατελθοντες εδιδαξαν αυτας παντα τα της φυσεως εργα, ὧν χαριν προσκρυσαντες εξω τυ ὑρανυ ἐμειναν, ὁτι παντα τα πονηρα και μηδεν ωφελυντα την ψυχην εδιδαξαν τυς ανθρωπυς. Εξ αυτων φασκυσιν αἱ αυται γραφαι, και τυς γιγαντας γεγενησθαι· εςιν υν αυτων ἡ πρωτη παραδοσις χημα περι τυτων τεχνων· εκαλεσαν δε ταυτην την βιβλον χημα· ενθεν και ἡ τεχνη χημια καλειται. Conf. Scaliger in notis ad Euſebii chronicon.

† Diſſertat. de ortu et progreſſu chmciæ.

dioufly defcribes the ftolen embraces of Mars and Venus, thefe fkilful profeffors of the art are fure to difcover fome chemical fecret, fome combination of copper and iron, painted in glowing colours. When they mean to fignify the making of gold, which they call the great work, they fpeak of broken conjugal faith:—They had perhaps erred lefs, had they thus interpreted conjugal fidelity unbroken.

But we have dwelt fufficiently on thefe things. It is however truly to be lamented, that thofe who cultivate the ingenious arts, as well as the ignorant vulgar, fhould pleafe themfelves with ridiculous opinions, which they afterwards venerate and defend, with as much zeal as they would the intereft of their country and religion; feeking out arguments every where, by which they may be fupported. For, fuch is the force and obftinacy of prejudices, that whoever fuffer themfelves to be led away by them always maintain thofe very errors of which they are confcious, a practice moft unworthy of, and prejudicial to an inveftigator of truth. He who defires truth earneftly, will always feek it, with Horace:

Si quid novifti rectius iftis,
Candidus imperti.

All that can be faid with certainty of the origin of chemiftry, is refolved fimply into this, that the various arts depending upon it are of the higheft antiquity. The fcriptures call

Tubalcain,

Tubalcain, the eighth man from Adam, the worker and hammerer of iron and copper *; the ſame whom the heathens ſeem to have worſhipped under the name of Vulcan. We are not acquainted with any proofs of his ſkill; and indeed it is moſt likely they would be of the rudeſt kind.—The title of chemiſt, however, with which he appears to have been honoured by many, would have applied fully as well to every ſmith and melter of metals.—Some indeed inſiſt, that neither braſs nor iron could be wrought and variouſly moulded, unleſs the method of inveſtigating the nature of minerals, of burning, purifying, and ſeparating them, were previouſly underſtood.

If metals however were found native in the neighbourhood of Paradiſe, there could be no occaſion for all theſe proceſſes. Mention is made of gold ſince the beginning of the world †; and in the time of Abraham many things were bought and ſold by determined weights of ſilver ‡. The moſt ancient monuments clearly demonſtrate the great quantity of theſe metals; and it is not unlikely that the ingenious Tubalcain ſhould obſerve they were capable of extenſion under the hammer, and of fuſion by fire §; and that he

* Gen. iv. 22.

† Gen. ii. 11, 12.

‡ Gen. xxiii. 16.

§ There was once a time, when mankind were totally ſtrangers to the uſe of fire; and they ſeem to have learnt its nature and he would ſearch for theſe properties in other bodies, and diſcovered them in iron and copper, is alſo very probable.

The

and its property of heating and deſtroying bodies, from volcanic eruptions, and from the effects of lightning. It will be eaſily ſuppoſed, that, on its firſt diſcovery, fire would be attentively and anxiouſly preſerved, and that care would be beſtowed to nouriſh it, in proportion as its great utility became known. Hence, it is beyond all doubt, that the office of ſupporting it was given, as an honourable reward, to thoſe illuſtrious men who had deſerved well of the ſtate. The authority of religion too became attached to it, and the ſuperſtitious veneration of perpetual fire, either worſhipped in the name of the Deity, or conſecrated to the gods; until, by degrees, it was diſcovered, that fire could be excited at will;—with which, however, few only were at firſt acquainted, and which ſeems to have been conſidered by them as a ſecret. We read of Abel's offering to God, which muſt neceſſarily have been conſumed by fire, unleſs he made his ſacrifices in ſome other manner.

I am clearly of opinion that the ſeparation of metals by fire was diſcovered by accident. But this powerful element was ſo far from being known to the whole human race, that, we are told by Pliny, the Egyptians in Africa, before the reign of Ptolemy Lathurus, were entirely ignorant of its uſe. —Nay, we are certain, that, three hundred years ago, the inhabitants of the iſlands between Aſia and America were equally unacquainted with it.

I do not apprehend there would be any difficulty in obſerving, that ſtones rubbed againſt each other produced ſparks of fire. The artifice of Prometheus, ſo celebrated in the ſongs of poets, appears to have been nothing elſe than fire produced in this manner from ſtones, except that he firſt ſhewed how it ſhould he nouriſhed.—To this applies the account of Pliny: " Pyrodes the ſon of Cilex firſt obtained fire from flints,

" and

The Siberian iron examined by Pallas was found to be malleable, though cold, or mode-rately

" and Prometheus taught firſt to preſerve it in a reed," L. 7. c. 57. And elſewhere, " It is well known, that fire is beſt che-" riſhed in reeds, and that thoſe in Egypt excel all others." Lib. 13. c. 22.

The vulgar opinion ſuppoſes Ariſtophanes to be the firſt who made any mention of burning-glaſſes. But if thoſe ver-ſes are genuine, which are attributed to Orpheus, it will ap-pear that this prince of poets, who lived long before Ariſto-phanes, had deſcribed the effect of the ſolar rays received into cryſtal, in the following lines:

" Take into your hands a ſplendid and pellucid cryſtal,
" A ſtone poſſeſſing ſuch divine brilliancy,
" As does the hearts of the immortal gods delight, in heav'n
" enthron'd:
" This, if to the temple then you bear,
" No god upon your vows ſhall unpropitious frown.
" The virtues of this wond'rous ſtone attend and learn:
" Should you, without burning fire, chuſe to excite a flame,
" To faggots dry'd approach it near.
" Upon the wood anon a gentle ray appears:
" Which, when once the dry and fat materials it has ſeiz'd,
" Smoke firſt, then fire and dreadful flame
" Aſcend: Earth's ſacred fire by the ancients nam'd.
" With other flame than this, ſacrifices to the gods
" Acceptable, I hope, will never burn.
" Moreover, of this wond'rous cryſtal add,
" That, though itſelf the cauſe of heat, yet, ſoon
" As from the blazing fire withdrawn, 'tis ſtraightway cold,
" And ſafely to be handled; and, to the reins applied,
" All pains and aches removes."

Plutarch, in the life of Numa, aſſerts that the holy fire of the veſtals was kindled by burning-glaſſes.

Of

rately heated. Iron of theſe qualities, however, is now very rare; though it is not impoſſible that, in the infancy of the world, it ſhould have been more abundant, and by ſucceeding ages corroded into ochre. The ſlight mention made of it in the ſcriptures proves nothing certain as to its proportion; it reſts therefore upon conjecture, and that by no means well founded.

The ſacred writings ſpeak of Noah, probably the Bacchus of the Pagans, that he made wine from grapes *, and mention the burning of bricks for building the tower of Babel †. Theſe are almoſt the only traces of chemical arts preceding the deluge ‡.

§ III. *The*

Of fire produced by friction, Pliny ſays, l. xvi. c. 40. "Thoſe trees from which touchwood can be made, as the "mulberry, laurel, and ivy, are all of a warm nature.— "Scouts of armies and ſhepherds make uſe of them for light- "ing fires, as ſtones are not always to be found. Two "pieces of wood are rubbed hard againſt each other, until the "flame breaks out, which is immediately communicated to "ſome dry fuel, of fungus or leaves. For this purpoſe no- "thing is better than the laurel and ivy. The wood-vine "alſo may be employed; not what is called wild-vine, from "which it differs, by twiſting itſelf round trees in the manner "of ivy."

By a ſimilar proceſs of rubbing pieces of wood together, the Arabs, and the iſlanders of America, obtain all their fire.

* Gen. ix. 20, 21.

† Gen. xi. 3.

‡ Beroſus the Annian relates that Noah had obſerved many of the ſecret works of nature, which were only entruſted to the prieſts. Of his knowledge derived from the pillars of Seth, Joſephus ſpeaks, Antiq. l. i. c. 3.

§ III. *The State of Chemiſtry in Egypt.*

THAT we may proceed in order, we ſhall firſt ſlightly touch upon the fortunate and unhappy fates of natural philoſophy;—afterwards we ſhall conſider the various chemical arts;—then the moſt celebrated authors in the ſcience of chemiſtry;—and laſtly, we ſhall review their principal theories.

Every body knows, that Egypt was in the poſſeſſion of Cham the ſon of Mizraim: And Plutarch mentions, that it was called Chemia * in the earlieſt times, perhaps from Cham the ſon of Noah †. But it is oftener the land of Mizraim, Gen. xiii. 10. xli. 41. xlv. 18.

In conſulting thoſe writings of antiquity that have withſtood the ravages of time, we have found mention made of a certain man, whom the Egyptians call *Thoyth*, the Phœnicians, *Taaut*, the Greeks Ερμην, and the Romans *Mercury*, and to whom they all attribute the invention of letters, and many arts and ſciences. From the teſtimony of Diodorus Siculus, he was highly honoured by Oſiris the king of Egypt, and eſteemed above all others for his penetrating genius in diſcovering every thing that could be uſeful in common life. The king, accompanied

* Of Iſis and Oſiris, c. 5.

† Pſal. lxxxviii. 51. cv. 23. 27. cvi. 22.

nied by people ſkilled in agriculture and other arts, travelled into foreign regions, in order to inſtruct the inhabitants, and ſubdue their native ferocity. During his abſence he committed the reins of government to his conſort Iſis, and appointed Hermes as her counſellor *.—Of this Hermes it is reported, that he engraved upon pillars, or, according to ſome, upon the walls of the Syringian caverns, an account of all the ſciences that had flouriſhed before the deluge. Diodorus ſpeaks beſides of two columns in the city of Nyſa, one of which is dedicated to Oſiris, who was the ſon of Creon, the youngeſt of the gods; and who had over-run many countries with his victorious arms, and rendered general benefit to mankind. The other column bears the following inſcription: "Iſis am I, the queen, ſiſter, "and wife of Oſiris, by Thoyth ſkilled in ſci-"ence, who taught agriculture to men, who "bore king Horus, who ſhines in the dog-days, "and who ordered Bubaſtus to be built: Fare-"well Egypt, where I was educated."

Some monuments ſpeak of another Hermes, who, (if Ælian is to be credited †), lived in the reign of Seſoſtris, was highly extolled for wiſdom, and called Triſmigiſtus. Manethus, the chief prieſt of the Gentiles at Heliopolis, relates, to his king Ptolemy Philadelphus, That all thoſe things which the firſt Hermes had written

* Bibl. hiſt. l. 1.

† Var. hiſt. l. xii. c. 4.

ten upon the columns, either in the holy or the Egyptian tongue, were by this man tranſlated, after the deluge, into Greek, and then written in hieroglyphics in books, and depoſited in the moſt ſacred places of the temples*. It is alledged by ſome, that through a miſtake of the extract or tranſcription, εις την Ελληνιδα, φωνην, is inſerted inſtead of Ελληνιςι, which indicates a ſtyle of writing, according to the Greeks, from left to right; or more properly perhaps, inſtead of εις την αλλην διαφωνον viz. διαληκτον †: As the Greek language was as yet but imperfectly underſtood, it is not impoſſible; for both the father and grandfather of Seſoſtris had ſubjected Greece to their authority.

Two hundred and eighty years before Chriſt, Manethus dedicated to the ſame king his work, entitled Βιβλον Σωθεως, in three volumes, containing all the hiſtory and arts of the Egyptians, whether compiled from the columns in Seriadica, or from the ſacred books.—Fragments only of this work are now remaining ‡; but from it Julius

* In libro I. Chronici Euſebii Manethos is ſaid χρηματισας εκ των εν τη Σηριαδικη γη κειμενων ςηλων, ἱερα φησι διαλεκτω και ἱερογραφικοις γραμμασι κεχαρακτηρισμενων, ὑπο Θωυθ του πρωτου Ἑρμου, και ἑρμηνευθεισων μετα τον κατακλυσμον εκ της ἱερας διαλεκτου εις την ἑλληνιδα φωνην γραμμασιν ἱερογλυφικοις, και ὑποτεθεισων εν βιβλοις ὑπο του Αγαθοδαιμονος του δευτερου Ἑρμου, πατρος δε του Τατ, εν τοις αδυτοις των ἱερων Αιγυπτιων.

† Baumgarten in Erl. der Alten Geſch. tom. 1. p. 11, 407. The Seriadic land is, by its ſignification in the Coptic tongue, aſſerted to be the ſame as the land of the ſun, or Heliopolitas.

‡ Syncellus in chronogr.

lius Africanus, from Africanus Eusebius, Pamphilius, and from Eusebius Syncellus, have severally made extracts;—and from the preface of Diogenes Laertius, it appears plainly, that he had made use of the φυσικῶν επιτομη of Manethus. The hieroglyphics of the Egyptians represent natural bodies entire, as well as in part, and also mathematical figures. These are perhaps the letters which were attributed to Hermes; expressing things rather than sounds: But however likely it is, that such should be the rude inventions of antiquity, yet we shall presently see, they were reckoned more ingenious than later improvements. Whatever might be the mode of writing that Hermes is said to have invented, although as yet rude and imperfect, it was clearly of the greatest importance. Hitherto the sciences, equally with the vulgar arts, depended entirely on the uncertainty of oral tradition; whereas, by the assistance of letters, the observations of ingenious men would be more easily collected, compared, and reduced into order, and the first foundations of instruction be established.

Many circumstances lead us to apprehend that the existence of both the Hermeses was not merely imaginary, as Ursinus and Corringius do. For although it was the custom of the antients to disguise the actions of their heroes in the ornaments of fiction, yet are we not to infer, that such persons are altogether fabulous.

There

There would be an end to all hiſtorical truth, if, from the diſagreement of records in reſpect to forms, we were to deny the exiſtence of the things themſelves. But, however, who they poſitively were remains ſtill in ſome obſcurity. Many agreeing with J. C. Kriegſman, ſuppoſe the firſt to be Canaan the ſon of Cham *. Others, again, with Kircher, imagine him to be Enoch. With Huet, he is called Moſes; by Philo, the ſon of Mizraim (Miſor) †. Nay, ſome of the moſt modern writers think they diſcover Abraham under that appellation ‡; who, from the united teſtimonies of Joſephus §, Eupolemus, and Artapanus ||, inſtructed the Egyptians in the uſe of numbers, and aſtronomy, and dwelt among them for twenty years.

There is no doubt, that the deſcendants of Seth knowing that Adam had foretold the general deſtruction of every thing, at one time by the flood, and at another by a conflagration, wrote all their inventions and diſcoveries upon two columns, leſt the knowledge of them ſhould periſh. Joſephus, who, upon the faith of others, relates, that ſuch a ſtone ſtill exiſted in his time

 in

* On the Smaragdine table.

† Philo Biblius reports from Sanchuniaton, that Miſor had a Son named Taaut, called by the Egyptians Thoyth, the inventor of the firſt elements of writing.

‡ Kochs Pharos der Chron.

§ Antiq. l. i, c, 2

|| Euſebii Præp. Ev. ix. c. 17, 18.

in Syria, is thought, not improperly, to have applied to Seth the above-mentioned account of Hermes, by Manethus. Sanchuniaton calls Hermes a Phœnician, which agrees with the opinion entertained of Abraham.

Many of the moderns * diſcover another Hermes in Joſeph the ſon of Jacob, from the authority of antient monuments; from which it appears, that Faunus (Hermes) was inſidiouſly betrayed by his brethren to the children of Cham; among whom he was highly honoured, clothed in garments of gold, and worſhipped as a god, from his knowledge of future events †.

In the ſeries of Theban kings, extracted with ſuch ſingular induſtry, under Ptolemy the Third, from the ſacred books by Eratoſthenes, the firſt is Menes, perhaps Miſraim the ſon of Cham, called elſewhere Oſiris. Then follow the brothers Athotis I. and II. of which the latter, the Toſorthrus of Manethus, was ſkilled in letters, and various arts. Here, unleſs I am deceived, we find the firſt Hermes. Siphoas, or Memnon, the thirty-fifth in order, is diſtinguiſhed expreſsly by the ſirname of Hermes. This is the Proteus of Herodotus and Diodorus, the Amenephthes of Manethus, and probably, the Agamemnon of Homer, as he was not leſs remarkable for perſonal ſtrength, than for his extraordinary inventions.

* F. J. V. Schröders Bibl. für die höhere Naturwiſſ. t. i.

† Cedreni Hiſt. & Chr. Alex. Conf. Gen. xxxix--xli.

inventions. Have we not, then, found Hermes II.? The great variety of names that occur in the hiſtory of Egypt, have rendered it extremely confuſed; as every king received a new ſirname as ſoon as he was initiated in the myſteries of his religion.

Seſoſtris is decorated with the name of Mercury, on account of his wiſdom, by Cicero; and by ſome is imagined to be the ſame with Cadmus, who, having received letters from the Hebrews, was the firſt who communicated them to the Egyptians, Greeks, and Phœnicians. If it is really ſo, then, as C. W. Beyer with great ſtudied arguments endeavours to demonſtrate, it will be eaſily underſtood, that the letters invented by the firſt Hermes were ſymbols of things only, and that the ſecond Hermes ſeems to have been the author of theſe ſigns of ſounds, which are at this time properly denominated letters.

That it may appear in what manner theſe ſeverally agree, it will be right to attend to the following circumſtances. According to him, the deluge was 2289 years before the birth of Chriſt;—the arrival of Cham in Egypt, and beginning of the reign of the gods, 2188 years;—the coming of Abraham, 1922 years;—the death of Cham, end of the government of the gods, and Menes king, 1857 years. Seſoſtris 987 years;—and Siphoa, 889 years*.

 However

* Baumgarten, l. c. Syncellus has preſerved the arrangement of Eratoſthenes.

However it may be decided with regard to these Hermeses, it is evident, that they far surpassed their cotemporaries in learning and sagacity, and that the Egyptians were indebted to them as the authors of that wisdom for which they were afterwards so much renowned. According to Herodotus, the Egyptians were the wisest of the human race. The things most worthy of being known were retained by the priests, of whom there were three communities, in the time of Diodorus, at Heliopolis, Memphis, and Thebes. Among them different sciences flourished, cultivated by different persons *; but so solicitously were they kept a secret, that not even the Hierophanti, or the Kings, who were often chosen from the sacerdotal order †, were admitted to the knowledge of the sublimer studies, unless they were first strictly examined. They were unwilling that their secrets should be communicated to many, and punished those who ever revealed them. The letters called sacred were known to them only, having learned them privately from their ancestors ‡. The people they amused with fables, but philosophised themselves under the names of deities §.——It is now proper to inquire, whether these mysteries bore any relation to the intimate nature of bodies.

That

* Herod. lib. iv.

† Plutarchus de Iside.

‡ Clemens Alex. Str. l. 1.

§ Origines contra Celsum, l. 1.

That the chief of their religious opinions were involved in enigmatical obſcurity, and allegorical ſymbols, is beyond all diſpute: But it is by no means a conſequence, that they each took their riſe in phyſical qualities, taken from the very heart of natural philoſophy, although it is poſſible that they came to treat afterwards of things more abſtract, and leſs obvious to the ſenſes.—We are ſurpriſed at the author of Atlantica, whoſe very fertile genius, ſupported by great ſhew of erudition, has ventured to tranſport the iſland of Plato to the north; but we are not leſs aſtoniſhed at the great undertaking of thoſe, who pretend to diſcover, in a myſtic ſenſe, the philoſopher's ſtone, the making of gold and ſilver, in the mythologic fables of the Greeks and Egyptians.—Certainly, whoever has conſidered theſe attempts will wonder at the extraordinary coincidence of ſo many monuments, even the moſt triffling*.—But the limits that we have precribed to ourſelves do not permit a more particular examination.

Pliny, ſpeaking of the Egyptian obeliſk, in the great circus and Campus Martius, adds: "Inſcripti "ambo rerum naturæ interpretationem Egyptio"rum philoſophia continent." Some, inſtead of "phiſophia," read "opera philoſophiæ." Which-

 ever

* See the various writings of Borrichius,—alſo the Chemical Heaven of Tollius in all the ſenſe of madneſs,—and D. Pernety, who, like all the reſt, has handled this ſubject, in a book lately publiſhed, entitled, "Fables Egyptiennes et Grecques devoileés.

ever reading is preferred, the ſenſe will be nearly the ſame, as it grants that natural philoſophy was written in theſe hieroglyphics *.

In the following pages, the teſtimonies of many will be found to corroborate the received opinion, that their phyſical tenets were expreſſed in ſuch ſymbols.—But, as no ſtranger was capable of reading and explaining them, there can be no authority for further conjectures.—Following the ſentiments of Julius Firmicus Maternus †, a writer of the 4th century, many as yet contend that the ſacerdotal art, or ſacred and divine ſcience, as it is called, conſiſted chiefly of magic and alchemiſtry ‡. By magic, however, they do not here underſtand thoſe diabolical and forbidden practices, which obtained even in the time of Moſes §, but merely an attention to the works of nature, and the particular qualities of bodies, whoſe ſecret modes of operation, diſtinguiſhed commonly by the epithets ſympathy and antipathy, enabled them to diſplay all their miracles.--Hence the difference between magical medicine, hermetic or philoſophic, and empiric; for the former, reſting ſolely upon obſervation, conſiders the cauſes of diſeaſe, the ſigns of bodies, and virtues of remedies, and which Iſocrates thinks ſo deſerving of praiſe, as to give to the Egyptians the

* L. xxxvi. 9.
† Matth. L. iii. c. 15. conf. Præf. l. ii. iii. iv. v.
‡ Schröder, l. c.
§ Exod. vii. and viii.

the ſuperiority in all the arts*. Their ſkill has indeed been greatly admired by many writers†; but, it muſt be confeſſed, their remedies bore often the appearance of ridiculous mummery.—Galen aſſirms, that King Nechepſus, 630 years before Chriſt, had written, that, if a green jaſper, cut into the form of a dragon ſurrounded with rays, was applied externally to the pylorus, the ſtomach would be ſtrengthened. Have we not here the traces of amulets and taliſmans?

Under all the changes in their government, under all their kings, and under the yoke of the Perſians, Babylonians, Grecians, and Romans, though ſcience did not flouriſh among the Egyptians with equal vigour, yet did it continue to be cultivated and protected, until the deſtruction of Alexandria by the Arabians. Ptolemeus Soter had collected a library in Bruchius, which by the care of his ſucceſſor, Philadelphus, increaſed from 100,000 volumes to 400,000; with which number it was ſo crouded, that it became neceſſary to erect a new hall at Serapis, ſufficiently large to receive thoſe who were daily coming to it. This offspring of the old library, in a few years, could boaſt of 300,000 volumes. The firſt collection was reduced to aſhes, by accident, in the war with Julius Cæſar, but the Se-
rapic

* Conf. Celſus, L. xxxvi. c. 2, 3, et 4. in laudibus Buſir. et Apuleius in Apol.

† Diodorus & Pliny.

rapic was continually augmenting, and poſſeſſed, at the taking of Alexandria, in 642, above 700,000 volumes. John Philopon, a philoſopher, petitioned the general of the Saracens, Amri Ebnol-As, that he would ſpare him part of this library; but he dared not to comply with his entreaties, without permiſſion from Omar, the ſecond caliph; who, when it was requeſted of him, returned for anſwer, that the books could not be ſaved; for, if they agreed with the tenets of the Alcoran, they were uſeleſs, if they differed from them, they were dangerous *. From this blow the greateſt treaſure of the knowledge of the ancient world was totally deſtroyed, and the barbarians employed, for above ſix months, all its various manuſcripts to kindle the fires of their baths, of which there were above 4000 in the city.

Cambyſes, indeed, carried off the ſacred volumes, but the prieſts either ſecreted ſome, or recovered them afterwards, or compoſed others again from the monuments; for both Herodotus and Diodorus, and Eratoſthenes ſaw ſeveral; and the latter diſtinguiſhed the genuine from the falſe.—But it is not unlikely, that the hiſtorical books were of eaſier compoſition, and written in another manner, as Eratoſthenes was able to underſtand them.

Candidly, however, it muſt be acknowledged, that doubts may yet be entertained of all the proofs

* Abulpharagii Hiſt. Dynaſt.

proofs that we have brought, eſpecially when they relate to the periods of the greateſt antiquity.

For, if we examine into circumſtances, that preceded the age of writers of the 15th and 16th centuries, and which were recorded by foreigners; if we conſider the enigmatical ſtyle of thoſe times; and, laſtly, if we attend to the imperfect ſtate of writing, the uncertainty of various relations and books, and the errors and alterations in manuſcripts, it will be impoſſible not to heſitate in our belief. Some authors ſpeak of one Mercury only, others will have two; Abulpharagius names three, Lactantius four, and Cicero inſiſts on producing five.---How, then, if their number is as yet undetermined, ſhall their actions be defined, and dates aſſigned to their exiſtence? Let us paſs therefore to the arts of the Egyptians, which may probably be involved in leſs darkneſs.

Diodorus Siculus, who viſited Egypt under the reigns of Julius and Octavius Cæſar, at a time when arts were in full ſplendor in the Roman empire, ingenuouſly confeſſes, that they were highly cultivated among the Egyptians, and brought to the greateſt degree of perfection. He mentions, that eggs were not hatched there by the birds; but that the Egyptians, contrary to the cuſtom of any other country, were able, by their ingenuity and ſome natural proceſs, to

bring

bring forth the fœtus into life *. But here let us rather examine the ſtate of thoſe arts which flouriſhed in Egypt upon chemical principles.—Of theſe proofs may be procured far leſs ſuſpicious, as they are yet to be found by thoſe who travel into that country.

Their pharmacy ſeems entirely to have conſiſted of extracts, infuſions, decoctions, and mixtures.—From Dioſcorides and Pliny we learn, that they uſed the cyperus papyrus, burnt to aſhes, inſtead of cauſtics †.—Galen ‡ aſcribes to the Egyptian prieſts the compoſition called *cypheos*, conſiſting of myrrh, cinnamon, turpentine, ſpice, cyperus, juniper, and bdellium, the perfume of which they uſed as being acceptable to the gods; and we are told by Dioſcorides §, that this mixture was conſidered as an alexipharmic, and ſerviceable in aſthmatic complaints. Galen aſſerts, that the compoſition of Hermon, the ſacred ſcribe, which is called alſo *Iſis*, was taken out from the ſacred depoſits in the temple of Vulcan ‖. Beſides turpentine, this receipt contained flakes of copper, ruſt of braſs, ſal ammonaic, burnt allum, and ſeveral other things. They had various plaiſters formed of litharge, æs uſtum, diphrygis, miſy, ſory, calx of ſilver, and other metallic ſubſtances; and which were known before the time of

* Lib. ii.

† H. N. xxvi. 2.

‡ De Ant. l. ii. c. 2

§ L. i. c. 24.

‖ Comp med. l. v. c. 1.

of Hippocrates.—Theſe and other examples, though they do not indicate a very profound knowledge of pharmacy, yet they are by no means contemptible.

That ſculpture in all its branches flouriſhed among the Egyptians, is evident from thoſe wonderful edifices of hewn ſtone, the Pyramids, which have ſo long withſtood the ravages of time; and from the marbles, ſtatues, obeliſks, and temples, which we every where meet in Herodotus, Diodorus, Strabo, Pliny, and Marcellinus; and are to be ſeen in Rome at this day. It ſeems highly probable, that Panopolis was the chief and moſt antient *paleſtra* λιθουργῶν. Strabo* makes mention of it; and it was hither without doubt, that the moſt famous Grecian ſtatuaries reſorted. In the earlieſt periods they were acquainted with the method of burning bricks†, of forming vaſes for ointments out of alabaſter‡, and of making mortars for medical purpoſes from granite, the Pyrrhopœcilus of the antients§. They had ſome mortars alſo of black marble||.

Pliny mentions, that common ſalt was obtained from a lake in the neighbourhood of Memphis¶, and nitre at Naucratis and Memphis.— Strabo

* Geogr. xvii.

† Exod. v. 5.

‡ Plinius, l. xxxvi. c. 8.

§ Dioſcorides, l. v. c. 102.

|| Plin. xxxvi. 17. Strabo, l. xvii.

¶ Plin. l. xxxi. c. 17. What he relates in this chapter of the

Strabo ſpeaks of two placed beyond Momemphis, where nitre is produced. The Egyptian nitre, according to Pliny *, was dark coloured, and hard like a ſtone; and the proceſs of making it ſimilar to that of ſalt, except that the ſea was let into the ſalt pans, while the Nile only entered thoſe for nitre. As the Nile retired they became dry, but were kept moiſt for forty days, by being ſprinkled with the nitrous ſolution. If rain fell, they diminiſhed a proportional quantity of the Nile, and removed the nitre from the pits as ſoon as it began to thicken, leſt it ſhould be again diſſolved. In this oily ſtate they applied it as a remedy for the ſcab in animals.—When laid by in large maſſes it becomes hard. They reckon the lighteſt part of nitre, and conſequently the frothy part, the beſt; but the coarſe dregs are ſerviceable in dying purple and all other colours.——The Memphitic nitre was foul in its concretions; from whence the ſtony maſſes of which vaſes were formed, and ſometimes reduced to a coal by means of ignition with ſulphur. The aphronitrum, or ſcum of nitre, was brought in veſſels covered with pitch, leſt it ſhould diſſolve by contact with the air.—Nitre was adulterated with lime, which was eaſily diſcovered by the taſte; the genuine melted readily in the mouth, but the ſpurious was extremely

the flower of ſalt, ſeems to apply properly to the flowers of ſal ammoniac.

* L. xxxi. c. 10.

extremely pungent, and emitted a powerful odour. They were diſtinguiſhed alſo by burning them in the fire; the adulterated being always in a cloſe veſſel, that it might not fly out; the genuine not requiring that precaution. From other circumſtances it appears, that the nitre of the Egyptians was mineral alkali, in ſome degree cauſtic, combined with nitrated volatile alkali *,

Pliny commends the Egyptian alum †. Dinon in his commentary on Athenæus, thinks, that ſal ammoniac was ſent from Egypt into Perſia ‡.

The Egyptians obtained oils from the richeſt olives, from radiſhes, graſs, ſeſamy, nettles, and other vegetable ſubſtances §. The mummies which are yet found entire, afford ſpecimens of the moſt perfect ſkill in embalming. Herodotus,

* Boyle received in a preſent from the Engliſh ambaſſador at the Porte, a piece of Nitre from the river Nile, which deliqueſced in the open air as readily as ſalt of tartar, and efferveſced violently with the acetous and marine acids. See De Produc. Chem. Princ. § 3. Barkhuſen reports, that the ſalt extracted from the Nile, when mixed with lime, has an urinous ſmell, Acroam. 134. To the ſame ſalt muſt be attributed what we read of the Nile in Proſper Alpinus, in Hiſt. Æg. that it poſſeſſes a ſaline taſte, is purgative, emmenagogue, and diuretic

† L. lxxxv c. 15.

‡ Dipnoſ l. ii. c. 29.

§ Plinius, xv. 7. xix. 5.

tus*, and Diodorus Siculus†, relate, that the Ethiopians formerly inclosed their dead bodies *in glass*; but which Gesner contends is to be understood as *amber*‡. As to what we are told of their perpetual lamps, from Arabian authority, if they are not wholly fabulous, they can have been nothing else than threads of amianthus (or earth flax,) and small streams of bitumen, with which those regions abound.

Diodorus mentions a place in which were several large golden mines, that were wrought by many thousand men in chains; and he speaks also of the working of gold and brass at Thebes§. It is worth while to attend to the description he gives of their operations, and of the minerals on the confines of Arabia, with which, he says, the kings were acquainted in the earliest ages. The soil is black, and produces white veins of marble. The mineral, rendered brittle by calcination, is first broken and then divided into smaller pieces, and pulverised in mills; the earthy part is separated by washing on an inclined plane; and then certain proportions of lead, of salt, tin, and a flux being added to the residuum, the whole was put into covered crucibles, and exposed to the fire for five *nychthemera*; and thus pure gold without any scoriæ was obtained. Here we

* Thalia.

† L. xv.

‡ Act Goetting, l. 2.

§ L. iii.

we ſee the ſame proceſſes as are yet employed by the moderns.

They did not engrave, but painted Anubis on their ſilver veſſels *; and Heliodorus records, that Chariclea the daughter of the Egyptian prophet wore at her breaſt golden ſerpents of an azure colour; that the ſplendor of the gold had been deſtroyed by art, to imitate the rough and various ſcales, and repreſent the ſkin ſpotted with black and yellow †. From this, then, it appears that the art of colouring metals by fire was not unknown in thoſe days.—The Egyptians made glaſs of a dark colour, ſometimes tranſlucid, called *obſidianum*, in imitation of that which was diſcovered by Obſidius in Ethiopia ‡. But their magnificent cups betray a conſiderable knowledge in the art of making glaſs; and of which the Emperor Adrian, then reſiding at Alexandria, thus writes to the conſul Servius: "I have "ſent to you ſome Alaſſian cups of various co-"lours, given to me by the prieſt of the tem-"ple: They are dedicated to you, and particu-"larly to my ſiſter; and I deſire that you will "always produce them at your feaſts on holi-"days §."——Beſides theſe proofs of their ſkill, we have teſtimonies of their being able to imitate the emerald. Pliny mentions, that in his time

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* Plin. l. xxxiii. c. 9.

† Æthiop. l. v.

‡ Plin. l. xxxvi. c. 26.

§ Lib. Phlegontis.

there was ſtill extant in an Egyptian labyrinth a Coloſſian Serapis of emerald, meaſuring nine cubits high: And Theophraſtus alſo deſcribes an obeliſk in the temple of Jupiter, formed of four emeralds, that was 40 cubits in length, and in ſome places four, in others two, in diameter *.—That, therefore, the Egyptians had very ſucceſsfully imitated the emerald, is beyond a doubt; for there ſcarcely, or perhaps never, was found real ſtones of ſuch magnitude. They repreſented the turqueois alſo, as we learn from Theophraſtus; and the merit of giving it the blue colour is aſcribed to one of their kings †. Were they acquainted with cobalt ‡? Pliny aſſerts, that

* H. N. xxxvi. 5.

† Of Stones, 98.

‡ The celebrated Pauw affirms that the Egyptians uſed ſmalt, and the Romans alſo, if we believe Lehman, were not ignorant of this mineral. Ferberus and Delaval entertain the ſame opinion, which the one ſupports, by appealing to the ſmall Egyptain images incruſted with blue glaſs, and the other from the little blue ſtones that are every where found in the ſepellated works and pavements of the ancients. The illuſtrious Gmellin, Prof. Gotting. however, denies that the account given of it by Pliny can poſſibly apply to cobalt, and chuſes rather to underſtand from the writings of this naturaliſt the native blue calx of copper, called ultramarine. Beſides, he thinks that the blue colour of Egyptian glaſs was imparted to it without fire; or, if indeed fire had been employed, that it was obtained from ſome other metal than cobalt. Experiments confirm this opinion. Not far from mount Peligard, a few years ſince, ſome ſepellated pavement of various coloured ſtones

that their opaque red coloured glaſs, called Hæmatinos, the white and *murrhine*, and the imi-

C 2 tations

ſtones was dug out of the earth. Some of thoſe that were blue Gmellinus diſſolved in aqua regia; and, having made a perfect ſolution, he diſcovered evident marks of iron. Had there been any cobalt, it would have formed the ſympathetic ink. There is no mention made of cobalt among ancient authors; for what is called *cadmia* by Pliny ſeems to have been zinc, or rather arſenic.—I have not heard of any one yet who has found cobalt, either in Egypt, Arabia, Numidia, or Ethiopia. And, as to the mineral of which Lehman ſpeaks, that was brought from mount Atlas, and poſſeſſed the property of tinging glaſs of a blue colour, it was probably the ore of ſome other metal. If you except Piedemont, there is no appearance of cobalt in all Italy. It was certainly found however in Piedemont after the time of the Romans: and the inhabitants of that country were ſo ignorant of the art of making it into ſmalt, that they ſold the cobalt but rudely calcined to the people of Nuremberg. The iſland of Cyprus ſo celebrated for its veins of copper, produced no cobalt. This mineral, however, was firſt dug up in later times in the country of the Griſons, in France, and in Spain. It is well known, that the Chineſe, Japaneſe, and Indians uſe a blue pigment in colouring their porcelain, and that they have long poſſeſſed this art; but, it is probable that they took the lapis lazuli for this purpoſe, with which the northern provinces of China every where abound. Delaval, by ſome particular proceſs, made a blue glaſs with iron, which he mixed with other glaſs that was white and pellucid, and thus obtained various degrees of colour, but not all thoſe which are diſcovered in the ancient monuments. Iron is found every where; and it is not poſſible, that thoſe who knew how to make porcelain ſhould be ignorant of its uſe. The Egyptians were acquainted with the hæmatites, and with red ochre, from both of which ochre is now extracted

in

tations in other colours of hyacinths and ſapphires*, nay, even the true precious ſtones could ſcarce be diſtinguiſhed from the falſe†.

Beſides wines, the Egyptians prepared a liquor from barley, in flavour and taſte very little inferior to the juice of the grape; and which they call *Zythus*, and ſuppoſe to be invented by Oſiris‡. Their vinegar is extolled as the beſt, by Chryſippus in Athenæus; and ſuch was its acidity, that it immediately diſſolved the greateſt pearl Cleopatra had in her poſſeſſion§.

Of their ſkill in colours we have many beautiful examples. They were acquainted with native minium. The words of Pliny upon this ſubject are worthy of attention: "Pingunt," he ſays, "et veſtes in Ægypto, inter pauca mi-"rabili genere, candida vela poſtquam attrive-"re, illinentes non coloribus, ſed colorem ſor-"bentibus medicamentis: hoc cum fecere non "apparet in velis; ſed in cortinam pigmenti "ferventis merſa poſt momentum extrahuntur "picta. Mirumque, cum ſit unus in cortina "color

in Numidia. And they muſt neceſſarily have known the blue ſcoriæ, alſo, that covers the ſurface of iron, obtained by fire from thoſe ores. From ſuch arguments as theſe, Gmelin contends that the blue glaſs of the ancients was not coloured with cobalt, but with iron. Vid Götting. gel. Anz 1776, St. 42.

* Lib. xxxvi. 26.

† Lib. xxxvi. 12.

‡ Diodorus Siculus, l. i. c. 20. 34.

§ Plin. ix. 35.

" color, ex illo alius atque alius fit in veſte, ac-" cipientis medicamenti qualitate mutatus, nec " poſtea ablui poteſt *."——Surely this is a deſcription of the colouring of ſilks.

But let theſe proofs ſuffice. Some of them are indeed not quite ſo accurate, and others are rather exaggerated: But we are not therefore to conclude, that though many chemical arts were not invented by the Egyptians, they were not cultivated ſucceſsfully by them. Indeed, if we credit Zoſimus, they were acquainted with diſtillations; for which he deſcribes various veſſels and apparatus, although he paints them in the rudeſt manner. Of the firſt uſe of pitch Pliny ſays: " Lignum (tæda) conciſum furnis undique " igni extra circumdato, fervet: primus ſudor " aquæ modo fluit canali: hoc in Syria cedrum " vocatur; cui tanta vis eſt, ut in Egypto cor-" pora hominum defunctorum eo perfuſa ſer-" ventur. Sequens liquor jam craſſior picem " fundit †." Of this we may underſtand a diſtillation *per deſcenſum*. In what manner oil is obtained from pitch he deſcribes elſewhere ‡; that while it is boiling, fleeces of wool are ſpread over it to receive the vapour, which is afterwards expreſſed from them. No doubt this is a proceſs of diſtillation in its infancy.

Whether they underſtood χρυσοποιησιν we cannot learn from the antient monuments. Some authors

* L. xxxv. 11.
† L. xvi. 11.
‡ L. xv. 7.

thors inſiſt, that is naturally to be inferred from the immenſe wealth and power of the Egyptians. So many huge pyramids, obeliſks, coloſſi, extenſive cities, and hanging gardens; ſo many ſepulchres, labyrinths, ſubterraneous caverns, and other works of Herculean labour, which were formerly found, and of which part remains yet entire, could never have been erected but at an incredible expence.

In Diodorus Siculus we find, that Seſoſtris covered a ſhip of cedar with gold; that on the top of the ſepulchre of Oſymandua, there is a circle of gold of 365 cubits; and that, in the time of Oſiris, ſtatues, and even entire temples, were made of gold. But we dare not vouch for the truth of theſe relations. However great might be their riches, we are certain, that they had no gold mines in the time of Hermes; and that thoſe which were afterwards diſcovered were wrought with great coſt and labour, and with very little profit: So that many are of opinion, the Egyptian kings worked theſe mines as a colour and pretext for the treaſures they had otherwiſe amaſſed. Herodotus and Diodorus both make mention of a temple at Memphis that was dedicated to Vulcan; and the latter adds, That the invention of all the operations relating to copper, ſilver, and gold, and of every other ſubſtance that is prepared by fire, was attributed to this deity *. Under the name of Vulcan

* Bibl. Hiſt. l. v. l. 1. c. 13.

Vulcan, they worſhipped fire itſelf, for they believed that it was eſſentially neceſſary to the creation and perfection of all matter*. Zoſimus calls Panapolis the ſchool of chemiſtry; and Syneſius confirms this ſentiment. Cedrenus in the eleventh century throws more light upon this queſtion, for he ſays, That "Faunus, named "elſewhere Hermes, του χρυσου την φυσιν (in other co-"pies την ποιησιν) εξευρεν εκ μεταλλων†." But nevertheleſs, all that has been ſaid does not, in my opinion, prove that the Egyptians underſtood the χρυσοποιησιν, or art of making gold; and we know from daily experience, that whole ſtates, ignorant of this art, riſe to wealth and power by induſtry alone. However, in ancient times, it is well aſcertained, that vaſt quantities of pure gold were concealed in that quarter of the globe, which had been extracted from the ſoil there, or imported by commerce, or wars with the neighbouring nations, and thus had increaſed their treaſures.

This extraordinary rage of converting every thing into gold ſeized all the chemiſts of the fourth century. As gold had been long conſidered as the medium of exchange in the purchaſe of every commodity, the chemiſts, who were better acquainted with the various qualities of bodies than others, and who ſaw miracles riſing daily under their hands, and allured

* Ibid. l. ii. c. 2.

† Hiſt. Comp.

alſo by the love of gain, and perhaps by vanity and arrogance, unanimouſly turned their attention to the making of this moſt precious metal. They knew that art could effect various changes in the appearance of metallic ſubſtances; and wherefore ſhould they think it not competent, by proper experiments, to form them in this moſt perfect character?

This problem, however difficult it may appear, no one had then demonſtrated to be incapable of ſolution; and, it may be added, that not, even in our times, has its abſurdity been proved. Therefore, not without ſome proſpect of ſucceſs, did theſe alchymiſts employ numberleſs means to attain their object. But, it is evident that they toiled in this occupation under no good auſpices; for their conſtant perſeverance, labour, and expence, were not only employed without ſucceſs, but they themſelves wandering from the true paths of philoſophy, and loſt in viſionary dreams, began to entertain conceits hoſtile to the principles of ſcience. Encouraged by the wiſhed-for gain, they bent all their thoughts, and every faculty of the mind, to the ſolution of this myſterious problem; ſo that, had any one been ſo fortunate as to have obtained the reward of his labours, he would have deſerved the appellation of a covetous χρυσοποιητοῦ, rather than that of a ſkillful chemiſt. Under the dominion of ſordid avarice, and miſerably envious, they impoſed upon themſelves a ridiculous ſilence,

ſilence, and, although they poſſeſſed ſcarce any ſecrets for carrying on what they called the *great work*, yet did they involve that art, which they pretended to deſcribe, in ſo many abſtruſe hieroglyphics, ſigns, and expreſſions, as not only to prevent others from receiving information, but alſo to conceal their own ignorance under the thick covering of ſuch darkneſs. Some writers imagine, that the table of Hermes alludes to this art, and that it is concealed alſo in the golden chain of Homer. Others, with more probability, believe it to exiſt metaphorically in the Golden Fleece of the Argonauts.—Johannes of Antiochus, who lived during the reign of Heraclius, and after him Suidas, are expreſsly of opinion, that it is underſtood in the Golden Fleece. ὅπως δεῖ διὰ χημείας χρυσὸν ἐργάζεσθαι γεγραμμένον. Beſides, it is well known, that the ancients did not ſpeak only of books, under the name of ſkins; but, as we are informed by Plutarch, 200,000 books, that were taken from the libraries of the kings of Pergamus, and which Anthony preſented to Cleopatra, were all written on the hides of goats. The profeſſors of this art explain to us the way, alſo, in which the knowledge of their great work reached as far as Colchis.—According to Strabo, Seſoſtris did not overrun Ethiopia, Trogloditica, and Arabia, only, but he paſſed through all Aſia, likewiſe, and erected temples in various places *. From hence the antiquity of chemiſtry among the

* Geogr. l. xvi.

the Chinefe derives its origin: And further, it is added, on the authority of Herodotus, Diodorus Siculus, Strabo, and Marcellinus, that the Colchians were the remains of his army. In confequence of finding cinnabar, (the bafis of their great work), they determined to fix their refidence at Colchis; and afterwards, according to Pliny, having obtained the *virgin earth*, they extracted from it fuch confiderable quantities of gold and filver, that they furpaffed even the fuperb Sefoftris in their difplay of their riches, and in all the fplendor, which thofe metals could give to their apartments, their pillars, and various ornaments*. The leaders of thefe new fettlers, initiated in the facred rites of the Egyptians, now torn away from their native country, foon grew inattentive to that fecrecy, in which, according to the cuftom of the Egyptian priefts, the art of chemiftry was inviolably preferved, and revealed the whole, under the myftic reprefentation of the Golden Fleece. They repented, however, too late of their loquacity, when it led the Grecian plunderers to undertake the Argonautic expedition. Happily as all thefe relations feem to coincide, yet the account Strabo gives is worth the attention of every one who makes the attainment of truth the object of his enquiry. He fays, that the Iberians, near neighbours of the Colchians, ufed to receive the gold brought down from the high lands by the torrents, into fieves and fheep-fkins,

* Lib. xxxiii. c. 3.

ſkins, and from thence aroſe the fable of the Golden Fleece. The feigned antiquity, therefore, of the art, if it is not deſtroyed altogether, is at leaſt rendered very ſuſpected. But although χρυσον ποιεῖν, or εργαζεσθαι, may, in a literal ſenſe, mean the making of gold from its firſt principles, yet, with many writers, it ſignifies nothing elſe than the ſeparation of this metal from its ores. So, in the Latin tongue, he is called *aurifex*, who makes veſſels or other utenſils of gold. To make oil ſurely can mean its expreſſion only; and ſo on as to other things. If Suidas is to be credited, many records of this art were deſtroyed by fire in the third century *. Six hundred years before him, Paulus Oroſius, a Spaniſh prieſt, relates the ſame ſtory †. The emperor Diocleſian is ſaid to have treated the Egyptians very cruelly, becauſe they rebelled againſt him, and to have burnt all their books of the chemiſtry of gold and ſilver, leſt they ſhould draw ſuch wealth from that art, as to enable them, at a future period, to oppoſe the authority of the Romans. From this account, however, we are not led to any concluſions: One thing only we will venture to aſſert, that chemiſtry, at firſt ſeeming to ſignify the intimate knowledge of bodies, came afterwards to denote the making of gold and ſilver; then aſſumed ποιησεως, the name of a ſacred and divine art; and laſtly, with a fooliſh pride, was entitled

* In lexico.

† Hiſt. l. vii. c. 16.

tled *alchemiſtry*, as if κατ ἐξοχὴν, chemiſtry. The word alchemiſtry is firſt mentioned by Julius Firmicus Maternus, a writer of the fourth century, and then in a remarkable manner. His language, which ſavours much of aſtrologic inſanity, is as follows: "Si fuerit domus Mercurii, "dabit aſtronomiam; ſi Veneris, cantilenas et "lætitiam; ſi Martis, opus armorum et inſtru-"mentorum; ſi Jovis, divinum cultum ſcien-"tiamque in lege; ſi Saturni, ſcientiam alche-"miæ *." It occurs, however, but ſeldom before the ninth century; but, after that period, indeed very frequently. In the mean time, it is proper to obſerve, that in Suidas, as above cited, as well as in John of Antiochus and Cedrenus, quoted before, the word *alchemiſtry* never makes its appearance, but, inſtead of it, χημείας only, which, in the times of thoſe authors, admitted various ſignifications.

Let us now conſider the *manner* in which the Egyptians treated our ſcience. Proclus Lycius commends them for preſerving their inventions upon columns †. And Galen ‡, and Iamblichus § aſſert, that every new diſcovery was firſt approved by the common voice of the prieſts, and then engraved without the author's name upon the ſtones of the temple. Of the obeliſks above-mentioned

* Matth. l. iii. c. 15.

† Comm. i. in Timæum.

‡ L. i. contra Jul. De ſimp. med. fac. l. iv.

§ De myſteriis Ægypt.

above-mentioned, one was made by the command of Seſoſtris, the other by that of King Semneſert, in whoſe reign Pythagoras viſited Egypt; which clearly implies an uninterrupted progreſs in their inventions. Beſides Diodorus tells us, that the prieſts were in poſſeſſion of ſome writings ſtill more ſecret *; and which Clemens Alexandrinus ſuppoſes to have been thoſe of Hermes †. Plutarch alſo ‡, and long before him Sanchuniaton the Phœnician, make mention of them. The laſt, according to Porphyrius, was a great lover of truth. The ſame is ſaid of Philo Biblius, a man of great erudition and thirſt for knowledge; who being deſirous to learn the hiſtory of every nation, beſtowed his attention chiefly to the writings of Taaut, as he underſtood him to be the chief inventor of letters, and of writing in books. Philo quotes a book of Hermes on the origin of the world. Iamblichus aſſigns to him 36,529 books; which, after the manner of thoſe times, were without doubt very conciſe, and conſiſted of a few ſentences only. In another place, the poſition is further illuſtrated; for he aſſerts, that his followers or diſciples, ſuppoſing all ſcience to have owed its origin to their great chief, dignified their works by his illuſtrious name; ſo that we

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* L. ii. c. 4.

† Strom. i.

‡ De Iſide.

§ Euſebii Præp. Evang. L. i. c. 7.

can give but little faith, in theſe days, to the title of ſuch books as are aſcribed to Hermes.

We have already mentioned the writings of the columns of Hermes, that were tranſcribed by the ſecond Hermes into the ſacred books. Manethus is ſaid χρηματίσας εκ των εν τη Σηριαδικη γη κειμενον ϛηλων, which is a divination of future events, rather than a recital of circumſtances that had already happened. Beſides, in the preface dedicated to the King, Manethus adds: Επιζητουντι σοι περι των μελλοντων τω κοσμω γινεσθαι, καθως εκελευσας μοι, παραφανησεται ἁ εμαθον ἱερα βιβλια γραφεντα ὑπο του προπατορος Τρισμεγιϛου Ερμου *. From which it is ſufficiently clear, that theſe columns did not contain an account of the paſt only, but that they in ſome manner alluded to times to come; perhaps from the ſituation of the ſtars, as Hermes was ſkilled in aſtrology. Abulpharagius, alſo, relates, that the deluge was foretold by them †. Whether any other ſecrets, eſpecially thoſe belonging to chemiſtry, were written on them, it is not poſſible at this day to determine; the ancients, however, apprehended that there were.

Galen ſpeaks of the medical writings of Hermes ‡. Clemens Alexandrinus affirms, that he had written 36 volumes on the ſecrets of the Egyptians, and ſix on the healing art. Six of the firſt contained hymns, the duty of kings, and ſome

* Fragmenta in chron. Euſebii.

† Hiſt. Dynaſt.

‡ De ſimp. med. fac. l. iv.

ſome things relating to aſtronomy. Other ten explained the myſterious modes of writing, treated of the univerſe in general, of the earth, of the motion of the ſun, of the moon and planets, of Egypt, of the Nile, of conſecrated places, and of ſacrifices. Ten others preſcribed ſacrifices, hymns, ceremonies, feſtivals, burials, and many other things of a ſimilar nature. The third decade inveſtigated the nature of the ſoul and of the gods *. According to Diodorus, the ſacred books were entruſted to every phyſician, that he might learn from their preſcriptions to to cure the ſick.

Of the writings of the Mercuries ſcarce any are at this time to be found genuine. The manuſcripts in the library at Leyden, honoured with their names, of which one treats of *poiſons and antidotes*, and the other of *gems*, are of a much later period. The ſame may be ſaid of the *poemander*, *of Aſclepius*, *of the ſecret of the phyſical ſtone*, *of compoſition*, *of alchemiſtry*, *of the introduction to chemiſtry*, *of the phyſical tincture*, *of the ſeven chapters*, and *of the art of Agathodæmon of making gold;* and of all the others attributed to Hermes, which were either printed, or lie yet as manuſcripts in the duſt of libraries.

Albertus Magnus aſſerts, that Alexander the Great, in the courſe of his expeditions, diſcovered the ſepulchre of Hermes, the father of philoſophers, filled with treaſures, not of metallic

forms

* Strom. l. 6.

forms, but with golden writings, on a table of zatadus, which is called elsewhere emerald *. Whence he had this account he does not say; but, although this tablet is not mentioned by any Greek author, yet was it known, before him, unto Avicenna, the Arabian Aristotle, the elder Zadit, and to others. W. C. Kriegsman reports a tradition, that, some ages after the flood, it was found by a woman named Sara, in the hands of the corpse of Hermes, lying in a cave near the Hebrus. This first Hermes he supposes to have been Cain; nor is it inconsistent with this opinion, that the woman who discovered the body should be the wife of Abraham. The tablet was written in the Phœnician character. As it is but short, and resembles the symbols of the alchemists, it may not be improper to introduce it here in its Latin dress, in which the propriety of the original context is preserved, by the skill and labour of Kriegsman.

Description of the Secrets of Hermes Trismegistus.

1. *Vere non ficte, certissimeque aio.*
2. *Inferiora hæc cum superioribus illis, istaque cum iis vicissim vires sociant, ut producant rem unam omnium mirificentissimam.*
3. *Ac quemadmodum cuncta educta ex uno fuere verbo Dei unius; sic omnes quoque res perpetuo*

* De secretis chymicis.

tuo ex hac una re generantur dispositione naturæ.

4. *Patrem ea habet solem, matrem lunam: ab aere in utero quasi gestatur, nutritur a terra.*
5. *Causa omnis perfectionis rerum ea est per universum hoc.*
6. *Ad summam ipsa perfectionem virium pervenit, si redierit in humum.*
7. *In partes tribuito humum ignem passam, attenuens densitatem ejus re omnium suavissima.*
8. *Summa adscende ingenii sagacitate a terra in cœlum, indeque rursum in terram descende, ac vires superiorum inferiorumqe coge in unum: sic potiere gloria totius mundi; atque ita abjectæ sortis homo amplius non habere.*
9. *Isthæc jam res ipsa fortitudine fortior existet: corpora quippe tam tenuia, quam solida penetrando subige.*
10. *Atque sic quidem quæcunque mundus continet creata fuere.*
11. *Hinc admiranda evadunt opera, quæ ad eumdem modum instituuntur.*
12. *Mihi vero ideo nomen Hermetis Trismegisti impositum fuit, quod trium mundi sapientiæ partium doctor deprehensus sum.*
13. *Hæc sunt, quæ de chemicæ artis præstantissimo opere consignanda esse duxi.*

Shroeder asserts, that this autographic tablet is still to be seen at Turin *; if so, it ought surely to be attentively examined and described.

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* Loc. cit.

It was firſt made public by Bernhard Caneſius the alchemiſt, as we are told by Kircher *; and that it contained the theory of the moſt valuable eſſence, which they call the elixir of life, potable gold, and the fifth eſſence. In the year 1657, W. C. Kriegſman explained the univerſal mercury of the philoſophers, and G. Dorneus gave an account of the practice of medicine, entirely upon the principles of chemiſtry.

As to the works of other authors which relate to this ſubject, none have as yet appeared except ſome written in Greek, or tranſlations from that language, and all of them alchemical. Many of theſe are ſpurious, as the *Eſſays of Iſis, addreſſed to her ſon Horus*, and the *Chemiſtry of Horus*. Of Moſes and Maria, Jews; of Sophar from Perſia; of Democritus the Abderite; and other Greeks, we ſhall ſpeak in another place. Leo Allatius, a Grecian, and with him Borrichius, both condemn as ſuppoſititious the works of Comarus, or Comanus, a prieſt, inſtructing the Queen Cleopatra in the ſecret of the philoſopher's ſtone; alſo the works of the Queen herſelf on weights and meaſures, on the making of gold, and the preſervation of beauty. The authors of theſe productions have attempted to gain both credit and attention by the ſplendour of illuſtrious names.

We

* Œdipus.

We ſhall proceed to make ſome few obſervations on the theory of the Egyptians reſpecting the principles and compoſition of bodies; as well as the mutilated fragments and enigmatical manner of writing will permit, and the various allegorical expreſſions, which allow ſuch different interpretations. Not Oedipus himſelf would be able to explain many of theſe. In Philo Biblius we find the following extracts by Sanchuniaton from the commentaries of Taaut on the origin of the world: "Principium hujus univerſitatis "ponit aerem tenebroſum ac ſpiritu fœtum, ſeu "mavis tenebroſi aeris flatum ac ſpiritum chaoſ-"que turbidum, atraque caligine circumfuſum. "Hæc porro infinita eſſe, nullumque niſi longo "ſæculorum intervallo terminatum habere. Verum, ubi ſpiritus amore principiorum ſuorum "flagrare cœpiſſet, eumque ſimul eſſet mixtio "conſecuta, nexum hunc motuum Cupidinem "appellarunt. Is quidem rerum omnium pro-"creationis principium fuit. Spiritus vero ſuam "ipſius procreationem minime agnoſcebat. Ex "hac illius conjunctione prodiit Mot, id quod "limum nonnulli, alii aquoſæ mixtionis corrup-"tionem eſſe volunt, ex qua ſecutæ productionis "ſemina, ipſaque adeo rerum univerſarum gene-"ratio extiterit. Ceterum animantia quædam "erant omni ſenſu carentia, quæ poſtmodum "intelligentia præditos animantes procrearunt. "Eos illi Zophaſemin, hoc eſt, cœli contempla-

"tores nominarunt, in figuram ovi conformatos.
"Illico autem MOT, cum ſole, luna, ſtellis, ac
"reliqua majorum aſtrorum multitudine emicu-
"it.——Cum igneum ſplendorem aer emiſiſſet
"ex ardenti maris ac terrarum inflammatione,
"venti nubes, magnoque ruentium impetu cœ-
"leſtium imbrium ac nimborum effuſiones ex-
"ſtitere: Cum autem hæc omnia, quæ diſtincta
"paullo ante, ac propter vehementiorem ſolis
"æſtum a propria ſede disjuncta fuerant, in eo
"committerentur, tonitrua ſimul ac fulgura pe-
"perere; quorum ad tonitruum fragorem, de-
"ſcripti antea intellectu præditi animantes ve-
"lut a ſomno excitati, horrendoque ſonitu ex-
"territi, mares pariter ac fœminæ, tam in ter-
"ra, quam mari, movere cœpere."*

Here we find ſome appearance of a tradition concerning the creation of the world, which, though ſo near the period of which it treats, is loaded with fictions, and diſguiſed with perſonifications. Coſmogony, which has, in a wonderful manner, ſurpaſſed all the powers of nature, muſt neceſſarily be a great obſtacle to the moſt ſagacious inveſtigation, not founded upon the principles of divine revelation. Beſides, they ſeem to have attributed a triple nature to all bodies, which they indicated hieroglyphically, under the names of Oſiris, Iſis, and Typhon, or of God, Air, and Night, ſignifying, perhaps, the

* Euſebii Præp. Ev. l. 1. c. 10.

the active Cause, the passive, and dead terrestrial matter *.

By divine energy they understand fire and the spirit of the world; by the passive æther, they mean something eternal, immaterial, and homogeneous †; and by mortuum malum, the inert matter of the earth. By the intervention of this spirit, they apprehend an uninterrupted communication is maintained between superior and inferior beings ‡. This system is assigned to Hermes, as he produced every thing by the means of two elements, Fire as acting, and Earth as acted upon §. They taught, that, by some internal separation, fermentation, or putrefaction, all bodies sprung from their seeds, were changed, increased, rendered perfect, and destroyed ‖. In these opinions some traces of a more intimate acquaintance with nature may be discovered: From which, it may be inferred, much light would be thrown upon natural philosophy from their doctrine, if we possessed it entire, and unclouded with fictions. The unconnected fragments only of it have reached us, and these collected by foreign writers; who, ignorant of the relation of the different parts of the system, have supplied many things from conjecture,

* Plutarchus de Iside et Osiride.

† Plato. Pythagoras.

‡ Porphyrius in vita Plotin.

§ Burgrave in Bibl.

‖ Diodorus, l. i. c. 13.

conjecture, and given to others a falſe interpretation.

§ IV. *The State of Chemiſtry among the Greeks.*

The Greeks, after they were inſtructed in the uſe of letters by Cadmus, cultivated various ſciences; but, for a long time they paid no attention to Natural Philoſophy, being more occupied in ſpeculation and debate, than in obſervation and experiments. From hence ſprung that variety of ſects and philoſophers, ſome of whom wandering about, diſplayed their wiſdom thro' ſeveral cities, with a view to profit; others, however, influenced by nobler motives, had a fixed abode, opened public academies, and taught their doctrines freely and without reward. But they were both led into a ſubtlety of diſquiſition and argumentation, highly inimical to the deſign of diſcovering phyſical truths. Therefore, the prieſt of the Egyptians of Sais ſays: "Oh Solon, Solon, ye Greeks will be always "children: There is not one grey head among "you, nor any ſerious kind of inſtitution *. "They reſemble boys in their loquacity and in- "ability to propagate: And, although wiſdom "falls from their tongue, their actions are weak "and puerile †." The words of Diodorus are remarkable: He ſays, That "Orpheus, Muſæus, "Melampus,

* Plato in Timeo.

† Bacon.

" Melampus, Dædalus, Homer, Lycurgus, Solon, Plato, Pythagoras, Eudoxus, and Democritus the Abderite, all went into Egypt, and they doubtleſs learned there all thoſe things which rendered them afterwards famous among the Greeks *. Plato and Eudoxus aſſociated during thirteen years with thoſe prieſts in Egypt, who moſt exeelled in the knowledge of celeſtial things: But, for a long while, they kept it in the greateſt ſecrecy, and would not deign to impart it to any one. At length, ſubdued by time and humble intreaty, they diſcovered ſome few things; but the greateſt part they concealed entirely from the barbarians †." Pythagoras ſuffered himſelf to be circumciſed, that he might have acceſs to the ſecret depoſits of the Egyptians, and learn their myſtic philoſophy ‡, Iamblichus ſhews clearly, that Pythagoras and Plato both had acquired a variety of knowledge in Egypt, from the columns of Mercury §; and Thales the Mileſian firſt brought geometry and aſtronomy into Greece from Egypt, about 530 years before Chriſt ||. Before the time of Pſammitichus, 660 years before our Saviour, the Greeks were not permitted to enter Egypt ¶; but,

* L. ii. c. 4. i. c. 69, 81, 96.
† L. xvii.
‡ Clemens Alex. Str. i.
§ De myſt. Egypt.
|| Diogenes Laertius.
¶ Herodotus. Strabo.

afterwards, many of them viſited that country, and even choſe their reſidence in it; and ſollicitouſly endeavoured to open an eaſier communication with their ſecrets: when, through Alexander the Great, Egypt became ſubject to the Macedonian yoke, 332 years before Chriſt, under the reign of the Lagidi, the moſt celebrated were received into the new academy of Alexandria. But it was the fate of all thoſe, who travelled into Egypt to be but little eſteemed in their own country; for, whatever ſublimity of knowledge they poſſeſſed, they communicated it at home ſo very myſteriouſly, as to be intelligible to a very few. In the mean time judicial aſtrology, muſic, and aſtronomy, were cultivated by them with great ſucceſs; and, though they were obliged to yield to the Egyptians in art's great undertakings, and in the magnitude of their works, and immenſe labour and expence; yet were theſe, in their turn, forced to acknowledge the ſuperiority of the Greeks, in the elegance and form which their artiſts gave to every thing, ſtrictly imitating nature; and in every work that depends upon fancy and imagination. In natural philoſophy they laboured with leſs advantage, unleſs inſtructed by the Egyptians. An Alexandrian ſect being eſtabliſhed among the Greeks, in the third century, the ſecrets of chemiſtry were ſtill more obſcured in darkneſs, and became dai-

ly

ly more involved in new enigmas, parables, and numberlefs Platonic and cabaliftic modes of expreffion. Greece and Egypt being equally fubjected to the power of Rome, fcience alfo was reduced to flavery, and was, at length, almoft finally extinguifhed by the conquefts of the Saracens.

Chemical arts made a much flower progrefs among the Greeks than among the Egyptians.

Ores were found in two places only. Thofe of the ifland of Thafo, in the Egean fea, yielded gold, and thofe difcovered in Laurus contained filver. But the Corinthians were acquainted with three metallic compofitions, formed in a particular way, by fire, and remarkable for their colour; one had all the white fplendor of filver, another the yellow hue of gold, and the third contained an equal proportion of both *. They feem to have carefully concealed thefe preparations, which were no other than of zinc and copper †. Copper takes its name from the ifland of Cyprus, in which it was firft difcovered. Pliny reckons the cerufe of Rhodes to be by far the beft ‡. According to Theophraftus, minium (cinnabar) was known to Callia, the Athenian, about five hundred years before Chrift, who

* Plin. xxxiv. cap. 2.

† The preparation of orichalcus, with copper and lapis-calaminaris was known to the ancients: Vid. Pliny, l. 34. Diofcorid. l. v. c. 85. The procefs of making fteel, by heating iron among coals is mentioned by Ariftotle, met. iv. c. 6. and Plin. l. xxxiv.

‡ L. xxxiv. 8.

who imagined that it contained gold; but, from making ſeveral experiments without ſucceſs, he learned the uſe of it as a pigment *.

Philippus Comicus, writing of thoſe times before the origin of the Grecian monarchy, aſſerts, that Dædalus took αργυρον χυτον to animate a wooden ſtatue, the knowledge of which metal he no doubt owed to the prieſts of Memphis; but, that Hermes ever obtained it from cinnabar, we can ſcarcely believe. Theophraſtus Ereſius and Ariſtotle ſpeak alſo of this metal †.

Sculpture and ſtatuary, though, perhaps, they did not owe their riſe, yet were they indebted for their perfection to the images of the gods. Dibutates, the Sicyon potter, was the firſt that wrought clay, at Corinth, into various figures and likeneſſes. Some indeed are of opinion, that Rhecus and Theodorus, in Samos, had invented the plaſtic art, long before the Bacchiadæ were driven from Corinth ‡. Before the taking of Troy, Dædalus the Athenian carved figures on wood; but Dipoenus and Scillis, born in the iſle of Crete, about the fiftieth Olympiad (576 years before Chriſt) were the firſt who ſignalized themſelves by ſculpture in marble §. The moſt ancient ſeals of the Greeks bear

* De lapidibus.

† Met. 4. 8. De anima, l. i.

‡ Pliny xxxiv. 12.

§ Pliny xxxvi. 4.

bear a ſtrong reſemblance to thoſe of the Egyptians, as Pliny writes; from whence it appears clearly, where they had been taught: although, following the footſteps of Phidias the Athenian, who lived 450 years before our Saviour, they carried this art to the greateſt perfection *. They did not cut and engrave ivory, pearls, corals, and marble only, but they worked in baſaltes, porphyry, and the hardeſt gems. On agates and cornelians they engraved chiefly concave figures; on onyx they raiſed them convex, often forming the head or image of the opaque ſtratum, lying on a ſurface more pellucid, and which they could darken at will, by a little pigment placed below it. Their later works of ſculpture and engraving are what we now call antique, and are in high eſtimation; and, on account of their perfect form, and exquiſite poliſh, have become models for the imitation of modern artiſts.

Long before the age of Homer, the Greeks knew how to melt, temper, caſt, engrave, and cement metals. Rhœcus and Theodorus ſeem to have fully underſtood the art of caſting copper; which, according to Pliny, took its riſe along with painting, under Phidias †. He reckons 366 maſters in this art ‡; and deſcribes various temperatures

* Pliny xxxiv. 8.
† Pliny. xxxvi. 5. See Heyne.
‡ Pliny, xxxiv.

temperatures of metals *. The caſting of ſtatues reached its height in the time of Praxitelis; although he is reported to have been more ſucceſsful in marble than in copper †. The name of Chares the Lindian is rendered immortal by the coloſſus of the ſun at Rhodes, which meaſured 70 cubits in height. This immenſe fabric, compleated in 12 years, at the expence of 300 talents, (about 274 years before Chriſt) was hollow within, and filled with ſtones; and without doubt muſt have been caſt at different intervals of time. After ſtanding 56 years, it was overthrown by an earthquake; and lay proſtrate where it fell, for nine centuries, until A.D. 651, when it was ſold in lots. Nine hundred camels were loaded with the different pieces ‡; and if we ſuppoſe each camel to carry 800 pounds, the weight of metal in the whole ſtatue will amount to the enormous ſum of 720,000 pounds.

Tychius a Bœotian is ſaid to have invented the art of preparing leather §.

Chemical filtration through wool is clearly deſcribed by Plato ‖. Hippocrates underſtood calcinations ¶. Galen gives an account of the *bal-* *neum*

* Ib. xxxiv. 9.

† Ibid. xxxiv. 8.

‡ Pliny, xxxiv. 7. Cedrenus.

§ Pliny.

‖ In Sympoſio.

¶ De hæmorrhoidibus, and elſewhere.

neum Mariæ, where he uſed oil inſtead of water *. He ſpeaks of ſublimation †, and diſtillation *per deſcenſum* likewiſe ‡. Dioſcorides, who was the great friend and follower of Cleopatra, the moſt luxurious of women, appears not to have been wholly unacquainted with diſtillation, as he ſpeaks very plainly of αμβικα, to which afterwards the Arabian particle *al* was added §. On looking into Pliny, we find a deſcription of a ſimilar proceſs for extracting quickſilver from cinnabar: "Patinis fictilibus impoſitum (minium) ferrea "concha calice (αμβιξ) coopertum, argilla ſuper-"illita; dein ſub patinis accenſum follibus con-"tinuo igni, atque ita callicis ſudore deterſo, qui "fit argenti colore et aquæ liquore." But certainly Galen knew nothing of this art; for he ſays: "Non multum abeſt, omnia vellem ſubire peri-"cula, ſi quam machinam, artemve invenire liceat, "ſicut in lacte contrarium partium, ſic et in ace-"to, ſeparandi ‖." He thought, however, that a lixivium could be made with waſhed aſhes; and therefore had ſome idea of alkaline ſalt, even of the cauſtic kind. But he ſeems to have been wholly ignorant of reducing them to a dry ſtate ¶.—In the iſland of Leſbos they had a manufactory of glaſs **.

In

* De ſanitate tuenda, l. iv. c. 8.

† De medic. ſimp. fac. l. ix.

‡ De facile parabilibus.

§ Mat. med. l. v. c. 110.

‖ De med. ſimp. fac. l. i.

¶ Ibid. c. 14.

** Athenæus Deip.

In this place may be remarked the invention alſo of Callinicus the architect, who, when he had fled from Heliopolis in Egypt to Conſtantinople, diſcovered the *marine fire*, (πυρ θαλασσιον) which they call *Greek* likewiſe; and burnt during winter the fleet of the Saracens at Cyzicus *. This fire, when thrown into the water, acquires greater force, flies about violently in all directions, conſuming every thing in its way that is the leaſt combuſtible. Conſtantinus Pogonatus, who was then on the throne, and his ſucceſſors, uſed it with advantage in their wars with the Saracens. It was reckoned one of their valuable ſecrets; and as ſuch has been faithfully kept, for we are not in the leaſt acquainted with its compoſition.

Among the writers on chemiſtry I ſhall not reckon Orpheus †, Homer, or Pindar, and ſeveral others of the ſame kind; as no one has demonſtrated, that the fable of the golden apples of Heſperis, of the Hydra conquered by Hercules, of the Phœnix riſing from its own aſhes, of the golden

* Cedrenus.

† Orpheus is the reputed author of the Argonautic hymns, and a ſingular book, entitled περι λιθων, which treats of the ſecret nature of ſtones, and explains their virtues in the offering of ſacrifices, and rendering the gods propitious. The ſtones mentioned in this book are nearly the following:——— Κρυσαλλος, γαλακτιτης, πετρακες, αχατης, κερας ελαφυ, βαρβαρος λιθος, ιασπις, τοπασιος, οπαλλιος, μαγνητης, οσριτης, γαγατης, σκορπιος, κορυφωδης, κυραλλιον, νευριτης, χαβασιος.

golden fleece, and ſimilar ſtories, contain any alluſions to the ſcience of chemiſtry.

In thoſe works which are attributed to Pythagoras and Plato, many ſubjects of chemiſtry are to be found; but they relate more to theory than experiment. Of the Greeks ſcarce any one had imbibed ſo much knowledge from the Egyptians as Democritus, who was born about 458 years before Chriſt at Abdera in Thrace.

Seneca reckons him the moſt ingenious and acute of all the antients; as he diſcovered the method of diſſolving ſtones; of making artificial emeralds, and tinging them with any colour; of ſoftening ivory; and was the author of many other uſeful inventions*. And Petronius alſo ſpeaks of him, that he expreſſed the juice of all plants, and that he paſſed his whole life in making experiments on the different properties of foſſils and vegetables†.

Often laughing at the follies of mankind, he was conſidered by the vulgar to be diſordered in his underſtanding; and Hippocrates being called in to cure him, ſoon found him to be the wiſeſt man of the age. In his preſence he determined the colour of an animal by looking at its milk only; and did many other things equally wonderful, if we admit the veracity of Diogenes Laertius. With ſo much earneſtneſs did he apply

* L. xiv. ep. 41.

† In Satyrico.

ply himſelf to the ſtudy of nature, that he declared, he would prefer the diſcovery of one cauſe in the works of nature, to the poſſeſſion of the Perſian monarchy*. Syncellus ſays, that he obtained the celebrated name of Natural Philoſopher from Oſtane the Mede, who was ſent by the kings of Perſia for the government of religious affairs into Egypt.———By him Democritus was initiated, and inſtructed in the ſacred writings, in the temple of Memphis, among prieſts and philoſophers; with whom was Maria, a Hebrew woman, ſkilled in all kind of learning, and Pammenes. He wrote of gold, of ſilver, of ſtones, and of purple colour, in the ſame enigmatical manner that Maria did. Yet both Democritus and Maria are praiſed for this myſterious and dark ſtile, in which they have buried the art; while Pammenes is blamed for having written fully, and with perſpicuity †.

Diogenes Laertius aſſerts, that he wrote περι ποιησεως, alſo περι λιθου: Of which Zoſimus ſpeaks thus: Δημοκριτος λεγει, δοξαι λιθον, τον ου λιθον, τον ατιμον και πολυτιμον, τον πολυμορφον και αμορφον, τον αγνοςον και πασι γνοςον, τον πολυονομον και ανονυμον. Yet may it be doubted, whether Democritus ever treated of the philoſopher's ſtone, when ſome will have the title of the work ſtand, περι λιθων. And beſides his treatiſe *de ſolis et lunæ tincturis, et purpura*, there is another attributed

* Dionyſ. Alex. apud Euſebium, xiv. 27.

† Chron. p. 248. Vid. Euſebius.

buted to him, *de lapidibus pretioſis*. Others alſo believe the *Phyſica* and *Myſtica* to be his: But it is not yet aſcertained that any of theſe are genuine, and which is entitled to his name.—Vitruvius ſpeaks of χειροκμητα *, which are ſo called on account of the waxen marks ſtamped with a ring which he uſed to put to all thoſe paradoxes that he had found to be true; or becauſe he inſerted nothing into that book but from his own obſervation and experiments.

Ariſtotle the Stagyrite, in his third and fourth book of Meteorologics, treats of foſſils, dividing them into ορυκτα and μεταλλευτα. His diſciple Theophraſtus Ereſius wrote περι λιθων, and although he was ignorant of chemical analyſis, yet he deſcribes ſeveral qualities, and ſometimes their condition by fire. Dioſcorides of Anazarba, in the firſt century †, and Galen in the ſecond ‡, enumerated all thoſe minerals that were uſed in medicine.

There is yet extant a manuſcript chemical treatiſe of Porphyrius in the third century, a work of Iamblicus in the fourth, and an Iambic poem of Heliodorus, to Theodoſius the Great, *Of the myſterious Art of Philoſophers*. The fifth century produced *the tinctures of Perſian copper and Indian iron*, by Philip of Sides; the

* L. xi. c. 3.
† Mat. med.
‡ Simp. med fac.

Eſſay of Dioſcorus, the high prieſt of Serapis in Alexandria, and the *Letter* of Syneſius to the ſame Dioſcorus; being a comment on the Tincture of gold and ſilver of Democritus. Zoſimus mentions this, who, therefore muſt have lived after theſe philoſophers; but it is impoſſible, in a general ſketch only, to fix the age of every one with perfect accuracy.

Zoſimus of Panopolis, ſo highly eſteemed by the alchemiſts, was alſo referred to the fifth century. His work, *Of the Compoſition of Waters; of the ſacred and divine Art; of Virtue, and Interpretation; of Inſtruments and Chimnies; of the Aſbeſtos*; and his myſtic treatiſe and writing to Theoſebia, are all preſerved in different libraries: None of them however have yet been printed.

Olympiodorus, who lived a ſhort time before the emperor Theodoſius, has commented upon the practical treatiſe of Zoſimus, of the *manner of working*, and upon thoſe which are attributed to Hermes, and others reſpecting the making of gold.

Theophraſtus the philoſopher, on the *ſacred and divine Art;* Hierotheus *on the Philoſopher's ſtone, on the ſacred Art, and the Method of making Gold;* Archelaus *on the chemical Art;* Anepigraphus *on Chryſopoiea, and the way to whiten divine Water;* Pelagius *on the divine and ſacred Art;* Eugenius *on the ſacred Art, and the*

chemical

chemical Secret; Cosmas *on Chrysopoiea*, and many others, are of such obscure origin, that it will be impossible to arrange them in chronological order, so long as they are kept from the press, concealed in ancient libraries *.

But the absurdities of alchemistry daily increased, and were blended with scholastic follies and the cabalistic frenzy of Pythagoras, until the seventh and eighth century, when chemistry, and every other science, became involved in chaotic darkness, and oppressed by horrid barbarism.

A nation too much inclined to hypothesis and fanciful conjecture was likely to give birth to various theories; but, of these it is apprehended, that they differed more in words and outward appearance, than in their true principles. We shall say nothing of cosmogony, as it abounds with such nonsense; but, we will touch on a few of their opinions, respecting the nature and principles of bodies. Thales the Milesian, the founder of the Ionic sect, about 600 years before our Saviour, preferred the study of Natural Philosophy to all other sciences.

He held water to be the principle of all material substances, from which they all proceeded, and into which they were all to be finally resolved.

 Some

* Of the writers on chemistry, those to be chiefly consulted are Libavius, O. Borrichius, and H. Conringius.

Some, however, are of opinion, that he considered it as the univerſal vehicle only *

Anaximenes the Mileſian, the third teacher of that ſchool, about 100 years afterwards, contended that air was the firſt general principle; Heraclitus was for fire †, and Heſiodus for earth.

Pythagorus of Samos, about the middle of the ſixth century before Chriſt, travelled into Egypt, Arabia, Judæa, and Italy, and taught in the moſt abſtruſe manner, for ſeventy years at Cremona. He was the founder of the Italian ſchool, and ſtill ſhines, by the ſplendour of his knowledge, like a ſun in the hemiſphere of ſcience and learning. From the teſtimony of Plutarch, we learn, that he propoſed to himſelf a perfect ſyſtem of the world. Being initiated in the ſacred rites of the Egyptians and Chaldeans, he ſet a great value on mathematics; and, perhaps, his partiality for this ſcience led him too far, when he concluded that not only this world was made by number, weight, and meaſure, but that there was a ſingular power in numbers and figures. According to his ſentiments, fire was of a pyramidal form, air was octahedral, water was icoſahedral, earth cubical, and the globe itſelf dodecahedral ‡. Hence proceed

* J. M. Verdries phyſ. p. 283.

† Plutarchus de plac. philoſoph. vid. Olzarius de principio rerum naturæ ex mente Heracliti.

‡ Plutarchus.

ceed the five regular ſolid bodies of Pythagoras; and which, on account of ſome phyſical virtue expected from them, have been conſidered by Euclid geometrically. Ecphantus aſſerts, that his *Monades* were corporeal. Ariſtotle gives magnitude to them; from whence ſome ſay they were the ſame as atoms, and think that Pythagoras was taught by the diſciples of Moſchus in Phœnicia. He likewiſe ſtudied magical medicine; but, whatever has been reported of his phyſical tenets, is yet obſcured in all the darkneſs of myſtery. It is ſaid he lived 105 years.

Leuſippus and Democritus were followers of the Eleatic ſchool, about 450 years before Chriſt: But they denied the tenets of their teachers, which deſtroyed the teſtimony of the ſenſes; and, laying aſide harmonies, ideas, qualities, and elementary forms, they contended that the bodies themſelves were preſent, and examined their figure, motion, ſituation of parts, tenuity, and other properties. Democritus aſſerted, that all bodies were compoſed of indiviſible and immutable atoms, which, having only figure and motion, were deſtitute of taſte, colour, and every other quality; and, that, by the union of theſe, bodies were created. The vacuum proſcribed by Thales, he recalled again, and maintained that the ſea was conſtantly diminiſhing *. This

* Diogenes Laertius.

manner of philoſophizing was followed by Epicurus the Athenian, at the beginning of the fourth age, who, from the various modifications of light upon the ſurfaces of bodies, firſt taught the origin of colours *.

Towards the end of the 4th century before Chriſt, Plato imagined every thing to depend upon three principles, God, Matter, and Idea. According to this hypotheſis, Matter was infinite and eternal, and deprived of all qualities, and bodies were created from it by ſome ſecret moving power. God was a pure ſpirit not to be apprehended but by the mind only; and Idea was the eternal model according to which God had made the world. He conceived matter to have had in the beginning a triangular form, from which the ſeveral elements were produced. In the order of creation, he aſſigns the firſt place to fire and earth, as without them nothing can have exiſtence; next he places air and water, which he contends may be mutually converted into each other: To theſe he attributes particular faculties, as heat, dryneſs, cold, and moiſture. He deſcribes fermentation to be the motion and evolution of earthy matter by the air that is contained within it †.

Ariſtotle, the diſciple of Plato, although he in ſome meaſure forſook the doctrine of his maſter; yet

* Lucretius de natura rerum.

† In Timæo.

yet, with reſpect to the theory of the elements, he nearly entertained the ſame opinion. He eſtabliſhed three principles, Form, Privation, and Matter, and four ſpecies of cauſes: the Material, *from* which; the Formal, *according to* which; the Efficient, *by* which, and the Final, *for* which, all things were made. He maintained two elements, ſimple and contrary, as Fire and Earth; between which Water and Air held a middle place. He denied the exiſtence of a vacuum. He imagined that animals were produced by putrefaction and natural heat; and advanced many other opinions, which were revered as oracles for ſeveral ages †.

As the particular theories of the Greeks were ſeldom founded upon obſervation and experiment, but were rather the monſtrous conceptions of prejudice and frivolous imagination; it may appear to the reader that we have dwelt ſufficiently upon the ſtate of chemiſtry as it flouriſhed among them. We ſhall therefore proceed to give ſome account of this ſcience, rather more general and miſcellaneous.

§ v. *Traces of Chemiſtry diſcoverable in various Parts of the World.*

Though from the want of proper monuments and records among other nations, we ſhall not be

† Bruckeri Hiſt. Phil. Crit.

be able to give ſo full an account of chemiſtry as we could wiſh; yet we think it will not be unacceptable to the curious reader, to lay before him the principal facts and circumſtances that we have collected.

There is no doubt, that the Iſraelites carried with them into Aſia a conſiderable portion of the knowledge of the Egyptians. Their leader Moſes was inſtructed in all their doctrines *; and according to Philo, had learned from them arithmetic, geometry, rythmus, metre, the theory of harmony, and their various muſic, and their philoſophy, written in ſymbols in their ſacred books †. That he was acquainted with precious ſtones appears from the bible ‡; and with the art alſo of cutting and hollowing them and granite §. The preparation of the *oil of ſacred unction*, and the *moſt holy perfumes* ||, according to the precepts of pharmacy, indicate no leſs a degree of ſkill. He made, beſides, a moſt ſplendid brazen ſerpent; and he gives an account of ſix metals, gold, ſilver, copper, iron, tin, and lead ¶. And the profeſſors of chemiſtry conſider the pulveriſing and diſſolving of the golden calf as a perfect ſpecimen of his knowledge of their art. No doubt, if the calf were all

* Acts vii. 22.
† In vita Moſis.
‡ Ex. xxviii. 17.—20. xxxix. 10.—13.
|| Ex. xxx. 22—25. 34. 35.
¶ Numb. xxxi. 9. and xxxi. 22.

all gold, that the diſſolution of it required conſummate art; unleſs perhaps he uſed the hepar ſulphuris, of which 16 parts will act upon one of gold; and the whole might afterwards be reduced into powder, and rendered ſoluble in water. Some writers inſiſt, that the calf was made of wood, covered with thin leaves of gold *; and if ſo, the reduction of it could be effected without any chemical operation. But Moſes ſpeaks alſo of thread dyed of various colours; of the expreſſion of oil; of fermented leaven †; of the vinegar of wine ‡, and other chemical products. And there are not wanting ſeveral who, in theſe days, contend, that under Urim and Thummim were concealed ſome chemical ſecrets §. In the time of Abraham, mention is made of butter ‖. Job, who lived before Moſes, underſtood fermentation, the ſprinkling of glaſs with gold, and metallurgic operations ¶. David was acquainted with the purification of ſilver in a furnace **. Solomon, whoſe wiſdom ſurpaſſed all the philoſophy of the Eaſt and of Egypt ††, ſpeaks of ſilver droſs ‡‡. Jeremiah mentions ſoap;

* Vid. Michaelis.

† Exod. xxvi. 1. xxvii. 20. xiii. 3, 7.

‡ Numb. vi. 3.

§ D. Schroeder, l. c.

‖ Gen. xviii. 8.

¶ Chap. xxxii. 19. xxvii 15, 17. xxviii. 1, 2.

** Pſal. xii. 7.

†† 1 Kings iv. 30.

‡‡ Prov. xxvi. 23.

ſoap *; and Siracides, the covering of earthen veſſels with a cruſt of glaſs †. Eliſha, by adding ſalt to water, rendered it ſapid ‡; and ſo of ſeveral other inſtances that might be adduced of the early acquaintance with chemical arts. But theſe that we have already given, though they diſcover inventions of general utility in common, yet do they not betray the leaſt ſigns of ingenious and ſubtle theory.

Thoſe comments on chemical compoſition and duplication in the royal library at Paris, written in the Greek language, and which are aſſigned to Moſes, do no doubt acknowledge a later author. The Practice of Chemiſtry, and Experiments on the Philoſopher's Stone, ſaid to be by Maria the Hebrew, may be alſo included in the ſame ſentiment. As to thoſe who endeavour to found Natural Philoſophy upon the Scriptures, Lord Bacon very juſtly remarks, that they ſeek the dead among the living. And he thinks it neceſſary to check and ſubdue this vanity; leſt, from a total confuſion of divine and human affairs, the truth of philoſophy ſhould be loſt in viſionary conjectures; and he recommends ſtrongly, that faith ſhould be given to nothing, but with deliberation, and to thoſe things only which are worthy of it.

The

* Chap. ii. 22.
† Chap. xxxviii. 34.
‡ 2 Kings ii. 20.

The Phœnicians by their induſtry and commerce excelled all other nations. Before the time of Moſes, and about 700 years after the flood, an accident ſuggeſted to them the making of glaſs: As ſome ſailors, on the ſhore of Belus for want of ſtones, had employed pieces of nitre to ſupport their kettle, in which they were boiling their proviſions, they obſerved the ſand and the nitre unite into vitrified maſſes *. The genius and penetration of the Sidonians ſoon improved upon this diſcovery, and carried it to ſuch perfection, that for 2000 years it brought them an immenſe revenue: And as glaſs was prized equally with gold, the ſand of Belus, which for a long time was reckoned the only kind fit for making it, even after Chriſt, was collected, and taken away by veſſels that came annually from foreign countries, as Strabo, Joſephus, Tacitus, and others affirm ‡.

They had three varieties of purple colour: The Tyrian, which was twice dyed, was reckoned the fineſt and deareſt. At the taking of Suſa,

* Pliny ſpeaks of the origin of glaſs; and he ſays alſo :— "Mox, ut eſt aſtuta et ingenioſa ſolertia, non fuit contenta "vitrum miſcuiſſe: cœptus et addi magnes (magneſia ?) la- "pis · quoniam in ſe liquorem vitri quoque, ut ferrum tra- "here creditur, l. xxxvi. 26. Lapis hic (magnes) et in Can- "tabria naſcitur, non ille magnes verus caute continuo, ſed "ſparſa bubbatione: ita appellant: neſcio an vitro fundendo "perinde utilis: nondum enim expertus eſt quiſquam," l. xxxiv. 14.

ſa, Alexander the Great found in the royal treaſure purple to the value of 50,000 talents, which had lain there 192 years, and ſtill retained its original beauty. We are told by Pliny in what manner they uſed the *coccus amethyſtinus* and *byſginus* for the purpoſe of dying cloths *. Mention is often made in Exodus of *argaman*, which is generally underſtood to mean purple.

Herodotus relates, that the Phœnicians fetched tin and amber from diſtant countries.

From the colonies which they had ſettled in Spain, and other places, they drew vaſt quantities of gold and ſilver. In Greece alſo, the Phœnicians were the firſt who ſought for ores, and extracted their metals.

Among others, Moſchus of Sidon is eſteemed as the moſt antient interpreter of nature; and Poſidonius in Strabo, and Sixtus Empiricus tell us, that he invented the doctrine of atoms. Cadmus, who is not celebrated for any knowledge in phyſics, is imagined to have brought thoſe letters from the Phoenicians, which they had obtained from Aſſyria, into Greece, and had adapted them to the Pelaſgian tongue †. Of Sanchuniaton, an author ſuſpected by many, and who is believed to have lived before the fall of Troy, we have ſpoken at ſufficient length already.

According to Diodorus, Babylon, in the time of

* L. ix. c. 41. † Bruker, l. c.

of Semiramis was removed from Egypt into Chaldea, by Belus, who afterwards inftituted there a facerdotal college. But it fhould appear, that the fciences had flourifhed among the Chaldeans long before; and were entitled as much, if not more, to the praife of antiquity with them, than among the Egyptians. They confider Zoroafter as the founder of their philofophy; of whofe name the Greeks were entirely ignorant until the time of Pythagoras *. But, indeed, any account of him is involved in fo much obfcurity, that we are hardly authorifed to affign to him a place among the learned. He is reported to have difcovered the principles of the world, and magical arts, and diligently to have attended to the motions of the planets †. In the following pages we fhall perhaps mention a few things, of which we are not certain whether they relate at all to this Zoroafter.

Zardus, or Zaradut, or, as he is called, Mog, was celebrated among the Perfians as the inventor of magic. Pliny infifts, that this art took its rife in Perfia from Zoroafter, who was inftructed in it by Azonace ‡: And that it feemed more properly to lay claim to fuch an origin, as he is reported to have laughed on the very day of his birth; and it is faid of him, that the palpitation of his brain was fo great, as to repel

* Clem. Alex Str.

† Plato in Alcibiade priori. Juftinius, l. 1.

‡ L. xxx. c. 1.

repel the hand of any perſon applied to his head. Theſe uncommon circumſtances were conſidered as preſages of future wiſdom *. Beſides, we are told, that he lived twenty years in deſarts upon cheeſe, and was of ſuch a conſtitution as not to be ſenſible of old age †; and that he had compoſed two millions of verſes. He is the reputed author of many writings on aſtrology, phyſics, magic, chemiſtry, and politics ‡.

It was an ancient cuſtom among the Perſians, to diſtinguiſh metals by the names of the planets. And Celſus, in his writings againſt Origen, mentions ſome Perſian ceremonies which eſtabliſh this account. In the following words he deſcribes the heathen worſhip of Mithra under thoſe ſigns: "Eſt in eo duarum cœli revolutionum ſignificatio, tum ejus, qua ſtellæ fixæ feruntur, tum ejus, qua planetæ, et animæ per eas tranſitus tale Symbolum: ſcala eſt in altum aliis ſuper alias portis ſurrecta uſque ad ſummum octavæ portæ fornicem; prima portarum plumbea eſt, ſecunda ſtanea, tertia ahenea, ferrea quarta, quinta mixti nomiſmatis, ſexta argentea, ſeptima aurea. Primam faciunt Saturni, plumbo notantes tarditatem ejus ſideris, ſecundam Jovis, comparantes ei ſtanni ſplendorem et "mollitiem,

* L. vii. c. 16:

† L. ii. c. 42.

‡ Heilbronner, Hiſt. Math.

"mollitiem, tertiam Veneris æratam et ſolidam; "quartam Martis, eſt enim laborum patiens, "æque ac ferrum, celebratus hominibus; quin-"tam Mercurii propter miſturam inæqualem et "variam; ſextam lunæ argenteam; ſeptimam "ſolis auream, coloribus ſuis ea ſidera referenti-"bus.

We have already alledged, that the hieroglyphic mode of writing uſed by Hermes, and the attentive care of his followers to involve in myſtery the operations of nature, moſt probably gave riſe to the application of chemical ſigns: Theſe, however, ſubject to the ſame variations to which the letters of every language are liable, differ, no doubt, widely from thoſe that were firſt employed; yet, we can ſtill trace in them certain original characters, which the lapſe of time has not been able to obliterate. We have ſeen that, almoſt from the beginning of the world, the ſtars were thought to have conſiderable influence on all terreſtrial affairs; and this opinion, as well eſtabliſhed as it is ancient, aſſigns clearly the reaſon why all the metals have been diſtinguiſhed unto this day, by the names of the planetary bodies. On a principle ſomewhat ſimilar, we find the triangular ſigns in the theory of Plato. As the ſtars held dominion over time, ſo the vanity of aſtrologers led them to ſuppoſe, that ſome, more than others, had an influence on certain days of the week; and,

that

that they could impart to thoſe metals correſponding to them, conſiderable efficacy upon their particular days. But we ſhall give preſently an example of this extraordinary folly.

From the Athenian ambaſſadors we learn, that among the Perſians, before the time of Alexander the Great, ὑαλινα εκπωματα, (veſſels made of glaſs) were daily uſed *.

Of the eſtabliſhment of the ſacerdotal college at Perſepolis, according to the Egyptian principles, we have the following account from Diodorus. Phanes, a certain Halicarnaſſian, having inſinuated himſelf into favour with King Amaſis, obtained from him the knowledge of the Egyptian myſteries, with which he fled into Perſia, and betrayed them to Cambyſes.— Tempted from what he thus knew, with the deſire of learning ſtill more, the King of the Perſians marched immediately againſt Pſammitus, the ſon of Amaſis; from whom he did not take away his treaſures only, (about 525 years before Chriſt,) but the Hierophanti alſo. With regard to them, however, he failed in his deſign; as they obſtinately refuſed to communicate any knowledge of their myſteries, until after his death they imparted them to his ſon Darius Hyſtaſpes †. We have already mentioned, from Syncellus, that Oſtanes was ſent by Xerxes

* Ariſtophanes, Acharn. i. 2.
† Bibl. Hiſt. l. i. c. 46, 95.

Xerxes into Egypt. The letter written to Petaſius, *de ſacra et divina arte*, commonly aſcribed to him, is without doubt entirely ſpurious. Equally unfounded are many other writings under his name. The ſame ſentence may be paſſed upon that work too which bears the illuſtrious name of Sopharis, who is ſaid to have been the preceptor of Oſtanis.

How far the inhabitants of the Indies had proceeded in their enquiries into the operations of nature, it will be difficult for us at this day to determine, as we are not in the poſſeſſion of any accounts ſufficiently authentic.—The following quotation, however, from Philoſtratus proves, that they cultivated equally with other nations of the Eaſt the ſcience of metallic aſtrology: He ſays, "Apollonius cum Jarcha Brach-
" mane ſecreto philoſophatus, muneris loco ab
" eo tulit annulos ſeptem, totidem planetarum
" dictos nominibus, quos ſingulos geſtaret per
" ſubjectos planetis dies; ſc. ut annulum aure-
" um geſtaret die ſolis, argenteum die lunæ, fer-
" reum die Martis, hydrargyrinum die Mercu-
" rii, die Jovis ſtanneum, æneum die Veneris,
" et plumbeum die Saturni, quod ſingulis pla-
" netis ſingula reſpondeant metalla *."

The Chineſe, according to Martini the Jeſuit, had been long acquainted with chemiſtry; and are even ſaid not to have eſcaped the rage of al-

 chemiſtry,

* Life of Apollonius.

chemiſtry, 2500 years before our Saviour: Tho' it muſt be confeſſed, they have left no writings on this art behind them, to ſupport ſuch an opinion*. But if China, as D. de Guignes alledges, is a colony from Egypt, the difficulty is not ſo great: And it is beyond all doubt, that many excellent chemical arts and inventions had flouriſhed long in China before it was viſited by the Europeans. Among their chemical preparations it may be ſufficient to reckon nitre, borax, alum, copperas, corroſive ſublimate, calomel, mercurial æthiops, mercurial ointment, ſulphur, exploſive powder, ſplendid fire-works, various dyes in ſilk and linen, and veſſels of porcelain painted in elegant colours. Beſides a great number of metals, as gold, ſilver, quickſilver, lead, copper, iron, and tin, they extract zinc, nearly pure from the mines; and, with it and copper, niccolum

* Hiſt. Sin. Le Compte, a Jeſuit miſſionary, in his account of Chineſe chemiſts, makes mention of one celebrated by his knowledge of the philoſophers ſtone, who lived 633 years before the Chriſtian æra, and 150 before the time of Confucius. Barchuſenius calls him Li-Lio-Kim or Li-Lao-Kiun. In the Chineſe Atlas Martini has placed a lake near the city of Pukiang, in the neighbourhood of which king Houang-ti who lived 2500 years before our Saviour, is ſaid to have practiſed alchemiſtry. The ſame writer met with a large maſs of gold on mount Zukin, which was reported to have been prepared by the art of chemiſtry, and to poſſeſs the virtue of curing many diſeaſes. He relates alſo a ſtory of nine virgin ſiſters, who paſſed their lives in celibacy intent on alchemical purſuits.

niccolum and iron, they compoſe what is called *white copper*.

It was not until long after the Romans had ſubjected the Greeks and Egyptians to their yoke, that they became acquainted with the ſcience of chemiſtry, as we learn from the teſtimony of Joſeph Scaliger. They made war their chief ſtudy, and cultivated thoſe virtues only that could ſupport and improve it; as fortitude and courage. The other arts they deſpiſed, until Marcellus, Scipio, Paulus Æmilius, Mummius, and others, brought to Rome the moſt exquiſite pieces of workmanſhip from the conquered countries. But they remained ſtill intent upon arms, and the means of extending their dominion; for, whenever they were in want of excellent ſtatues, noble edifices, or fine paintings, they always had recourſe to the talents of the Greeks.

Ariſtotle, however mentions, that the Umbrians were in the practice of extracting a ſalt from the aſhes of reeds and bulruſhes *. About the beginning of the Chriſtian æra we can diſcover ſome traces of chemical knowledge; which, though ſometimes not eaſily defined, may be aſcribed to the Romans. Vitruvius clearly deſcribes the reduction of gold into an amalgam: He ſays, " Cum in veſte intextum eſt aurum, " eaque veſtis contrita propter vetuſtatem uſum " non

* Met. l. ii. c. 3.

" non habet honeſtum, panni in fictilibus vaſis " impoſiti ſupra ignem comburuntur. Is cinis " conjicitur in aquam, et additur ei argentum " vivum, id autem omnes micas auri corripit in " ſe et cogit ſecum coire: aqua defuſa, cum id in " pannum infunditur, et ibi manibus premitur, " argentum per panni raritates propter liquo- " rem extra labitur, aurum compreſſione coac- " tum intra purum invenitur *." What Vitruvius ſays of the cloth, Pliny has written more particularly in theſe words: " In pelles ſubactas " effunditur, per quas ſudoris vice defluens purum " relinquit aurum †." Pliny gives further an account of gilding by means of quickſilver, and of the ſearching for ſilver with the Lydian ſtone ‡. Pure gold has been ſaid to be extracted from ochre, or orpiment, alſo, by Caius Caligula, a ſlave to avarice, though in ſuch ſmall quantity as not to defray the expence of the proceſs §.

Petronius, ſpeaking of flexible glaſs, relates, " Fuit faber, qui fecit phialam vitream, quæ non " frangebatur. Admiſſus ergo ad Cæſarem eſt " cum ſuo munere, deinde fecit reporrigere Cæ- " ſari, et illam in pavimentum projecit. Cæſar " non pote validius, quam expavit: at ille ſuſtu- " lit phialam de terra: colliſa erat, tanquam va- " ſum æneum. Deinde martiolum de ſinu pro-

" tulit,

* L. vii. c. 8.

† L. xxxiii. c. 6.

‡ L. xxxiii. c. 8.

§ L. xxxiii. c. 4.

"tulit, et phialam otio belle correxit; hoc pacto "putabat ſe cœlum Jovis tenere. Utique poſt- "quam illi dixit: num quis alius ſcit hanc con- "dituram vitreorum? Vide modo. Poſtquam "negavit, juſſit illum Cæſar decollari; quia e- "nim, ſi ſcitum eſſet, aurum pro luto habere- "mus *." The ſame ſtory is told by Dion Caſ- ſius †, Johannes Sariſburienſis ‡, and Pliny; who adds, that, though the fame of the flexible glaſs diſcovered under Tiberius was very general, yet it wanted farther confirmation §.

What Seneca means, by the "collectio ignis "alumine," is rather obſcure, unleſs it refers to ſome kind of pyrophorus ||.

The ſame luxury and diſſipation that deſtroy- ed the warlike genius of the Romans led them to a corrupt and intemperate abuſe of the arts. Not ſatisfied with the fineſt garments, they re- quired them to be tinged with a variety of the moſt ſplendid colours. The face was rendered delicate and beautiful, by means of a poultice made of bread and aſſes milk, a fine colour be- ing ſuperinduced with a mixture of ceruſe and purple. The hair was powdered with gold duſt, as we learn from Ovid, Martial, and Plautus. The apertures or windows of their

* Satyr.
† Hiſt. L. vii.
‡ Polycr. L. iv. c. 5.
§ L. xxxv. c. 26.
|| Q. N. L. ii. c. 12.

houſes were at firſt cloſed with a tranſparent ſtone, a kind of gypſum; and afterwards they uſed glaſs: And Hieronymus and Lactantius mention, that the windows in the fourth century were all made with it. Pearls and gems were highly valued by them, and were often poliſhed, carved into various figures, either concave or prominent. Nonnius, a ſenator, when flying from Rome, carried with him, of all his wealth, a pearl alone worth 20,000 ſeſterces. Pliny, with great propriety, expreſſes his ſurpriſe at the cruelty of Anthony in proſcribing a man for the ſake of a ſingle jewel, and at the folly of Nonnius for chuſing baniſhment rather than part with it; when, even wild beaſts would frequently ſave their lives by biting from themſelves thoſe parts for which only they knew they were purſued *.

Under the reign of Nero, the art of making glaſs, which had been long known in Spain and Gaul, was diſcovered at Rome; but it was yet ſo ſcarce, that two ſmall cups made of glaſs, called *pteroti*, ſold for the immenſe ſum of 6000 ſeſtertia †.—Many other examples of their luxury and profuſion, occur in ſeveral authors.

On the converſion of Conſtantine the Great to Chriſtianity, a fatal blow was given to the ſuperſtitious darkneſs of mythology, and the arts

* L. xxxvii. c. 6.

† Pliny, l. xxxvi. c. 26.

arts and ſciences began to wear a more favourable aſpect *.

Nor

* By way of ſupplement, we ſhall add here ſome few obſervations on the preparations of medicine known to the ancients. Siracides, c. xxxviii. ſays "Dominus medicamenta creſcere facit, "et ille, qui unguenta præparat, inde miſcelas conficit." In the Septuagint verſion ointments are called ῥοποπωλαι, vid. 1 Kings, x. 15. Exod. xxx. 25. 35. xxxvii. 29. The word ῥοποπωλης ſignifies properly, a man engaged in all kinds of commerce, as alſo a perfumer. Among the ancient authors we find mention made often of perfumers and dealers in ointments. Thus, for example, Hermæus is ſaid to be a Perfumer, whoſe rich widow was afterwards married to Æſchines: Ilus of Theſprotia in Epire, who refuſed poiſon to Ulyſſes which he afterwards obtained from King Anchilaus; was called an Apothecary: Nicomachus the Stagyrite alſo was named a Quack: Ariſtophilus a Quack of Platæa: Antonius is deſcribed as a Quack by Galen; and many others who we need not mention. Ariſtotle himſelf, if we can give credit to Ælianus and Epicurus, had profeſſed the trade of a perfumer before he turned his mind to the ſtudy of philoſophy. But, in general, the practice of this art was conſidered as very mean and contemptible; and therefore Solon drove all the perfumers out of Athens, and Lycurgus was not leſs ſevere to them at Sparta: Under this idea too, Antony reproached Auguſtus that his great grand-father had kept a perfume ſhop. Formerly the preparation of almoſt every medicine was in the hands of the perfumers; and it appears from Hippocrates that the ancient phyſicians paid but little attention to pharmacy. It muſt, however, be acknowledged that chemiſtry is indebted for many inventions to the perfumers of old, and Greek phyſicians, and eſpecially to thoſe of a later period. In this view we may conſider the various compoſitions of medicines, of which we ſhall ennumerate thoſe only that were moſt eſteemed. Dioſcorides deſcribes the method of extracting the oil from pitch; that it

 was

Nor in the moſt remote times were the chemical arts wholly unknown to the northern regions. Pytheas of Marſeilles relates, that the inhabitants of Thule even made a beverage of grain

was collected in clean fleeces ſpread over the vapour of boiling pitch. He alſo ſpeaks of the diſtillation of quick-ſilver from αμμιν (native cinnabar) and the burnt droſs of wine (ſalt of tartar) which were judged to be well prepared, if they were white, and acrid to the taſte.' Galen, Oribaſius, Paulus Ægineta, and Ætius extol much a Gallic ſoap: Ætius mentions a black ſoap alſo. Ægineta prepared an extemporaneous ſoap from oil, the burned dregs of wine and nitre. The oil of ſulphur alſo is mentioned by him, which was probably a ſpecies of balſam of ſulphur. The *lixivium protoſtactum* of Ægineta is nothing elſe than the cauſtic alkali. Ætius deſcribes the diſtillation *per deſcenſum* of ſmoking oil, and relates the preparation of braſs and purification of antimony. Various plaiſters alſo of which mention is made frequently by ancient authors, may be reckoned among the preparations of chemiſtry. Oribaſius and Ætius added the droſs of ſilver (lithargyrium) to ſeveral plaiſters, and the compoſition of the ſnowy-like plaiſter from minium was long preſerved among their valuable ſecrets. Syrups, droſata, juleps and zuleps are not well diſtinguiſhed among them. Myrepſus reckons 129 formulæ of ſyrups and 137 of pills. Electuaries, confections, pills and boluſes made two thirds of their internal medicines. The drangeæ of the Greek phyſicians ſeem to be ſame with our trageæ. Smegma is underſtood by them in ſeveral ſenſes: Sometimes it ſignifies a dry powder, at other times a ſoft maſs, chiefly mixed with ſoap; and again, a certain kind of paſtils. Under the name of troches, paſtils were formed of various figures.—Of bitters they had ſeveral kinds, as powders, pills and electuaries. Their acidulated medicines, infuſions of herbs, and mixtures of vinegar and water were prepared by expoſure to the ſun. What is called *eclegma* by the Greeks, the Arabians call *looch* and with us is *linctus*.

grain and honey *, many ages before the birth of Chriſt.

For their inſtruments of agriculture, as well as for their arms in war, they required both the uſe of metals and artificers: But they involved all thoſe arts in fables and myſteries, fully as much as the nations of the ſouth. They believed that the beſt ſwords were made by certain pigmies, who were concealed in the mountains †. It is related alſo of the Aſi, that, in Idavall, (a wood in Vermelandia, which derives its name from Edda) they had conſtructed furnaces, and made pinchers, inſtruments, and *aud*, which ſome interpret *money* ‡. Frode king of Denmark, paying a viſit to the Upſal Fioln, is ſaid to have obtained two female ſlaves, one of which was ſkilled in making gold, the other in making ſalt §. The moſt ancient temple of Old Upſal is deſcribed as being not only very finely ornamented with gold within, but alſo as being adorned with a border of gold without ||. From other accounts likewiſe, it appears, that the inhabitants of the north were not only acquainted with the uſe of metals, but had made ſome progreſs in chemical arts.

§ VI. *Synopſis*

* Strabo, geograph. l. iv.
† Edda Damiſ.
‡ Havamal Voluſpa.
§ Edda Damiſ.
|| A. Brem. and A. Cranz.vid. Shefferi Upſalia antiqua.

§. VI. *Synopsis of Things known in Chemistry during the first Period.*

We have feen, very foon after the creation, the invention of fuch arts as laid afterwards the foundation of chemiftry. After the deluge, we have obferved the cultivation of them in Egypt until the devaftation of that empire by the Arabs. And, although the genuine tenets of natural philofophy were fo ftudioufly concealed from us; yet fome glimmerings of a theory, eftablifhed upon the various phenomena with which they were acquainted, have not efcaped our attention. We have alfo followed out the fcattered traces in other countries, and chiefly have afcertained the wonderful practical progrefs of the Chinefe. Chemiftry, then, feems to lay claim to as high an origin nearly as the other fciences; and with refpect to many, is certainly of much greater antiquity. During all this period of near 5000 years, we find Polytheifm every where; but efpecially among thofe nations where chemiftry was moft cultivated; and the myfteries of fcience and religion were thus perpetually blending. Immediately after the redemption of the world, the followers of the true faith were every where fo harraffed and perfecuted, that they were neceffarily more occu-

pied

pied with the means of avoiding perſonal diſtreſs and torture, than anxious for the improvement of the ſciences.

Before the time, therefore, of Conſtantine, ſcarce any Chriſtian had beſtowed a thought upon chemiſtry; and after him, indeed, we find very few, and thoſe chiefly inclined to alchemiſtry; in the ſingular ſtudy of which ſo many have ſince loſt both their time and labour. Some general idea may be formed of the ſtate of chemiſtry in thoſe days, from the conſideration of the ſeveral ſubjects of the art with which they ſeem to have had no acquaintance. Except the *acetous*, no trace can be diſcovered of any other acid. The *mineral alkali* was known to them by the name of nitre: But of the vegetable alkali they knew little; and of the volatile they were altogether ignorant. Of neutral ſalts they had the *marine* and the *ammoniac*. Of earthy ſalts they had native *alum* only: And of metallic ſalts, *copperas* and native *green vitriol*. Certainly a very limited halurgy.

Of earths they ſeem to have diſtinguiſhed the calcareous and argillaceous; and of ſtones, a very conſiderable number.

Of inflammable ſimple ſubſtances, they were acquainted with ſulphur, expreſſed oils, and oils diſtilled *per deſcenſum*. But they knew no other method of extracting eſſential oils than by the means of the unctuous. We find no account whatever of ſpirit of wine and ether.

Of

Of the ſeven perfect metals hitherto known, they were acquainted with all except Platina: But they were ignorant of the imperfect. Some authors, indeed, make a diſtinction between tin and white lead; which was perhaps zinc, biſmuth, or regulus of antimony. But it is impoſſible to draw any certain concluſion with reſpect to this; when even Pliny diſtinguiſhes *hydrargyrum* from *argentum vivum*.

Expreſſions, digeſtions, and decoctions were almoſt the only operations in their chemiſtry. Perhaps, indeed, they uſed ſome varieties of elixation, evaporation, and inſpiſſation; as likewiſe of cryſtallization, ſublimation, calcination, diſtillation *per deſcenſum*, fuſion, eliquation, vitrification, and fermentation.

From the authorities, therefore, already cited, it may be naturally inferred, that, at the period under conſideration, the dawn only of chemiſtry had made its appearance; and that it was rather a collection of unconnected and ill-founded axioms, the reſult of obſervation and remark, than a ſcience eſtabliſhed upon the broad baſis of an infinite variety of experiments. At this time they were in want alſo of the proper inſtruments, and unacquainted with the neceſſary ſteps by which the principles of natural bodies can be exactly ſeparated, collected, and properly defined. They were, therefore, without thoſe means ſo neceſſary to the evolution of truth, and the conſtruction of a genuine ſyſtem.

THE

THE

HISTORY

OF

CHEMISTRY,

During the Obscure or Middle Age, from the Seventh to the Seventeenth Century.*

Existimare oportet naturam multa et varia a rebus ipsis edoctam et coactam esse; rationem vero ea, quæ ab illa sibi mandata et tradita fuerant, posterius adcuratiora et politiora reddidisse, et inventus addidisse, in nonnullis citius, in aliis tardius.

LAERTIUS.

§. 1. *General Idea of this Period.*

THIS period may be reckoned from the destruction of the Alexandrian library by the Arabs about the middle of the seventh century, unto the first institution of scientific societies, a little beyond the middle of the seventeenth century;

* This Dissertation was publicly delivered in the great Gustavian Hall, on the 11th of June, 1782.

tury; comprehending in all about a thousand years. In the year 1651 the Academy del Cimento was founded at Florence; in 1660 Charles II. established the Royal Society of London. The Academy of Inquirers into the works of nature, in 1664, and the Academy of Sciences, in 1666, both arose at Paris under the auspices of Lewis XIV. From the dark obscurity in which the history of chemistry remained buried during all this interval, we are naturally led to compare it with the civil history of the same time, and perhaps to assign to it similar features: And, indeed, the circumstances to be related in the following pages will fully explain the character of this period, and furnish sufficient reason to call it by the name of Hermetic or Alchemistic.

At the first view, we find the political constitution of those countries where chemistry received its earliest growth, in a state of the greatest barbarism. The inhabitants of Arabia Felix whom Ptolemy long ago calls Saracens *, were for many ages subject mostly to the Roman authority, and served occasionally as mercenaries in the armies of that empire. But about the beginning of the seventh century, under the reign of the Emperor Heraclius, they overran Egypt, which they had been threatening with an invasion for three years. A short time before

* Geogr. vi. 7.

fore, they had embraced the Mahometan religion, and had laid waſte all Syria under the banners of Mahomet. In Egypt theſe new Lords deſtroyed, with indiſcriminating hand, every monument of ſcience, every abode of learning. Ptolemy Soter, who founded the academy at Alexandria, had begun to collect a very conſiderable library alſo; which, at the death of his ſon Ptolemy Philadelphus, contained already 100,000 books; and which increaſed ſoon after to the immenſe number of 700,000*. Manuſcripts were collected from every quarter; and being accurately and neatly copied, the originals were preſerved in the library, and the copies were exchanged for them, accompanied ſometimes with large preſents. The firſt collection amounted to 400,000 books, in that part of the city called Bruchion; the other conſiſted of 300,000, and was kept in the Serapeum. The former was accidentally conſumed by fire, while Julius Cæſar was beſieging the city; and the latter, though often plundered, recovered ſo much from its misfortunes, that it became at length greater than the Bruchian collection †. To this were added 200,000 volumes alſo from Pergamus, which Mark Anthony had preſented to Cleopatra. But when this ineſtimable library fell into the hands of the victorious Saracens

in

* Strabo. l. xvii. Euſeb. Chron.

† Plutarch in the life of Julius Cæſar.

in the year 1642, a certain philoſopher, named John Philoponus, who was high in favour with their leader Amri Ebnol-As, requeſted of him to ſpare him a part of it. The Caliph Omar, however, without whoſe permiſſion Amri dared not to ſave a ſingle volume, ordered them all to be deſtroyed; adding, at the ſame time, that they were uſeleſs if they agreed with the Alcoran, dangerous if they differed from it. During ſix months almoſt four thouſand baths were daily heated with theſe valuable manuſcripts *. How little learning was eſteemed by the heroes of thoſe days ſufficiently appears in this unfortunate example. In a ſimilar manner the Goths, and other wandering tribes, ſpread terror far and wide, and depredated entirely the nations they had vanquiſhed. But we ſhall not enter into the unpleaſant detail of the effects of barbariſm and ignorance; as the fate of Egypt, where chemiſtry had fixed her throne, too clearly illuſtrates the melancholy condition of the ſciences.

Although the firſt influence of the Mahometan dominion was fatal to letters, and the conſtitution of that religion even afforded no proſpect of a happier ſituation; yet ſoon after, under the Achemidic dynaſty, the ſmiles of fortune inſpired them with ſome new hopes. Abu-Jaafer-Almanſor, the ſecond of this family, who, in the

* Abulpharagius, hiſt. Dyn. x.

the eight century made Bagdad the ſeat of the Babylonian empire, whether from thoroughly underſtanding the Alcoran, or from the affection he bore to the ſciences, became famous for learning, and for his ſkill in aſtronomy eſpecially; to which he had always given a preference. After him the encouragement given to ſcience daily increaſed. Harun or Aaron Raſchid, who was cotemporary with Charles the Great, lived in habits of intimacy with ſeveral philoſophers, and took great delight in their converſations. But, of all the princes of Arabia, his ſon Abdalla Almamun was by far the moſt diſtinguiſhed. This Prince held the reins of government from the year 815 to 831, not leſs celebrated for his clemency than for the ardour with which he encouraged letters. At great pains and expence he collected books in all languages, and had them accurately tranſlated, and carefully preſerved. Negotiating a peace with Michael the III. among other conditions, he ſtipulated for permiſſion to collect and export in Greece whatever books he wanted. From this period we find the ſciences protected every where in the Eaſt, and in Africa. The Arabs highly honoured thoſe who cultivated learning, and inſtituted academies for the propagation of knowledge. But they ſeemed to ſet the higheſt value on aſtronomy and alchemiſtry, which were at this time abſolutely inſeparable. Indeed, it was not until long afterwards, that theſe ſciences were found independent of each other in Europe. The celebrated Tycho Brahe, not only attended to the motions of the planets, but had a laboratory alſo, in which he tried experiments upon earthy ſubſtances by fire. The great Newton, too, when reſting from his immenſe labours, employed himſelf occaſionally in chemical operations. There are, beſides, many other inſtances which we need not mention.

In the mean time, Europe overrun with ſwarms of barbarians, whoſe ſavage thirſt of wealth led them to ravage and deſtroy wherever they came, was almoſt wholly forſaken by the liberal arts. The Muſes fly from Goths and Vandals. Charles the Great, however, the moſt powerful prince at that time, offered them his protection; and it is in a great meaſure to the expeditions undertaken for the ſake of religion, that we are indebted for their recovery. Theſe were begun about the end of the 11th century; and gaining an entry among the Arabians, afforded the Europeans an opportunity of converting their literary treaſures to their own uſe. When Conſtantinople was taken by the Chriſtians in the year 1205, a conſiderable number of manuſcripts made their way into Europe, where a great part of them was gradually tranſlated into a more general language. About the year 1230, the Emperor Frederic II. turned his attention to the

cultivation

cultivation of the liberal arts. Several princes followed his example: So that they feemed now to be quitting their former habitations, and to feek more and more for fhelter and protection in our quarter of the globe. But the fuperftition under which Europe groaned, retarded for a long time the progrefs of natural fcience. For every one who attempted to explore the works of nature, or had acquired the leaft acquaintance with her, was deemed a conjuror, and agent of infernal fpirits, and fentenced to be burned to death. By degrees, however, the thick clouds of ignorance and enthufiafm were diffipated, and men of fcience and of genius were permitted to purfue their ftudies in a wider field. And this change was efpecially remarkable in the 16th century, when the zeal of Luther freed the church from that load of abfurd and ridiculous garments with which it had been long disfigured and oppreffed.

If we confider ftep by ftep the progrefs of chemical fcience, we fhall find indeed that various properties of bodies were difcovered, but that they were neither fo accurately determined, nor exactly compared together, as was neceffary; and formed only a rude and undigefted mafs, arranged into no fyftem: In fuch myftery and confufion was true fcience as yet obfcured. The vaft number of experiments that were made about the end of this period, with-

 out

out order or regularity, were not unlike to a confufed heap of ftones, lime, fand, beams, and rafters, requifite for conftructing an edifice; but which, being combined with no fkill, fail in producing the propofed effect. The falfe and perverfe opinions likewife which were entertained by many, contributed in a great meafure to thicken this darknefs. Several had perfuaded themfelves, that gold could be compofed from its principles by art; and that medicines endowed with the virtue of curing all difeafes, and of rendering man immortal could certainly be found. Thus they were perpetually grafping at wealth, and defirous to protract life beyond its natural limits. This was the goal to which every fearcher into the works of nature ran with all his might. Truth, however, they anxioufly avoided, left it fhould fuggeft any thing that might enable others to folve thefe problems, which they confidered of the greateft importance. In order, therefore, to effect their myfterious purpofe, they made ufe of particular characters and figns, and employed a ridiculous and metaphorical manner of fpeaking, that their words and their writings fhould be underftood by themfelves only. But notwithftanding, a confiderable number of books were produced; though to what purpofe is not fo eafily determined, as they had fpared no pains to render them as obfcure as poffible. Our furprife, how-

ever

ever, at this rage for writing is greatly increaſed, when they tell us, that the art of making gold is beyond the reach of human capacity, and that it is made known by God to thoſe only whom he favours, and whom they call Adepts. They aſſert alſo, that dire misfortunes will alight upon his head, who, poſſeſſing this knowledge, ſhall in any way communicate it to others.

During almoſt the whole of this dark period, the art of printing was unknown; and hence we may imagine the labour beſtowed upon tranſcribing all their books. Great, however, as it was, the number brought forth was not affected by it: For which we cannot otherwiſe account, than by ſuppoſing them to have produced an adequate gain to the authors. They ſeldom put their own names to their writings, but uſed others, antient or feigned, to obtain perhaps a credit they could not of themſelves have acquired.

In the mean time the number of *chryſopoei* increaſed almoſt every where; but the favour of the public did not keep pace with them. This divine art had been ſo propitious to the inhabitants of Africa, that it could not be reſtrained at Fez. Some of them were in queſt of a certain elixir that ſhould convert all common metals into gold. Many, who were amaſſing wealth by adulterating the coin, paid the penalty of their dishonesty with the loss of their hand *. Pope John II. in the fourteenth century, publicly condemns them in his bull as impostures: *Spondent quæ non exhibent*, &c. Henry IV. of England, in the fourteenth century, and the faculty of medicine at Paris in 1609, followed the example of the Pontiff. But we will not dwell longer upon the sufferings and misfortunes to which they were now exposed.

Towards the close of this period, the society of *Rosicrucians*, an institution congenial to the spirit of the age, began to disturb the repose of Germany. While academies of sciences were establishing a short time after, for the purpose of exploring the secrets of nature by proper experiments, and of publishing an account of their transactions, and were thus gradually subverting all bold and obscure mysteries; this society not only claimed to itself the transmutation of metals, and an universal panacæa, but asserted likewise, that by the cabala and numbers every thing was made known to the adepts, and to those that were kept by the peculiar care of the Deity, by invisible unknown beings; and that even thoughts could not be concealed from them.———They had likewise many other opinions equally as absurd and ridiculous. From the year 1609 to 1630, an incredible number of books were poured out from this fraternity; though it is not less to be doubted whether it

* Johannes Leo de viris illustribus apud Arabes.

it really had an exiſtence, or whether Europe was made the ſport of one or a few individuals. It will not be foreign to our purpoſe to inſert here a ſtory made by ſome in the name of this ſociety. A nobleman of Germany travelling, in the year 1378, into Arabia, was ſaluted in his proper name by the wiſe men of that country, though they had never ſeen him before, and they related every thing that had happened to him, during all his life. He was initiated by them in their myſteries. On his return to Germany, he inſtructed ſeveral diſciples, until the year 1484; when, at the age of 150, he voluntarily choſe to depart this life. Some one of his ſucceſſors, 1604, diſcovered his tomb, in which, beſides various remarkable inſcriptions, was a book engraved in golden letters. But here we can learn nothing further. Their own confeſſion has furniſhed us with the above circumſtances. They had for their general conduct ſix fundamental rules: By the firſt they were to heal the ſick wherever they met them; the ſecond directed them to aſſume the cloathing of the country in which they happened to be; the third obliged them to attend the annual general meeting, unleſs they could aſſign ſome lawful cauſe of abſence; the fourth enjoined every brother, as ſoon as he choſe to die, to nominate a worthy ſucceſſor; the fifth ordained the roſy croſs to be their ſymbol; the ſixth directed that the fraternity ſhould be concealed carefully for 100 years *. In France this ſociety gained but little ground; and, after 1630, it paſſed almoſt wholly into oblivion. In this year one Mormius offered to reveal the whole of its ſecrets to the magiſtracy of Holland; but his propoſal was treated with contempt.

It was not to be expected, that ſcience wholly occupied in the purſuit of other objects would contribute to the improvement of chemical arts. They were however rendered gradually more perfect, partly by accident, as the artiſts diſcovered ſhorter and better proceſſes, and partly by experiment, as they ſometimes choſe to riſk a path unbeaten by their teachers;—and in ſome meaſure, by the unſucceſsful attempts of the alchemiſts. For theſe laborious inveſtigators, though they ſeldom gained their propoſed end, yet often brought to light much uſeful knowledge, which had otherwiſe perhaps lain concealed to this moment.

As to medical chemiſtry, and the principles upon which its theory was eſtabliſhed during this period, we ſhall explain them ſeparately further on: Here it may be proper to take notice of a few things relating to the pharmaceutical part of this ſcience. The prolix compoſition

* Morhoſius in Polyhiſtore, et Mormius, in arcanis naturæ ſecretiſſimis, may chiefly be conſulted.

tion of Mithridate, theriaca, and antidotes ſufficiently demonſtrate the low eſtimation of ſimpler medicines, which ſtill fell more into diſrepute, as the Greeks and Arabians vied ſeveral ages with each other in uſing the longeſt formulæ. At the time the knowledge of the Arabians firſt enlightened the weſtern part of Europe, it was ſhrouded with ſuch impenetrable darkneſs, that neither reaſon nor perception could form the leaſt probable conjecture of its future improvement. From Ariſtotle we learn, that medicines were divided into the warm and cold, the dry and humid, which were combined according as circumſtances required. Hippocrates was the author of the attenuating, incraſſating, debilitating, and aſtringent qualities, and ſeveral others, in which Eraſiſtratus and his followers committed wonderful abuſes. As we have many medicines that act particularly on certain parts, as the cephalic, ſtomachic, diuretic, hepatic, &c. an opinion was afterwards entertained, that others affected equally the whole ſyſtem. They divided every quality into four degrees, and each degree into three parts. All compounds they examined with attention; and, if they found them faulty, ſomething to correct them was added: That their force might not be impaired by digeſtion, they were defended by ſome particular ingredient from the action of the ſtomach; to thoſe that operated too

haſtily

haſtily, they added ſomething to occaſion delay; to others rather ſluggiſh, they joined a ſtimulant; and, thoſe that were to act on a certain part, they accompanied with ſome medicine that was to perform the office of a conductor. Others were compounded according to the conſtitution of the patient. With ſuch arithmetical preciſion was the healing art practiſed in thoſe days.

Thoſe perſons who were intruſted with the preparing of medicines, about the middle of the fifteenth century, and were called *pharmacopolæ*, beſides their collection of formulæ, had ſcarce any other books, than one of Avicenna, another of Serapio on plants, another written by Simon of Januenſis on ſynonymous appellations, a fourth called the book of Servitor on the preparation of plants, and ſome chemical medicines, and two liſts of antidotes, of John of Damaſcus, or Meſuis, and Nicolai of Salerno *. Towards the

* If the Arabians were taught their chemiſtry by the Greeks, it muſt be confeſſed they made a much greater uſe of it in the practice of phyſic than their preceptors did: But it cannot be denied that they alſo invented many either inert or even dangerous medicines. It does not very clearly appear that the Arabians were the inventors of ſugar; yet there is no doubt they were the firſt who employed it in the materia medica, under the name of *honey of cane*. The medicines of Rhazis were chiefly galenicals.—Pills, powders, electuaries, decoctions, troches, ointments, and plaiſters. Oils he digeſted either by inſolation or ſand heat. He mixed lead in ſeveral of his plaiſters.

the end of the ſame century, Nicolaus Prevoſt, a phyſician of Tours, wrote a general pharma- copœia,

ers. The Ægyptian ointment, oil of ſcorpions, diachylon plaiſters, and others of Arabian origin, are ſtill uſed at this day, under the ſame names, and with very little change of compoſition. We know nothing of the preſerved litharge, the white ſulphur, the earth of mercury, &c. of Rhazis. He commends much a martial vinous elixir, by the title of a preparation of the ſcoria of iron with wine, and water of roſes alſo; but whether he prepared it by ſimple infuſion or by diſtillation we are not told. Of the ſyrups, he mixed ſome with honey, others with ſugar and honey, and ſome with manna. The inſpiſſated juices of plants the Arabians called *rob*; and they reckoned among their ſyrups whatever was preſerved with aromatics. The names of oxymels and oxyſacchari they uſed indiſcriminately; from which it might be conjectured that ſugar and honey were equally common to them. Rhazis contrived various mixtures of ſugar; ſuch as the ſugar of water lilly, of voilets, of roſes, &c. He is ſaid to be the firſt who expreſſed oil from eggs, and Friend ſuſpects, that the oil of bricks was his invention. Albucaſis, who probably lived after Rhazis, ſurpaſſed all his countrymen in chemical knowledge Of all his remarkable, and in ſome meaſure voluminous, work on the unverſal materia medica, we have the 27th book only remaining, entitled *Servitor*, and which contains all the precepts of pharmacy, conciſe indeed, but ſufficiently clear and intelligible. Beſides other things, are to be found in this book, the preparation of ſal ammoniac; three modes of diſtillation, of vinegar, of wine, &c. It deſcribes four kinds of alembics and cucurbits,—of glaſs, of earth incruſted with glaſs, of lead, and of braſs. Albucaſis has a decoction of hiera; which was a tincture prepared in the ſun; and various extracts from the juices of plants inſpiſſated in the ſolar heat. He diſſolved gums in water or acetous acid, and filtrated the ſolution through courſe hempen clothes. He deſcribes the preparations of alkaline ſalt in the ſame manner with Dioſcorides;

copœia, which contains more formulæ than any other, eſpecially of antidotes *. Afterwards, many of the ſame kind made their appearance: But Valerius Cordus publiſhed a diſpenſatory, compoſed of extracts from all the others, which was ſanctioned by the law, and recommended by a decree of the State of Nuremberg, in 1542, to be the guide of the apothecaries. Many of

des; and mentions the ſoda from the plant kali, and the lixivium of aſhes. Rhazis is the firſt who ſpeaks of quickſilver rendered white; and which is perhaps the ſame as the ſublimed quickſilver of Avicenna. He orders quickſilver, mixed with acetous acid and vitriol to be rubbed into a perfect amalgam, and then the maſs to be dried and diſtilled, or ſublimed between two deep diſhes; and this proceſs to be renewed ſeven times, and at each a freſh ſprinkling of the vinegar. In another way he ſublimes quickſilver, by mixing it with lime, ſal ammoniac, and yellow arſenic. Geberus ſeems alſo to have deſcribed a ſpecies of corroſive ſublimate: See *Lib. de invent. verit. p.* 720. "Sume de eo (quickſilver) lib. i. vitrioli rubificati, lib. ij. a-"luminis rochæ calcinati, lib. i, ſalis communis, lib. ß. et "ſalis petræ, lib. $\frac{1}{4}$, tere totum, et incorporatum ſublima, et "collige album, denſum, clarum, et ponderoſum, &c." He appears to have had ſome idea likewiſe of aqua regia, and of its property of diſſolving gold. Crocus Martis, too, was prepared by calcination, and by corroſion with the acetous acid. Lime obtained from the ſhells of eggs was reckoned preferable to that of burnt ſtones or marine ſhells. Meſues, whom ſome authors imagine to have lived before the time of Rhazis and Albucaſis, acquired great reputation from the invention of ſeveral medicines, and the diſtinguiſhing title of *Evangeliſta Pharmacopæorum*. Some of his compoſitions are in uſe to this day, as *confectio alkerimes*, and various others.

* Entitled, De compoſitione medicamentorum particularium, &c. Lugd. 1505, in 4to.

of the compoſitions were only mixtures, or more ſimple preparations, as extracts, decoctions, electuaries, ſyrups, and ſuch like. He deſcribes however very clearly the method of making ether (which he calls *oleum vitrioli dulce*); of which we find only obſure traces in Baſilius Valentinus.

Medicines that required the aid of more profound chemiſtry were at the beginning of this period very rare, though not altogether unknown. The emperor Conſtantine IX. ſurnamed *Porphyrogeneta*, who died in the year 959, relates in the life of Baſilius of Macedon, his grandfather, that the empreſs, when juſt dying, was recovered by εκ τῦ ροδυ ςαγματι. Conrad Geſner has taken great pains to prove, that the *ſyrupum roſatum* is underſtood here; for he ſuppoſes that *rhodoſtagma* is the ſame as *rhodoſtactum*; but, from the preparation of it deſcribed by Paulus of Ægina, there is no doubt of its being the ſyrupum roſatum. But although many ages paſt, the ſame thing was expreſſed under two different names, it by no means follows, that they were afterwards conſidered as ſynonymous. Actuarius alſo makes mention of rhodoſtagma; but, from its uſe, it is evident, that under this appellation he means the water that droppeth from roſes. How could it happen that diſtillation was not known, when the utenſils for it ir had been ſo long deſcribed by Geber? We are indebted to the Arabian phyſicians, not only for our knowledge of ſeveral purgatives, as manna, ſenna, rhubarb, tamarinds, caſſia, and myrobolan; but alſo of muſk, nutmegs, mace, clove gilliflower, and other aromatics; and from them we learned the uſe of ſugar, which they employed inſtead of honey, in ſyrups, juleps, conſerves, and ſome confections. Rhazis ſpeaks of corroſive ſublimate, in the ninth or tenth century; and Avicenna mentions not only it, but likewiſe ſublimed arſenic, diſtilled water of roſes, and the diſtillation of bones and hair. Johannes Meſues, the younger of Damaſcus, writes of the diſtilled water of roſes, and the oils of amber, barley, and bricks, in the twelfth century, as if they were well known to the antients. In the thirteenth century, however, chemiſtry became of more importance to medicine. Thaddæus a Florentine, who died in 1270, at eighty years of age, among chemical preparations, beſtows great commendations on the virtues of ſpirit of wine. Baſilius Valentinus prepared various kinds of antimony, which he ſtrongly recommends in practice. As to what is ſaid by ſome, that it derives its name of antimony from its bad effects on the monks of his ſociety, as if *antimonachal*, is entirely without foundation, as Baſilius himſelf makes uſe of that appellation, which otherwiſe he certainly would not have done.——

Theophraſtus

Theophraſtus Paracelſus drew the attention of every body ſo much by his chemical medicines, that he was the firſt who was appointed to teach publicly chemiſtry at Baſil, in the year 1527. He was ſo violent in his hatred at all ſcholaſtic and Arabian productions, that in a rage he burned the writings of Avicenna and Galen at his firſt lecture; ſwearing, that full as much learning was contained in his cap. By his induſtry, the difference between chemical remedies and galenical was daily increaſed. It is reported, that he cured many diſeaſes by the means of opium and quickſilver. The ſingular manner of living practiſed by this man gained him equal enemies and admirers. His followers Joſeph du Cheſne, commonly called Querceta, Theodore de Mayenne, and ſeveral others, proclaimed the univerſal excellence of chemical medicines. In the year 1609, Crollius publiſhed a method of preparing *mercurius dulcis*. Many difficulties, however, attended as yet the progreſs of ſcience. The uſe of antimony was prohibited by the ſupreme council of Paris, by an edict in 1566: which was renewed in 1650: And Beſnier was expelled the faculty of medicine in 1609, for having given antimony in his practice. In the year 1590, the Faculty of Paris publiſhed a collection of all the proper medicines to be uſed. The edition of 1637, contains *vinum antimoniatum*: But this diſpenſatory was not ſanctioned

by

by the ſupreme council, until the 10th April, 1666. I. Schroeder gave to the world in 1644, a chemico-medical pharmacopœia, which was printed, for the third time, with many additions, in 1649. It delineated exactly the pharmacy of thoſe times, and enumerated almoſt all the chemical medicines that were known towards the cloſe of this period. About the ſame time, the Auguſtan aud London diſpenſatories were publiſhed. The Copenhagen diſpenſatory did not appear before 1658.—All of them wonderful performances, conſidering the ſtate of phyſic at that day. The diſcoveries and improvements ſubſequent to theſe do not come within the limits of the obſcure period.

It was long before ſhops for the ſale of medicines were eſtabliſhed in Sweden. When Guſtavus I. was on his death-bed, Johannes, the Ordinary of Stockholm had the charge both of his body and mind. Inſtead of an apothecary, Lucas was employed; but it is probable he was not furniſhed with any medicines of his own, but rather preſerved and prepared, when neceſſary, thoſe for the uſe of the royal family. Things were ſo circumſtanced at the time, that John III. granted on the 21ſt March, 1575, to Anthony Buſenius, the power of ſelling medicines, that they might not be ſpoiled with age; on condition that a proper and freſh aſſortment was always ready. The records of that time

make

make mention of a Simon Walder, an apothecary, living near the great market. Towards the end of this century, the number of apothecaries ſhops at Stockholm were much increaſed; and by degrees they were eſtabliſhed in the other cities. But it was not until the year 1686, that pharmacy was ſanctioned by the voice of the legiſlature.

Scarce any thing certain can be advanced with reſpect to the ſtate of ordinary chemiſtry, and the attention that was paid to it in theſe times; nor have we better intelligence of that part of the ſcience that relates to the various arts, except ſome account of metals, and a few others.

Metallurgy was cultivated long before the birth of Chriſt. Gold, ſilver, lead, copper, iron, and tin, were extracted from their ores; but in what particular manner is yet unknown to us.

Without doubt the proceſſes employed until the eight century muſt have been exceedingly rude and ſimple. From that date, however, all the writings ſpeak frequently of metals. The ſtatute publiſhed by Charles the Great about the year 800, mentions "argentum de noſtro labo-"ratu, ferrarias, et ſcobes." The chart of diviſion alſo of Lewis the Pious, in 817, ſpeaks of metals. Ofredus, a monk of Weiſenberg relates, that in his country, ſilver, copper, and

 iron,

iron, were dug out of the earth, and gold obtained by washing the sand.

After this we perceive metallurgy gradually assuming the form of a systematic science. In that manner was it treated by G. Agricola. His twelve books on metallurgy were first published at Basil in 1546; though it appears from his epistle dedicatory, that they had been prepared for the press ever since the month of December of the year 1500. As they contain much of the knowledge of the present day, we think it consistent with our plan, to enumerate them singly.——In his dedication he complains, that he had received no assistance from the ancient writers, except a little from the second Pliny. Not one of them attended sufficiently to a part, and much less to the whole art. Of the Greeks he found no writers, except Strato of Lampsacus, the successor of Theophrastus, who was the author of a book (since lost) on metallic machines and instruments; unless, perhaps, the poet Philo in his *Metallicus* treated upon this subject. But this work too has not escaped the wreck of time. He mentions two books written in the German language, one anonymous, on the experiments on metallic bodies and metals; but which he says is very confused: The other is by Calbus Friberg on veins; on whom he makes this observation: "Venter eam "quam sumsit, partem absolvit." He speaks of

Vannon

Vannon Biringuccius, as of the moſt modern author who writes in Italian, on the fuſion, ſeparation, and ſoldering of metals; though not very perfectly. Upon all this he remarks: "Quo "autem minus multi ſunt, qui de re metallica "ſcripſerunt, eo magis mihi mirum videtur, tot "chemiſtas extitiſſe, qui compoſuerint artifici"um de metallis aliis in alia mutandis." The firſt book refutes all the objections that are commonly made againſt the exſpectation of any public or private advantage from the ſtudy of metallurgy, and vindicates all the honour due to ſuch labours. In the ſecond, he treats of thoſe places abounding in veins of metal, and of the marks by which they may be diſtinguiſhed; and of the rod of divination, of which he ſays the learned mountaineer has no need. The third book contains an account of the metallic veins and ſtrata of the mountains. The ſubject of the fourth is the limitation of the mines. In the fifth we find a treatiſe on the extracting of ores, on pits, on cutting of mines, on drains, and on ſubterraneous geography and architecture. In the ſixth are deſcribed the various implements, as baſkets, tubs, and machines for taking away the different materials; as capſterns, ladders, hand baſkets, hydraulic and pneumatic machines, pumps; and, laſtly, all the inconveniencies, but chiefly the diſeaſes to which the miners are expoſed. The ſeventh treats on the docimaftic art. In this are defcribed the docimaftic furnaces, ovens, difhes, cupels made of burnt bones or afhes, alfo fhades, melting furnaces, crucibles, iron hooks, fcales, buckets for wafhing the ore, and various kinds of weights: It teaches the method likewife of afcertaining how much gold, filver, quickfilver, lead, copper, iron, tin, or bifmuth, is contained in every ore; and in what manner gold or filver coin may be examined on the Lydian ftone, by proof needles; the inveftigation of the qualities of gold by the nitrous acid, quartation, and the increafe of weight from the filver refiduum; and many other things. We meet in this book with almoft every thing now in ufe in the docimaftic art, and the fame kinds of proceffes; except that the inftruments and methods of operating are become more fimple and accurate. The lead of Villachia is faid to contain no filver. In the eighth book we have an account of the feparating ores from the rock, of calcining and pounding them; and alfo a particular method of purifying them through a fieve, or by wafhing in fome other manner. The ninth enumerates the various forts of furnaces, with their bellows, and the feveral methods by which, from the greater portions of minerals, gold, filver, lead, copper, iron, tin, and bifmuth, may be extracted by the means of fire. The tenth relates in what way gold and filver may be be ſeparated from each other by acids, or, in the dry way, by ſulphur, antimony, and cementation. The eleventh ſhews the method of ſeparating ſilver from copper and iron, by eliquation with lead. The twelfth deſcribes the preparations of common ſalt, nitre, alum, martial vitriol, bitumen, and glaſs. From all theſe accounts, therefore, it appears, that the chemiſts of thoſe days proceeded in their operations as we do at preſent, except that we have learned, in a a more cultivated ſtate of the ſcience, to reject many things as uſeleſs, and to form ſhorter proceſſes. In his book on the nature of foſſils, Agricola treats particularly on minerals. He divides all earthy bodies into two claſſes, thoſe which flow out from the earth, as water and ſubterraneous air, and foſſils; which he again arranges under five heads: 1*ſt*, Earths are enumerated according to the uſe that is made of them: the earth of huſbandmen, of potters, of fullers, painters, artificers, and phyſicians. 2*dly*, Concrete juices: ſalt, nitre, alum, vitriol, chryſocolla, ultramarine, Armenian ſtone, ruſt, orpiment, ſandaracha, ſulphur, bitumen, aſphaltus, camphor, piſſaſphaltus, ampellites, jett, foſſil coal, and amber. 3*dly*, Stones ſtrictly ſo called: magnet, ſchiſtus, morochtus, gypſum, talc, amianthus, mica, the Jewiſh ſtone, and other petrifactions; geodes, ætites, enhydrus, pumex, lapis molaris, and fluor mineralis. Gems; not thoſe only that are tranſ-

 parent,

parent, but others that are opaque: as the jasper, &c.: Whatever admits of being polished; as marble, porphyrites, ophites, tophus, and flints: Various kinds of stone; as the sand-stone, the stone that cuts easily, calcareous, and a stone of a thread-like texture. *4thly*, Fossils properly so called: metallic minerals, plumbago, pyrites, cadmius, antimony, pompholyx, lapis assius, and earths heavy with concrete juices. *5thly*, Metals: gold, silver, quicksilver, copper, white lead (tin), black lead (common lead), ash-coloured lead (bismuth), and iron. Although this mineralogical essay is not without many faults, yet they should be safe from the severity of criticism, when we consider that Agricola was the first who attempted such a system.

The progress of metallurgy, after the time of Agricola is fully illustrated by a comparison of his writings with those of others; as of C. Encellius *de re metallica*, in 1557; of Modestinus Fachs, whose *Docimasia*, though written in 1567, did not appear until 1595, published by his son; of L. Ercker in *aula subterranea*, in 1575; and of Mathesius of Sarphat, 1578, and a few others. White vitriol begun to be manufactured at Rammelsberg, anno 1574.

About the time that the light of the Christian faith had dispelled the idolatrous gloom of the northern regions, it is most likely that the people

people turned either to open the inward treaſures of the earth, or to apply them with more ſkill to purpoſes of utility. At a convention of the ſtates of the kingdom at Stockholm, in the year 1282, during the reign of Magnus Ladulas, all the mines and their produce were aſſigned to the public treaſury. Before this time we have no authentic writings that give any account of metallurgy. King Magnus regulated by a law, in 1354, the mine of Norberg: The privileges of the mine of Atvidaberg, and of the metallic ſociety, were granted by King Eric in 1413. In 1420, the mines of Norberg, Bitſberg, Vikaberg, Silfverberg, Tunaberg, and Skinſkatteberg, obtained their privileges. Some privileges, indeed, are mentioned of a more antient date; but the original manuſcripts have fallen in the general ravages of time, which requires not many ages to overturn and deſtroy things far more durable. At a time when nothing but what was antient was held in any eſtimation, many perſons of ſkill in theſe matters, contended, that the mine of Sahlberg was opened a ſhort while after the birth of our Saviour: But no papers or records ſpeak of it ſooner than the time of Suante Sture. Otto Biſhop of Aroſien, in his letters to him, dated about the beginning of the year 1511, ſolicited a part of this mine. He founded his claim, firſt on his right as biſhop; and ſecondly, on a plea of indemnification for the loſs he had ſuſtained of the tenths of the field in which the mine had been diſcovered. In another letter, he wrote to Steno Sture, in 1513, he urges his pretenſions ſtill further. The inhabitants of the metallic country of Norberg, in the year 1510, complained to Suante Sture, that the mine of Sahlberg lately opened had driven them to great diſtreſs, by enhancing the value of proviſions, of which it bought up the greateſt part. In Norway we find ſcarce any account of working of metals being properly underſtood, until the ſixteenth century *.

Glaſs was long known, but its application to the purpoſe of windows is of a later date. It is one of the moſt uſeful inventions; as it admits man to the enjoyment of the clear light of the heavens, and the ſplendour of the ſun, without expoſing him to the unwholeſome changes and qualities of the air. There are ſome paſſages, indeed, to be found in antient authors, that ſeem to imply the uſe of glaſs in windows in the time of Caligula: But we may, with equal reaſon, underſtand them as meaning pellucid ſtones, that bore ſome reſemblance to glaſs. Lactantius is the firſt of them all, who has given any certain account reſpecting this matter. He ſays, " Verius et manifeſtius eſt mentem eſſe, quæ per " oculos ea, quæ ſunt oppoſita tranſpiciat, qua-

" ſi

* Köpenh. Sälſk. Handl. 7 del.

"ſi per feneſtras lucente vitro aut ſpeculari lapide obductas *."

Not leſs deciſive are two paſſages in Hieronymus. In the firſt of which he ſays: "Feneſtræ erant factæ in modum retis, ad inſtar cancellorum, ut non ſpeculari lapide, nec vitro, ſed lignis interraſilibus et vermiculatis includerentur †." In the other he ſpeaks of "feneſtris, quæ vitro in tenues laminas fuſo obductæ erant." Windows made with glaſs were known towards the end of the third century: But this application of it did not become general until ſeveral ages after. Some churches in France were furniſhed with windows after this manner, in the time of Gregory of Tours ‡. The Greeks beſtow great praiſes upon the vaſt number of glaſs windows that adorn the round tower, commonly called the cupola, of the great church of St. Sophia built at Conſtantinople, and which was dedicated to our Saviour by Juſtinian §.

In the ſeventh century manufactories of glaſs were eſtabliſhed in France; from whence, towards the end of it, ſeveral artificers migrated into England, where the art was hitherto unknown ‖. The eight century carried the invention into Germany and Italy, and the ninth extended it to the northern regions. On reading

* De opificio Dei, c. 8.

† In Heſ. xli. 16.

‡ De gloria martyrum.

§ Paulus Silentiarius.

‖ Fleury hiſt. eccleſ.

ing of the ſingular effects which the rays of the ſun, tranſmitted through the windows of the cupolas, are reported to have produced within the churches, it would appear, that the glaſs then uſed was tinged with various colours; although we do not find it mentioned to be ſo any where.

In Italy, long before the birth of Chriſt, we meet with ſepellated works, compoſed of various kinds of ſtones, and pieces of glaſs of different colours, the art of which the Italians had acquired from the Greeks. And yet, until the eight century, coloured glaſs was never uſed in ornamenting the windows of their churches. After that time, however, they had windows conſtructed with bits of variegated glaſs, under the form of flowers, crowns, and other devices. And at length, in order to give encouragement to pious meditations, artiſts were employed to repreſent upon them ſtories from the holy ſcriptures, or the tranſactions of ſaints. At firſt, and even as late as the end of the twelfth century, black figures only were burned in upon red glaſs, which afterwards became rather ſcarce. In the thirteenth century the art was communicated through Germany, Holland, and Italy. About the end of the fourteenth century, glaſs was ſtained with many other colours than red, owing chiefly to the pains and induſtry of John van Eick, or von Brugges; and by degrees the

art

art was carried to perfection in the 16th century: From which time it has fallen insensibly into decay; in so much, that there is reason to fear, it is now totally lost.

The method of painting in enamel is nearly the same as in glass. Raphael Sanzio and Michael Angelo Buonarotti were the first in Italy who carried this antient art to any height. Neri affirms *, that pictures were made in this manner by the means of a lamp, in the year 1601; and that John Toutin a French goldsmith rendered them afterwards much more perfect †.

The art of imitating gems engaged considerably the attention of the alchemists. R. Lullius is supposed to have made great proficiency in it, and Isaac Hollandius still more about the beginning of the seventh century ‡. Neri laboured yet further in this pursuit. He collected all the various processes of others, examined them carefully, and published those that he thought were most likely to succeed. He knew in what manner red glass was prepared with gold, and taught how to stain it with any other colour. He describes the preparation of ultramarine and lac, and makes mention of the Piedmontese magnesia.

Some of the more antient *amausa* § of a bluish colour

* Ars vitr. c. 42.

† Dict. des arts et des metiers.

‡ Op. min. l. i. c. 70. ii. c. 89.

§ A kind of semi-pellucid stone, of which the antients made vases and other vessels.

colour, from Egypt, and pieces of glaſs of the ſame dye from the ruins of Herculaneum, are yet in exiſtence. Hence it has been concluded by ſome, that the uſe of cobalt was known to the antients: Though the more modern chemiſts * rather queſtion it; as by all the trials to which they have ſubjected the ſpecimens of their art, they diſcovered traces of lapis lazuli, iron, or copper, but no cobalt.

Among the collection of ſtones in the academy of Upſal, are preſerved ſome glaſs checquers, found in Herculaneum, which have an azure tint, are tranſparent, and ſeem to owe their gold colour to a thin plate of yellow glaſs, to which they are very ſkillfully united. But they are by no means coloured with cobalt. For having only a ſlight bluiſh tint, if they are examined by the refracted rays of light, the redneſs characteriſtic of cobalt will not be found in them. Beſides, when ſmall pieces of theſe checquers are melted by the blow-pipe upon charcoal, either alone or with borax, the red and opaque hue of copper is eaſily diſcovered.

The ores of cobalt, which, together with ſilver, contain biſmuth, ſhould have ſuggeſted the application of the blue ſcoriæ to ſome uſeful purpoſe †: But they were long reckoned among the refuſe only; until Seb. Preuſsler eſtabliſhed a manufactory for glaſs with cobalt, in Bohemia, in

* Cel. Gmelin. in Actis Gœtin.

† Encelius de re metallica.

in 1571, and John Jenitz and Joſeph Harren, followed his example, in 1575, in Saxony. In the year 1564, David Heidler, in Bohemia, and Hier. Zurch in Miſnia, had already found proceſſes for collecting arſenic from them.

From the paintings in Herculaneum we ſee, that all the colours that are prepared with water were known long before the year 79. With theſe the ancients painted on walls freſh plaiſtered. The art of mixing colours with oil, it is commonly believed, was invented by John Von Brugges, about 1431; though it is ſufficiently evident that it was practiſed in the 11th century.

Very little improvement was made in the art of dying, for many ages from the beginning of this period. The Greeks and Saracens of Europe uſed the purple of the Weſt; but at length this colour fell into diſeſteem, and the more brilliant red was preferred: In ſo much that, in the 12th century, the ſecret of ſtaining with the purple periſhed likewiſe in the Eaſt. By the expeditions of the cruſades, many artiſts, and with them various arts found their way into Italy; and the chief of them took up their reſidence at Venice, to which port moſt of the veſſels from the Eaſt reſorted. As early as the year 1194, 1198, and 1306, mention is made of the *grana de braſile*, *braxilis*, and *indigo*: Though they certainly did not mean thoſe ſubſtances which

which were afterwards furniſhed by America. The name *braxilis* no doubt was derived from ſome other place than the Braſils, which in thoſe days was yet undiſcovered; and the indigo ſeems to be the ſame pigment with what is called *indicum* by Pliny *.——About the year 1300 a Florentine merchant diſcovered by accident that the moſs of Rochelle (called by the Engliſh manufacturers *cudbear*) gave a blue tinge to urine; and, making repeated experiments, he learned to uſe it ſo ſucceſsfully in dying this colour, that it not only procured wealth to himſelf, but was ſo advantageous to the Florentines, that his deſcendents all went by the name of *Rucellians*. In 1429 the Venetians preſcribed rules to their dyers; which were rendered more perfect, and republiſhed in 1510 by John Ventura Roſetti, under the feigned name of Plichtus. With theſe inſtructions the art improved elſewhere, and was daily extending: But the materials afforded by the diſcovery of America, of which the principal were the indigo and cochineal, contributed more than any thing elſe to its great increaſe. Indigo, however, was not altogether truſted, and, for a long time, was not in ſuch eſtimation as woad; and the uſe of logwood too was often prohibited. During the reign of Francis I. of France, Gilles Gobelin attempted thy dying of ſcarlet. His firſt eſſays were

* H. N. l. xxxvi. c. 6

were confidered as madnefs; and when, contrary to expectation, they proved fuccefsful, he was robbed of the praife due to his genius by the fuperftition of the age, which attributed the difcovery to the interference of the devil, with whom he was believed to be in league. P. Kloeck, a Dutch painter, acquired great fkill in the ufe of colours in the Eaft; which he carried to great perfection in his own country, and died there in 1550. In England and in Germany, about the fame time, this art was making great progrefs; though it was ftill generally involved in rudenefs and obfcurity; until the patronage of Colbert in France gave it new powers, and threw light on all its operations *.

The mortar employed by the antients in their buildings, is of fuch confiderable hardnefs, that many have been led to fufpect it was prepared in fome way with which we are unacquainted. Though there can be no doubt that the materials that compofe it were better mixed in thofe days than at prefent; yet, as hard lumps of the fize of a pea or a bean are often found in it, there muft furely have been fome error, either in the burning or flaking of the lime, or in the mixture itfelf. On examining narrowly the mortar of the antients, it is found to contain more fand than the mortar of the prefent day. The authority of

* Bifchoff Gefch. der Färberkunft.

of Pliny *, and Vitruvius †, confirms this obſervation; for they both direct, that when it is made with pit ſand, a fourth part of lime ſhould be uſed; and, when with river or ſea ſand, a third part, according to the bulk. From experience, however, we are taught, that the proportion of the materials muſt be varied, according to their quality, and to particular circumſtances. The antients burned their lime on the ſpot where they were building; and it is certainly of the greateſt importance to uſe it quite freſh. But, even as it is, the common mortar employed at preſent hardens in a ſeries of years, and will become a perfect ſtone, unleſs local obſtacles ariſe to the abſorption of the aerial acid, or counteract its effects.

§ II. *Of*

* H. N. l. xxxvi. c. 23.

† Arch. l. ii. c. 5.

‡ Not many years ago it has been diſcovered, that the petrefaction of mortar requires a much larger proportion of ſand than is generally given, viz. about three to one (according to the obſervation of Pliny); and that by uſing lime hot from the kiln, without tempering it, the mortar binds and conſolidates to the hardneſs of ſtone. It is not a little extraordinary, that this confirmation of antient oeconomy in maſonry ſhould have been ſo lately eſtabliſhed.

Note of the Tranſlator.

§ II. *Of the Great Work.*

Before we take into confideration the making of gold, a fubject on which the alchemifts laboured with the greateft zeal and induftry, two queftions naturally prefent themfelves, and demand our immediate attention. The firft is, Whether the problem is capable of a folution? the next, Whether any one has really ever made gold? Let us examine them feparately.

Firft of all, it is neceffary to determine the precife meaning of the "making of gold," before we can venture to hazard an opinion, or purfue the enquiry. Gold, as well as all other metals, is compofed of a proper metallic earth, and the principle of inflammability. Therefore, if we do but find the former, and expofe it to a fufficient degree of heat, we are prefently in poffeffion of perfect gold. If then this operation is called making of gold, by the fame parity of reafoning, we may beftow that appellation on the daily proceffes of reducing metallic calces; which is repugnant to the ufual mode of expreffion. Let us then trace the matter from its fource. There can be no doubt, that the Almighty only is equal to the tafk of creating the original elements and principles of bodies; but, it is fo far from being inconfiftent with this idea, that, by a due examination of the laws of attraction obſerved by nature, chemiſtry ſhould be able, from theſe principles variouſly connected and prepared, to compoſe numerous inorganic ſubſtances, either reſembling the ſpontaneous productions of our globe, or wholly new and different from them; that it is rather in ſuch operations, and the proſecution of ſuch deſigns, that the ſcience of chemiſtry is at this day employed; and, in proportion as the conſtituent parts of bodies and their properties are previouſly known, will always be the ſucceſs of its labours. If therefore the proximate principles of this golden earth are phlogiſton and a certain acid, which may be eaſily ſuppoſed, the queſtion then is reduced ſimply to the obtaining this acid in a ſufficient quantity; for the phlogiſton is every where to be found. By the means of the latter, the acid being fixed and coagulated, the earth is procured, and the reſt of the proceſs is carried on without any difficulty.

As it is moſt probable, that the acid of gold has ſo powerful an attraction for phlogiſton that it cannot exiſt long without it, it may be queſtioned, whether more of this acid can be found in the bowels of the earth than what has already aſſumed the form of gold, or at leaſt of the earth. In this opinion, however, though we are ſafe from contradiction, it does not imply that, if the

the acid were found in a ſeparate ſtate, it would be either impoſſible, or beyond the powers of chemiſtry to ſaturate it with phlogiſton.

The alchemiſts contend, that the principle of gold, though corrupted by various cauſes, is contained in all the metals; and that, if properly purified and freed from extraneous matter, it may be brought into its perfect ſtate. From what has been ſaid before, then, this is as much as to declare the original acids of all metals to be the ſame; from which, either by varying the proportion, or by the admixture of heterogeneous ſubſtances, nature produces ſuch different effects, that, by the addition of a certain quantity of phlogiſton, according to the capacity of the ſubſtance, not only gold, but various kinds of metals are in the uſual manner produced. To correct the errors of theſe proportions and combinations, by the means of their elixir, or philoſopher's ſtone, was the great aim of the alchemiſts; ſo that all the baſer metals might be converted into gold, or, in their own language, to tinge the imperfect, in ſuch a manner, as to render them all the moſt perfect of metals.

If we attend to the experiments hitherto known, and made with the greateſt care, we ſhall find but little or no encouragement to believe in the tranſmutation of metals or other more ſimple bodies. In thoſe days, when the inveſtigation of philoſophers were not made with the ſame preciſion as they are at preſent, the event of many experiments ſometimes aſſumed ſuch appearances of change; but theſe illuſions no longer exiſt. For ſubſtances which are not ſuppoſed to contain any gold, may ſtill conceal a very ſmall portion of it in their compoſition; as we know that, except iron, no metal is more frequently to be found, though, from its extreme minuteneſs, it often eſcapes our obſervation. Let then ſuch a ſubſtance be expoſed to a continued and violent fire, which nothing will reſiſt, except the grain of gold. At the ſight of it, the operator, believing it to be created by his ſkill, not extracted (as it really is) from the ſubſtance he employed, is tranſported with joy. Diſcouraging, however, as this may appear, no one, who has at all explored the ſecret paths of nature with induſtry and penetration, will deem that impoſſible, which does not militate againſt a known and eſtabliſhed truth. In the queſtion now before us, no ſuch difficulty has been diſcovered. Daily experience furniſhes effects analogous to thoſe, of correcting and purifying bodies mentioned by the alchemiſts. For, do we not ſee, that a ſmall quantity of leaven is ſufficient to ferment a large quantity of new wine; ſo that the vinous ſpirit, which was before contained in the grain, or entirely concealed, is evolved and liberated from thoſe particles with which it was in intimate union, or compounded, ed, by a due proportion of its conſtituent principles. Who then will be bold enough to aſſert, that no change can be wrought upon the baſer metallic acid, by any additament however ſmall, either by adding, ſubtracting, tranſporting, or in any other way, ſo that it may be converted into a nobler kind?

The opinion that bodies formed by art are leſs firm and perfect than thoſe of the ſame kind produced by nature, is to be received with ſome limitations; as art has given birth to many ſubſtances, that agree perfectly in their qualities, with thoſe of natural growth. Cannot neutral ſalts, and ſuch like ſubſtances, perfectly ſimilar to thoſe that are native and pure, be prepared by art? And may not many other bodies likewiſe? If ſometimes, indeed, the combination ſeems to be rather looſer, it is to be aſcribed to the greater quantity of moiſture retained in them, and which natural productions have loſt through time.

From all, then, that has been already ſaid, it is evident, that the impoſſibility of making gold, or tranſmuting metals by art, cannot be demonſtrated: Yet whoever thinks therefore, that the poſſibility is proved, will find himſelf greatly miſtaken. Between two ſuch extremes the interval is very wide. Or if it be imagined, that any certain concluſion can be drawn *a priori*, it will be found, that a more perfect knowledge of nature is required, than has as yet been diſcovered. But even granting the poſſibility, it remains next, to carry it into execution: For it does not follow, that every thing that is poſſible to be done is within the power of art to perform. Should the experiment ſucceed by a fair proceſs, all further enquiry about the poſſibility of it is at an end; for the fact under ſuch circumſtances is abſolutely deciſive.

We are now, in the next place, to conſider, whether, of the great number who called themſelves adepts, any one has actually compoſed gold. The ſolution of this queſtion is entangled in many difficulties, owing to the want of proper and faithful deſcriptions of the many tranſmutations. The teſtimony of ignorant ſpectators is as little to be depended on as the aſſertions of the writers themſelves. In the proceſs many deceptions have been practiſed: Gold has been concealed in the veſſels, in the inſtruments, in the coals, and in other materials. But tho' this may be ſaid of ninety-nine of a hundred ſuch aſſertions concerning the tranſmutation, it may be alledged, that it does not apply indefinitely: Where, however, ſuch aſſertions are not ſupported by abſolute proof they muſt remain inadmiſſible.

But ſome accounts are entitled to a greater degree of credit. For, doubtleſs, if a perſon who has no faith in the changes of alchemiſtry, ſhould obtain by chance a ſmall piece of the philoſopher's philoſopher's ſtone, and, on making the experiment alone in his cloſet, procure a quantity of gold heavier than the weight of the ſtone; will it not be difficult to explain in what manner he was liable to be deceived.—Something ſimilar to this ſeems to have happened to Dr. Helvetius at the Hague. He was a conſtant oppoſer of the great myſtery that was to cure all diſeaſes; and declared his opinion of it in a work he publiſhed againſt the ſympathetic powder of Digby. On the 27th December, 1666, a ſtranger paid him a viſit; who after diſcourſing ſome time on the nature of an univerſal medicine, produced the philoſopher's ſtone, of the colour of ſulphur, and five pieces of gold; deſcribing the manner in which they had been prepared. Helvetius earneſtly petitioned for a ſmall piece of the ſtone in remembrance of him; or elſe that he would diſplay its virtues in the fire. The ſtranger refuſed both requeſts, but promiſed to return in three weeks. Accordingly, he kept his word; but it was with great difficulty that he would part with a bit of the ſtone not larger than a grain of rape-ſeed: And Helvetius doubting, whether ſo ſmall a quantity was ſufficient to change four grains of lead into gold, the ſtranger cut off more than the half of it, aſſuring him the remainder would be more than was neceſſary. At their firſt meeting, Helvetius had ſcraped off with his nail, unknown to the ſtranger, a ſmall particle of the ſtone, which he afterwards threw into ſome melted lead; but the whole almoſt evaporated, leaving behind only a kind of vitreous earth. On his relating this diſappointment, the alchemiſt candidly acknowledged the deceit; but directed him in future to incloſe the ſtone in wax, that it might not be affected by the fumes of the lead. He inſtructed him in other circumſtances likewiſe; told him that the whole proceſs could be compleated in a few days, and that two florins would defray all the expence. In order, however, to teach him the method of performing the operation, he promiſed to be with him again the next day. The appointed hour came, but no ſtranger; and Helvetius having waited for him with ſome impatience, but to no purpoſe, reſolved on making the experiment in preſence of his wife and his ſon. To ſix drachms, of lead melted in a crucible, he added the piece of ſtone he had received the day before, wrapped up in yellow wax; then covering the crucible, he left it for a quarter of an hour expoſed to the fire; at the expiration of which he found the whole maſs converted into gold. At firſt, it appeared of a greeniſh colour; but being poured out into a veſſel of a conical ſhape, it aſſumed a tinge like blood, and afterwards, as it grew cold, the true golden hue. This gold was examined by a goldſmith, who found it ſo very pure, that

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he reckoned an ounce of it to be worth fifty florins. Porellius, the general aſſayer of the coin throughout the province of Holland, requeſted, that he might be permitted to make trial of it; and examining two drachms of it by quartation and aquafortis, he found it had increaſed in weight two ſcruples. This change he attributed to the effect of the great abundance of colouring matter, which had tranſmuted ſo much of the ſilver he had employed. Suſpecting, however, that the ſilver was not firmly united with the gold, he melted it again, with ſeven times its bulk of antimony, and treated it in the uſual manner; but without producing any alteration on its weight.

Such, then, is the account given by Helvetius; and as the man who furniſhed this extraordinary ſtone never entered his laboratory, or was even preſent at the operation, no fraud could be practiſed by him; and it will not be eaſily proved in what way he might have deceived himſelf. The whole argument, therefore, reſts on the credit of Helvetius. For, if he has concealed any one circumſtance relating to the proceſs, or added others that are falſe, the queſtion will be juſt as obſcure as it was before.

His deſcription, to be ſure, betrays the ardour of his deſire to learn the chryſopoietic art; nor can any one anſwer for the probity of another: Yet it would be highly unjuſt to accuſe

any

any one of a design to deceive all mankind, unless upon better grounds; as the impossibility of the transmutation in question can never be demonstrated. Berigardus of Pisa, gives an account of something similar that happened to himself. He describes it in the following words*: "Referam, quod olim mihi contigit, cum vehe-"menter ambigerem, an aurum ex hydrargyro "fieri posset, accepi a viro industrio, qui hunc mihi "scrupulum auferre voluit, drachmam pulveris, "colore non absimilis flori papaveris sylvestris, "odore vero sal marinum adustum referentis, "atque, ut abesset omnis suspicio jocosæ fraudis, "vasculum e multis venalibus accepi, carbonem "et hydrargyrum, quibus nihil auri occulte, ut "fit a circulatoribus, subjectum esset. Decem "istius drachmis pulverem injeci, subjecto igni "satis valido, statimque omnia, exiguo inter-"trimento in 10 fere drachmas auri optimæ na-"turæ coaluerunt: quippe quod aurificum judi-"cio nullam non subiit tentationem. Hoc mi-"hi in solo loco et remoto ab arbitris nisi com-"probassem, suspicarer aliquid subesse fraudis: "nam fidenter testari possem rem ita esse." I. B. Van Helmont thus expresses himself: "Co-"gor credere lapidem aurificum et argentificum, "qui distinctis vicibus manu mea unius grani "pulveris super aliquot mille grana argenti vivi "projectionem feci, astanteque multorem corona "nostri

* Circulus Pis. 25.

"noſtri omnium, cum titillante admiratione ne-
"gotium in igne ſucceſſit." And in another place he ſays, "Dabat mihi forte ſemigranum illius "pulveris, et inde unciæ 9 atque ¾ argenti vivi "tranſmutatæ ſunt. Iſtud autem aurum dedit "mihi peregrinus unius veſperi amicus *.

It is related of the Emperor Ferdinand likewiſe, in 1648, and of the Elector of Mentz, in 1658, that they both made trials of the philoſopher's ſtone with the greateſt attention, removing every thing that might in the leaſt countenance impoſition: But the meaſures they took are not expreſsly deſcribed †: From the nature of the evidence, however, in ſupport of this relation, there can be no reaſon to ſuſpect the truth of it. With regard to other accounts of tranſmutations, of which the liſt is ſo numerous, ſome bear ſuch ſtrong impreſſions of fraud, as to betray the means even by which they were effected; while others have been conducted in ſuch a manner, that though their fallacy cannot be inconteſtibly proved, yet there is every reaſon to apprehend they are equally doubtful and uncertain. As to the ſtory of ſix drachms of lead changed by one drachm of the philoſopher's ſtone, into a maſs of gold equal to the weight of 147 golden ducats, by General Otton Arnoldus Paykull, when in priſon in the year

* De arbore vitæ.

† Moncony's travels. See alſo in § 6. under the name Richthauſen.

year 1707; ſome circumſtances in it are mentioned by Dr. U. Hiærne *, formerly the King's phyſician, which, though different from any in the former accounts, do not altogether exclude ſuſpicion. There is no doubt, that Colonel Hamilton ſaw the preparation of the powder to be employed in giving the neceſſary colour, and that, unknown to Paykull, he had made it from materials he purchaſed himſelf, and which he was certain contained no gold; but the colouring powder was thrown in by Paykull; and it does not appear that the crucible was ever carefully examined, in which gold might have been concealed in various ways. Beſides, the very circumſtance of the weight occaſions doubts. For, ſuppoſing that the whole of the ſix drachms of lead, and one of the colouring powder was converted into gold, how are we to underſtand, that the weight of the gold ſhould exceed that of the materials in the crucible more than twenty times, without aſſuming the power of the Almighty, who alone is equal to the taſk of creation? Arnoldus of Villa Nova, at Rome, is reported to have tranſmuted iron into gold. The ſame is ſaid of R. Lullius, who performed this change before King Edward at London, who ordered ſome roſe-nobles to be coined from the metal. And we read of L. Thurneiſerus exhibiting in 1587, before

* Su. Magaz. part i. p. 220.—237.

fore Ferdinand I. Grand Duke of Tuſcany; and of Coſmopolita, in the preſence of the Duke of Saxony; and Sendivogius before the Emperor Rudolphus II. and ſimilar ſtories of many others. But from all theſe various accounts, the truth is not rendered in the leaſt more obvious. Nay, by the diſcovery of the fraudulent meaſures of Thurneiſerus, it is evident he took pains to conceal it.

There is a report of a tranſmutation performed in Pomerania, before king Guſtavus Adolphus, and that ducats ſtamped with the ſigns of mercury and copper were coined from the gold produced by it *. Alſo, a ſtory is told of a merchant of Lubec giving in a preſent a hundred pounds of chemical gold, to the ſame king, from which ducats were made bearing the ſigns of mercury and ſulphur. One of theſe pieces of money, ſtruck at Erfordia, in the year 1634, is ſtill to be ſeen in the royal cabinet of medals; but no concluſion can be drawn from it, as we have other coin of Erfordia, called *groſchen*, with ſimilar impreſſions. After the Saxons made peace with the emperor, the Erfordians were no longer permitted to coin money with the Swediſh arms †.

Among all the various inſtances of tranſmutation ſo warmly ſupported by the believers in alchemiſtry

* Borrichius de ortu et progreſſu chemiæ, ad finem.

† Berchs Beſkriſn. om Suenſka mynt och Skädep. p. 3.

alchemiſtry, the greater number are fallacious, manyuncertain; and ſome are of ſuch a nature, that, while the faith of hiſtory is admitted, they cannot well be called in queſtion. The harſheſt ſentence, therefore, that we can pronounce upon them is, that the perſons who made the experiments may poſſibly have been deceived themſelves; and that, as the different ſteps they took are not very clearly related, we ought to ſuſpend our judgement, until ſuch time as we can have an opportunity of repeating the experiments under our own immediate obſervation. It muſt be acknowledged, however, that more circumſpection will be neceſſary in the inveſtigation of a ſubject of this kind, on which particular phyſical opinions are eſtabliſhed, than of a fact on which every witneſs of common ſenſe is able to give a determination *.

§ III. *Of*

* It is now almoſt five years ſince the eyes of all the world were attracted by the experiments of Dr. James Price, F. R. S. of London, which ſeemed to revive the ſpirit of of alchemiſtry, ſo long neglected by every genuine chemiſt. He produced a red and a white powder that he had prepared himſelf; with which he boaſted he could convert mercury into gold or ſilver. And that he might prove the truth of his aſſertions he made ſeven different experiments before a number of reſpectable perſons aſſembled for the purpoſe. See, "Account "of ſome Experiments on Mercury, Silver, andGold, made at "Guilford, in May, 1782, in the Laboratory of James Price "M. D. F. R. S. &c. Oxford, 1782. 4to." Likewiſe the London Chronicle, 19th October, 1782, and "Crell's Neueſte "Entdeckungen in der Chemie, th. 8. 1783. p. 275." But as

§ III. *Of the Universal Medicine.*

Agreeable to the plan of this work, the history of an universal medicine offers itself next to our consideration: And from the great patience and industry with which the study of it has been prosecuted, equally with the making of gold, by many chemists, it becomes a subject more worthy to be investigated.

Although

as all the powder he had prepared was consumed in these experiments, and as he declined making any more on account of the tedious and unwholesome process, the question remains yet to be decided. Probably, though in other respects a man of learning and integrity, yet he was not proof against the insinuations of vanity and the desire of fame, through which he was led to declare he had discovered the crysopoietic art. His unfortunate end in some measure authorizes this conjecture. For when pressed on all sides, by the doubts and interrogations of his adversaries, to renew his powder, and repeat his experiments before men of skill and science, he seems to have thought it easier to put an end to his own existence by laurel water, than to create gold for their satisfaction. Crell's Chem. Ann. 1784.

Note of the Translator.

Sir Kenelm Digby at a meeting of the Royal Society, soon after its institution, produced a small piece of gold, which he asserted to have been made by the great process of transmutation; saying, " Gentleman, I assure you I was formerly so great an " infidel that I could not have believed it, except I had seen " the fact with mine own eyes." " Marry come up (said Sir " Thomas Brown of Norwich) I am perfectly of Sir Kenelm's " opinion; nor will I give credit to the making of gold, until " I behold it with my own eyes."

Although from the remoteſt period an opinion has obſtinately prevailed, that a medicine endowed with the property of defending the body from diſeaſe, and rendering old age vigorous and chearful, might certainly be diſcovered; yet we do not find any of the celebrated phyſicians make mention of ſuch a wonderful medicine except Actuarius *. Of the virtue of the philoſopher's ſtone, and the preparations of gold in the cure of diſeaſes, we have the firſt account from the Arabians. Geberus long ago ſaid, "Elixir rubeum omnes infirmitates chronicas, de quibus medici deſperarunt, curat, "et facit hominem juveneſcere ut aquilam †." And Morienus ſays, "Lapis noſter perfecta medicina eſt, habens virtutem præ omnibus medicinis et potionibus, ſanandi univerſas infirmitates hominum ‡." The ſtory of Arthephius, who ſaid he had lived 1000 years, by means of an univerſal tincture, is known to every body. Roger Bacon propoſed a ſimilar medicine to Pope Clement X. which he extolled highly, as the invention of Petro de Maharncourt. Afterwards authors frequently inſerted ſeveral things in their writings reſpecting this univerſal medicine; and of theſe Arnoldus de Villa Nova, R. Lullius, Joh. de Rupeſciſſa, Baſilius

* Meth medendi. l. iv. c. 6.
† Summa Perfectionis Magiſterii.
‡ In Dialogo cum Rege Calid.

silius Valentinus, and J. Hollandus, were the moſt remarkable. Hence aroſe the abſurd and dangerous notion, that all diſeaſes could be cured by one medicine, health preſerved without interruption, and old age protected from infirmity unto the laſt hour of exiſtence. In this manner, though the practice of medicine was rendered exceedingly ſimple, yet it was erroneous and inconſiſtent with its true principles: For phyſicians neglecting the neceſſary inveſtigation of cauſes, truſted entirely to the general virtues of their ſpecifics, and rendered their art dependent upon chemiſtry; which Boerhaave ſays, " Egregia illius ancilla eſt, non alia pejor " domina." But of all thoſe who were remarkable for ſupporting this opinion, the moſt extravagant were Theophraſtus Paracelſus, and Joh. B Helmont; who not ſatisfied with having by means of their remedies protracted the term of life to a good old age, carried their folly ſo far, as to inſiſt it might be extended conſiderably beyond the limits aſſigned by nature. They indeed performed ſeveral cures by their violent medicines. But neither could Paracelſus, with his " Elixirum Proprietatis," defend himſelf againſt the king of terrors; nor Helmont, with his Alkaheſt, diſarm the fury of that ſubtle ſpirit, to which he attributed every diſeaſe: For both dying before they were old men, afforded a ſtrong inſtance of the vanity of their doctrine, and inefficacy of their practice. Such then, were the chief opinions of authors on the subject of an universal medicine, which prevailed so long, and with such extensive influence; nor ceased until the nature of diseases, and the powers of remedies were better understood.

What it was that occasioned gold to be considered as an universal medicine is perhaps not so easy to determine. Probably it was indebted for this character to the metaphorical language of the Arabians; who, considering all the *media* they believed necessary to the transmutation of the baser metals into gold as medicines, distinguished gold by the appellation of a strong and healthy man, while the other metals were in general described as men labouring under disease and infirmity. The chemists of the succeeding age reading this language, would probably apply it literally to the human body. And it is not unlikely, from the high opinion they entertained of the power and activity of the philosopher's stone, and the moderate temperature of gold, with regard to heat and cold, that they conceived some hopes of its efficacy in diseases of a very opposite nature.

The great virtues ascribed to the universal tincture, were believed to arise from its agreement with those elementary and general principles on which the phenomena of life and death depended; and, from its great purity, that could

could not ſuffer the preſence of any earthy, groſs, or unclean ſubſtance in the human body; but conſuming them, as it were by a ſecret and inſenſible fire, diſcharged them by the ordinary natural ducts. They imagined, that it did not act like other medicines, but ſpread its influence chiefly on the natural heat and vital ſpirits, preſerved the radical moiſture, averted every thing noxious from the heart, moiſtened the arteries, and purified the blood. Such were the wonderful qualities they attributed to their tincture, that they recommended it in all diſeaſes, except thoſe that were conſtitutional, coeval with our birth, or that required chirurgical aſſiſtance. There can be no doubt, therefore, that its ſucceſs was wholly imaginary. For let it be admitted, that it had the power of effecting the tranſmutation of metals, ſurely it will not follow, that it ſhould poſſeſs the ſame influence on the human body. The immenſe difference between animated exiſtence and unorganiſed maſſes, muſt convince us of the abſurdity of ſuch an opinion. Amidſt the numerous band of diſeaſes to which the human race is expoſed, ſome ariſe from obſtructed viſcera, from debility, from a defect in the nervous ſyſtem, from redundency of bile or blood, or from various other cauſes; and each, according to its peculiar character, requires a particular method of cure, and medicines very often exceedingly oppoſite. It is therefore ſufficiently obvious, *a priori*, that little faith can be given to the virtues of any one medicine, which is expected to ſubdue inſtantaneouſly all diſorders, though ariſing from very different cauſes; and ſo both to excite and repreſs evacuations;—that is required to cure thoſe diſeaſes that ſpring from a too rapid circulation of the blood, as well as others occaſioned by a circulation too ſlow;—that is to reſtore parts affected with gangrene to their former health and vigour;—and perform many other things equally as ſtrange and contradictory. The want of proper experiments prevents our reaſoning *a poſteriori*. As to the various accounts of Artephius, of the ſtone of Butler, and of the ſurpriſing cures performed by Polemannus and Burrhus, they are ſo vague, and repugnant to the general character of truth, that the ignorant and the credulous only can liſten to them.

§ IV. *Of the chief Diſcoveries in Chemiſtry made during this Period.*

To throw ſome light upon the progreſs of this ſcience, we ſhall now take notice of the various new preparations, of the inſtruments employed, and the different operations.

In Salts the greateſt variety has been produced. And to the acetous acid, which was formerly

merly the only one known, many other acids have been added. The method of extracting an acid from vitriol of iron is deſcribed by Baſ. Valentinus, who calls it *oleum vitrioli*; and ſtill better by Dornæus, who occaſionally makes mention of *oleum ſulphuris per campanam*. R. Lullius obtained an acid from nitre; and B. Valentinus, when about to diſtil the *aquam nitri*, as he calls it, put a triple proportion of the pulveriſed fragments of unbaken earthen veſſels with the nitre into the retort, and half a proportion of water into the receiver. But Glauber was the firſt who employed the ſtronger vitriolic acid for this purpoſe; and by means of which he procured the *acidum nitri fumans*. With the ſame agent he extracted the *acidum muriaticum fumans* from ſea ſalt. B. Valentinus in diſtilling vitriol with common ſalt, obtained what he calls, *aqua fortis*. *Aqua regis*, or as Valentinus chuſes to name it, *liquor ſolem ſolvens*, was prepared by Hollandius, by diſtilling nitre with brine. And menſtrua were generally called, *aquæ valentes, aut fortes*; and various ſubſtances were propoſed as neceſſary to their preparation. Beccher throws out ſome obſcure hints on the nature of the Sedative Salt, which combines like an acid with Borax. Lullius ſpeaks of the diſtillation of Tartar.

They appear to have been no leſs acquainted with Alkaline Salts likewiſe. Geberus deſcribes the proceſs of rendering alkali of tartar cauſtic by means of lime; and Lullius mentions its deliqueſcence. Geberus takes ſome notice alſo of the Salt of Soda. Lullius ſpeaks of the production of Volatile Alkali by putrefaction; and we find in Valentinus the method of ſeparating it from Sal Ammoniac, by the fixed alkalies. Moſt of the neutral ſalts were known to them. But they apprehended that the *Alkali veg. vitriolatum*, which they diſtinguiſhed by various names, retained always ſome quality peculiar to the manner of its preparation. The direct union of Alkali of Tartar and Vitriolic acid is called by Crollius *Tartarus vitriolatus*, while the ſame ſalt, obtained by precipitation with the Alkali of Tartar, from vitriolated Iron, he denominates *Specificum purgans Paracelſi;* that procured by the detonation of Sulphur and Nitre, is the *Nitrum fixum* of Schroeder; and what remains in the retort, after the diſtillation of Aquafortis, is the common *Panacea Holſatica*, the *Arcanum duplicatum* of Schroeder, and the *Nitrum vitriolatum* of Rolfinckius. The word Nitre, which formerly ſignified the mineral Alkali, was in this period applied to the *Alkali veg. nitratum*, and it ſtills retains this ſignification. The *Alkali veg. ſalitum*, which Jac. Sylvius, called *Sal digeſtivus*, was alſo in their liſt of neutral ſalts. Vitriolated mineral Alkali received from its inventor, Glauber, the name of of *Sal mirabile Glauberi*. Of the *Alkali min. nitratum* there is no account, and the brine mentioned by Pliny was properly common Salt. Borax is mentioned by Geber. The vitriolated volatile Alkali, invented by Glauber, was called *Sal ſecretus*. Of the *Alkali volat. nitratum* they ſeem to have had no knowledge, though Sal Ammoniac was diſcovered long before the beginning of our period. The *Alkali veg. acetatum* is celebrated for its many virtues by Pliny, though it was afterwards ſtill more extolled by Muller, under the name of *Terra foliata ſecretiſſima*. Crollius makes mention of the Salt of Amber, and Bartholetus of the Sugar of Milk. The *Sal Seignetti* was prepared at Rochelle very near fifty years before its compoſition was generally known.

Among the middle ſalts, with baſes of earth, they were acquainted with few except Alum, although they diſſolved corals and pearls in the muriatic or acetous acid. Hollandus gave the name of *Sal ammon. fixus* to muriatic chalk.

Moſt of the metallic ſalts were known and examined in this period. The combination of ſilver and the nitrous acid, under the name of *Magiſterium Argenti, vel Chryſtalli Dianæ*; and the ſame ſalt rendered cauſtic, by being melted in the fire, and called *Lapis infernalis*, are deſcribed by Angelo Sala. Crollius gave the appellation of *Luna cornua* to ſilver and the muriatic acid. *Mercurius ſublimatus corroſivus* is mentioned by Avicenna and Rhazis; and *Mercurius dulcis* by Crollius. B. Valentinus hints obſcurely at the *Mercurius præcipitatus ruber*, to which Crollius gives the name *Arcanum Corallinum Paracelſi*. Crollius deſcribes the *Sal Jovis* alſo, a Salt of tin and acetous acid. In B. Valentinus we find an account of the Salt of Lead in chryſtals, being a combination of lead and acetous acid, and which he names *Saccharum Saturni*. He likewiſe makes mention of the Butter of Antimony. The white Precipitate obtained from antimony by water, is the *Mercurium Vitæ* of Paracelſus, and the *Pulvis angelicus* of Algaroth. The ſame Butter of Antimony, dephlogiſticated by means of the nitrous acid, gives a powder which Crollius called *Antimonium diaphoreticum*, and Beguinus *Bezoardicum minerale*. *Tartarum emeticum* was firſt uſed by Mynſicht. B. Valentinus and Paracelſus obſerved, that Sal Ammoniac combined with metallic ſubſtances, and ſublimed, produced flowers containing metals. Of the Vitriols, the principles of the blue were known to Galenus, thoſe of the green to B. Valentinus; and the white alſo, though its compoſition was not well underſtood, yet was certainly made in this period.

Of the earths very little was known, and even that little was unſupported by the principles of chemiſtry. They diſcovered, however, that

that it was neceſſary to burn calcareous earth, before it could be employed in making mortar. In the Pharmacopœia of Schroeder we meet with *Calx viva* and *Lixivium Calcis*, commonly called Lime-water. Clay was diſtinguiſhed from ſand, but not according to its genuine character; and various kinds of ſtones were defined in the ſame ſuperficial manner. Fine and coloured earths were ſtudiouſly ſought for the purpoſes of medicine; and that the genuine might not be confounded with the ſpurious, they were incloſed on the ſpot that produced them, and ſealed by the governor or chief magiſtrate; from whom they paſſed into the ſhops of the apothecaries.

Among the phlogiſtic bodies, they were acquainted with Sulphur and its Flowers; and B. Valentinus mentions a ſolution of it in fixed alkali, and Beguinus deſcribes it as diſſolved in volatile alkali. Vigenerus ſuſpected that it was compoſed of phlogiſton and vitriolic acid. Eſſential oils were very early diſtilled, as well as philoſophic and empyreumatic, from unctuous ſubſtances, but with a ſtronger fire. Beccher diſcovered the vitriolic acid dulcified with ſpirits of wine. B. Valentinus mentions the Vitriolic and Nitrous Æthers but very ſlightly. Crollius however has tranſmitted very diſtinctly the art of preparing the former. The analyſis of Soot was attempted by Vigenerus. Of thoſe who

who give any defcription of Spirit of wine, the principal are Thaddæus, Villanovanus, and Lullius, who calls the ftrongeft, *Alcahol*; and fhews how it may be freed entirely from water, by means of fixed alkali; which B. Valentinus affirms is done more effectually by lime. The falt known under the name of *Offa Helmontii*, and which was long fince defcribed by Lullius, is nothing elfe than the aerated volatile alkali. Fr. Sylvius prepared the fame under the name of *Alkali Oleofum*.

All the metals poffeffing maleability, except Platina, were known before this period; but the brittle were yet undifcovered. G. Agricola is the firft who mentions Bifmuth. As to white Arfenic, it is difficult to fay when it was firft reduced to a regulus. Schroeder defcribes the procefs of reduction, in his Pharmacopœia of 1649.—In the former edition of this book it is not to be found. Albertus Magnus fpeaks of Zinc, by the name of *Marcafita aurea*. G. Fabricius reckons Stibium, or Antimony, in the number of metals; but B. Valentinus had long before related the method of extracting the regulus from the crude ore, and compared it afterwards with lead. Whether more of the femimetals than thefe four were difcovered during this period, is a queftion yet to be determined.

Thofe metals that are calcinable by fire, even Mercury, were very early mentioned by

Geberus.

Geberus. He likewiſe gives an account of factitious Cinnabar; and B. Valentinus makes mention of the Cinnabar of Antimony. Under the name of *Pulvis albus Antimonii*, and *Vitrum Antimonii*, Valentinus deſcribes the detonation of Antimony with Nitre. The calcination, ſublimation, fuſion, digeſtion, ſolution, precipitation, and amalgam of metallic ſubſtances, afforded a great variety of preparations, chiefly calculated for medical uſe. Beſides thoſe already deſcribed, ſuch are the *Purpura mineralis*, *Aurum fulminans*, *Flores Solis*, *Aurum potabile*, *Luna potabilis*, *Turpethum minerale*, *Mercurius præcipitatus albus*, *luteus*, *incarnatus*, *Corallinus corallatus*, *viridis*, *Arcanum Corallinum*, *minium*, *Lithargyrium*, *Colcothar*, *Crocus Martis*, *Lilium Paracelſi*, *Crocus Metallorum*, *Antimonium diaphoreticum*, *Ceruſſa Antimonii*, and many others, as magiſteries, flowers, oils, and tinctures, though not equally of all metals.

With regard to waters and aeriform ſubſtances, their peculiar properties and different characters, very little, if any thing, ſeems to have been determined during this period. It was not, however poſſible to avoid obſerving the ſubtle elaſtic air produced by effervеſcence, fermentation, and combuſtion. They gave it the name of *Spiritus ſylveſtris*, and it was conſidered by Paracelſus and his cotemporaries to be exactly ſimilar to reſpirable air. Helmontius probably was the firſt, who thought this ſubſtance worthy of more

minute

minute attention, and called it *Gas*, or *Gas ſylveſtre.* In his account of it he ſays, it could neither be ſhut up in veſſels, nor diſcerned by eyes, but that it was fixed in bodies, and as it were coagulated. He imagines, that in this air, which is very different from atmoſphere air, lies the cauſe of all theſe phenomena that are obſerved in the Grotta del Cane, in fermentation, effervеſcence, exploſion, and epidemic diſeaſes. It had been long known that the weight of metals increaſed by calcination; but Rey was the firſt, who ventured to account for this change by the abſorption of air.

The number and variety of furnaces, inſtruments, veſſels, and modes of operating, of this period are altogether ſurpriſing. Lullius mentions the Athanor as being long in uſe. Geberus deſcribes particularly various diſtillations. Agricola was acquainted with the crucibles of Ypſenſia, and veſſels of Waldenburgh. Aludels alſo were employed, and apparatus of ſeveral kinds for the purpoſe of continued digeſtions, cohobations, circulations, volatilizations, cementations, ſublimations, and reverberations, were contrived.

From this view, by no means very minute, that we have taken of the progreſs of chemiſtry during an æra of obſcurity, we may, by comparing it with that formerly preſented of times

more

more remote, have a very diſtinct idea of the increaſe of chemical knowledge within a period of a thouſand years; and obſerve it to be fully equal to any expectation that could be formed. But our eſtimation of its importance is conſiderably diminiſhed, when we turn our attention to the improvements and diſcoveries of the laſt ten years, in which chemiſtry, purſuing a ſublimer path, has not only ſoared into regions of inviſible aerial ſubſtances, but has dared, with a perſevering ſpirit, to explore the nature of theſe ſubſtances, and ſearch into their conſtituent principles. Such, however is the conſtitution of things, that in order to attain the ſummit, it is neceſſary to aſcend the ſide of the hill by ſlow and ſteady paces; and the progreſs of ſcience, however great and aſtoniſhing, claims no exemption from this general law. In the dawn and infancy of chemiſtry our experiments are too rude, and attempts too feeble, to afford any certain concluſions; but in proportion as they are often and diligently repeated, and varied when neceſſary, our ſtrength increaſes, and truths are unceaſingly evolved. But very frequent and accurate trials are required to eſtabliſh the purity and perſpicuity of genuine ſcience. The more truths, therefore, that are collected, the more readily and happily will others be diſcovered. But in the period now before

fore us, the progreſs of chemiſtry was much indebted to two ſuch powerful ſtimuli, as the deſire of wealth and of long life; by which it was enabled to remove all the obſtacles that ignorance and ſuperſtition could oppoſe, and attain to that height at which we have now beheld it.

THE

THE

ANALYSIS

OF

LITHOMARGE.

Quorſum igitur nos corporibus circum undique ſepti
Materiæ decus ac formam, externumque nitorem,
Miramur tantum, ſummoque in cortice rerum
Ludimus? Internam cur non penetramus in ædem
Naturæ, atque adytis immitti poſcimus ipſis?

ANTI-LUCRETIUS.

§. 1. *The general Character of Lithomarge.*

THE celebrated A. F. Crondſtedt, in his Mineralogy, diſtinguiſhes among argillaceous earths, a particular kind under the name of *Lithomarge*, to which he aſcribes the following characters *: 1*ſt*, When dry its ſurface is ſlippery and ſmooth like hard ſoap. 2*dly*, On being thrown in ſmall portions ſucceſſively into water, it ſeparates in a few

* § 85.

few ſeconds into little bits not unlike curdled cheeſe, or coagulated ſubſtances; but it is not ſo minutely divided as to become plaſtic. 3*dly*, It is eaſily reducible by fire into a white or reddiſh ſlag, which, by frothing up, is conſiderably encreaſed in bulk. 4*thly*, Its fractures are irregularly concave or convex.

He deſcribes three varieties only, the Oſmundic, the Tartarian, and the Lemnian; but according to theſe criteria, he ſhould have added that from Hampſhire, which is a genuine fuller's earth. This however he never ſaw, as the exportation of it is prohibited; and, truſting entirely to the deſcription of others, he has ranked it in general among the abſtergents. Specimens of all theſe, except the Tartarian, are in the collection of minerals at the academy of Upſal; and it is their compoſition and properties that we are now going to explain, in order to determine whether they conſtitute more than one ſpecies of argillaceous earth. In our examination of fuller's earth we have beſtowed particular attention; as, from its great uſe in the preparation of woollen cloth, it is of importance to underſtand it thoroughly, that, whenever it is wanted, the proper kind may be readily diſtinguiſhed.

§ II. *Of the Lemnian Earth.*

From the iſland of Lemnos in the Egean ſea, where this earth was firſt diſcovered, it has obtained its name; and which, though the iſland is now called Stalimene, it ſtill retains. It was called *Sigillum Caprinum* (σφραγις αιγος); for when taken out from the ground, the prieſts of Venus, in the time of Dioſcorides, uſed to mix it with the blood of a goat, and moulding it into ſeveral pieces, ſtamped upon each the figure of that animal. Theſe rites were aboliſhed while Galen lived; but others equally abſurd and ridiculous ſucceeded to them. When Bellonius viſited the iſland, it was the practice to open the vein annually on the 6th of Auguſt; and, after prayers ſaid by the prieſts, as much of the earth was taken out as was thought ſufficient for the enſuing year: The entrance to the vein was then cloſed, and the inhabitants threatened with the heavieſt puniſhments, if they ſhould venture to open it. The greateſt part of the earth obtained in this manner was ſent to Conſtantinople to receive the ſeal of the Emperor; and from this circumſtance it has often been named *Terra Turcica*. The remainder was ſold by the governor of the iſland, either in its rude ſtate, or ſtamped with his ſeal. From the time of Homer and Heſiod this earth was held in ſuch eſtimation, that it was never dug up without great parade of religious ceremonies: And they aſſert, that whether uſed internally or externally, it was a medicine endowed with alexipharmic, diaphoretic, deterſive, and healing virtues *.

As to its outward appearance, it is diſtinguiſhed by its colour more or leſs reſembling clay: for as yet we have not ſeen any of a fleſh colour. The ſurface of it is ſmooth and ſhining, ſomething like agate, and eſpecially in recent fractures, which are almoſt always concave and convex. When applied to the lip it adheres cloſely. The form of its maſſes is rude and ſhapeleſs, rather angular, but not regularly determined. The ſmall particles, of which it is compoſed are ſo very ſubtle and minute, that they eſcape both the touch and the ſight. It is of ſuch a texture as to be ſcraped with the nail; has an earthy ſmell, but no taſte; and feels between the teeth like tallow, and a little ſiliceous. Old fiſſures often become black. This is the deſcription of the common kind not ſealed, ſuch as is found in the ſhops, and which we have examined by the following experiments.

When a lump of this earth is thrown into water, it divides ſpontaneouſly into ſeveral pieces, and with ſome degree of a cracking noiſe.

* Geoffroi Traité de la Matiere Med.

noiſe. Theſe pieces ſeparate again into others ſtill ſmaller, but the diviſion does not go ſo far as to render the particles impalpable, for they remain always viſible and ſenſible to the touch.

This earth, when pulveriſed and boiled in fixteen times its weight of water, for half an hour, the mixture paſſes eaſily through a doubled ſheet of filtering paper, almoſt perfectly clear, except a ſmall degree of whiteneſs communicated by the ſuſpended argillaceous particles. This liquor neither reddens paper that is dipped in the tincture of turnſole, or deſtroys the red colour it may have acquired; from which it has neither the property of an acid, or an alkali. The nitrous ſolution of ſilver poured into it occaſions little white clouds, which afterwards, on being expoſed to the light, turn quite black. The nitrous ſolution of quickſilver produces almoſt immediately ſmall white particles; and the terra ponderoſa, diſſolved in muriatic acid, does not affect it in any manner.

On rubbing this earth between the hands in water, it generates no froth like ſoap, but it removes impurities, though not ſo readily as the other kinds.

Pulverized Lemnian earth, expoſed in a glaſs veſſel to the fire, gradually raiſed to a red heat, emits aqueous vapours, and a grateful aromatic odour. Papers, qualified for reagents, either dyed red with Braſil wood, or blue with the turnſole, are a little affected by theſe vapours; the firſt becoming yellowiſh, the other inclining to red; thus indicating the preſence of a very weak acid. While the ſand that ſurrounds the veſſel approaches to a red heat, the powder within aſſumes a black colour; but as the fire encreaſes, this obſcurity gives way, and the original colour returns. From this appearance of black, and its ſubſequent deſtruction by the fire, it might be ſuppoſed, that ſome oily ſubſtance was contained in the powder, which being firſt reduced to a coal, was again conſumed by a greater heat. After the operation was finiſhed, and the powder cooled, it was found to have loſt 17 *per cent.* of its weight.

A ſmall piece of this earth placed upon charcoal, and expoſed to the flame of a blow-pipe, does not decrepitate, but turns black, melts with ebullition, and is converted into a dark frothy cinder. With the microcoſmic ſalt, it deſolves partially at firſt, and with effervefcence; but afterwards, the remainder is ſcarcely diminiſhed. Borax acts moſt effectually upon the reſiduum, but it is ſome time before the whole is conſumed. The ſalt of ſoda occaſions a conſiderable effervefcence with noiſe. Hence, then, it would appear to contain a portion of aerated earth, though the greateſt part of it is ſiliceous. The little glaſs globules are tinged in the ſlighteſt degree with a colouring of iron.

When

When expoſed to the action of acids, no effervescence is produced. The powder, indeed, excites a degree of motion in the mixture; but not greater than when water is poured upon it, throwing out a few air bubbles.

In order to be well acquainted with the proximate principles of this earth, it is neceſſary to learn by a few judicious experiments, what, and how many they are *. After this diſcovery the next ſtep is, to purſue the proper method for determining their ſeparate quantities. In the preſent caſe, we have judged the following mode of analyſis the moſt convenient.—A centenary, or a hundred docimaſtic pounds of the earth, being reduced to powder, and inſerted in a ſmall glaſs cucurbit, with twice the weight of highly concentrated vitriolic acid; an alembic with a receiver was adapted, and cloſely luted, and the whole apparatus placed in a ſand bath. By a gentle heat an acid vapour was firſt expelled; which being examined, was found to contain muriatic acid, that had doubtleſs ariſen from decompoſed ſea ſalt. A greater degree of heat brought over no ammoniacal flowers. The ſu-

* If a ſmall quantity only of calcareous earth is preſent, it will be in vain to expect a precipitation by the tartarized vegetable alkali. The waters of Upſal, in which the leaſt grain of the cryſtallized acid of ſugar occaſions white clouds and ſtreaks, in a few ſeconds, are not in the ſmalleſt degree affected by the tartarized veg. alkali, though a hundred times their weight; but remain perfectly clear without any depoſition.

perfluous acid being poured off, and the refiduum throughly wafhed in diftilled water, and afterwards dried, it weighed 47 pounds; one fourth of which was a fine white filiceous powder, and the reft, a powder rather coarfer, and of a colour inclining to purple. The colour was poffibly obtained from the muriatic acid, and owing to a portion of iron.

That the folution, containing argillaceous earth, calcined iron, magnefia, and chalk, required an excefs of acid, is evident from the few former experiments.

But that thefe fubftances might be procured feparate, and their weight afcertained, the folution was divided into two equal parts. The firft was employed for the inveftigation of the chalk and magnefia, the other referved to examine the argillaceous and ferruginous matter.

The firft being made very warm, was gradually faturated with aerated chalk, with fuch precifion, that neither too much nor too little of the precipitant was ufed; fo that the argillaceous earth and the iron only being affected by it, the whole of the magnefia, which burnt lime, not aerated chalk, precipitates, might remain undifturbed. The fediment was then collected into a filtre, and was wafhed with warm water, until all the gypfum was diffolved. The folution being evaporated to drynefs, difcovered vitriolated chalk and magnefia, which were fe-

parated

parated from each other by a little warm water. But as it was ſcarce poſſible to prevent ſome of the gypſum alſo from being taken up, another evaporation and ſolution became neceſſary to get rid of it entirely. In this experiment, the ſolution of vitriolated magneſia, when precipitated by aerated fixed alkali, gave 3.1; and that of vitriolated chalk, by the ſame medium, 2.7; the weight of the aerated chalk employed as a precipitant being ſubtracted. Twice the amount of theſe ſums indicates the quantity of each contained in a hundred weight. But it muſt be obſerved, that the liquors remaining after the precipitations made by aerated alkali, hold a portion of the ſediment in ſolution, by means of the aerial acid; but this may be recovered from them by boiling them during a quarter of an hour *. It is neceſſary, however, to add this

* That argillaceous earth may be diſſolved by the aerial acid, is aſſerted in the 1ſt vol. of theſe Eſſays. But a certain proportion of phlogiſton might perhaps aſſiſt the ſolution here, in the ſame manner it does when the calces of ſome metals are to be diſſolved. Tin ought to be dephlogiſticated to a certain point, before the acid menſtrua can act upon it; but if it is too much deprived of its phlogiſton, the acids loſe all their power. Phlogiſton therefore aſſiſts the ſolution, but does not directly occaſion it; unleſs we chuſe to affect novelty of expreſſion. But if any one thinks otherwiſe, let him deſcribe the method by which argillaceous earth can be diſſolved in water with phlogiſton only. When argillaceous earth is roaſted in the fire, in gives out a quantity of aerial acid.

to the precipitate, to aſcertain the true weight of it *.

To examine the other half of the ſolution, the phlogiſticated alkali was employed; and from it was obtained 12 lb. of blue ſediment, containing 2 of iron in its metallic ſtate, and 2.7 of the calx of that metal. In a hundred weight therefore, there is 5.4 lb. of ferruginous matter, beſides that portion to which the ſiliceous earth owes its colour.

The liquor being paſſed through a filtre, contained argillaceous earth, magneſia, and chalk, all combined with the vitriolic acid; but we were now inquiring after the firſt only. To the ſolution, then, reduced to the bulk of ſix cubic inches, and heated to 90 degrees of the Swediſh thermometer, was added gradually as much aerated magneſia as would be ſufficient to deſtroy entirely the exceſs of acid, ſo that the paper ſtained with the turnſole gave no ſign of any remaining unſaturated. In order that the quantity of magneſia ſhould not exceed the proper limits, every bit thrown in was ſuffered to diſſolve before more was added. The ſaturation being then compleated, the liquor was boiled for half an

* Calcareous earth is precipitated by the ſaccharated fixed veg. alkali. As ſaccharated magneſia remains diſſolved in an exceſs of acid with pure argillaceous earth; it is therefore to be made perfectly dry by roaſting; and in order to deſtroy the acid of ſugar, muſt be burnt in a ſtrong fire.

an hour, and the ſediment collected proved to be the argillaceous earth, exactly ſaturated with vitriolic acid. Alum, it is well known, requires an exceſs of acid; without which it loſes its ſolubility with its other properties. Of this exceſs it may be deprived in various ways, and the argillaceous earth precipitated, exactly ſaturated, but inſoluble *. If the ſediment is ſufficiently digeſted

* The exceſs of acid in alum may be deſtroyed by alkali, lime, magneſia, pure argillaceous earth, iron, or zinc. In the firſt volume of theſe Eſſays, page 334, aerated chalk is employed to ſeparate alum from vitriolated magneſia; and this medium never fails unleſs its ſucceſs is purpoſely obviated. If any one, with an intention to miſlead, ſhould dilute the ſolution too much, and uſe large pieces of the chalk inſtead of its powder, he will certainly be diſappointed in his deſign, for ſcarce any ſenſible effect will be produced. Too great a quantity of water removes the particles of alum ſo far from any contact with the chalk, that no decompoſition can take place. Beſides the pieces employed preſent a much ſmaller ſurface than when they are reduced to powder. Whoever is really bent on giving a fallacious appearance to this experiment, will not conſider the remarks made here as worthy his attention. But ſhould any one be deſirous of certain conviction, let him mix a known weight of alum and vitriolated magneſia, and diſſolve them in as much tepid water as is neceſſary, and add afterwards gradually ſmall portions of powdered chalk until ſuch time as the ſolution ceaſes to redden the tincture of turnſole. If the effect is required very ſoon, expoſe the ſolution to a ſtrong digeſting heat, otherwiſe a leſs degree of temperature will be ſufficient. The acid being thus deſtroyed, paſs the liquor through a filtre, and waſh the maſs with pure water; evaporate the whole of the liquor that paſſed through the filtre to dryneſs, and the reſult will be the true weight of vitriolated

digested in a solution of aerated alkali, pure argillaceous earth is obtained; and which, in the case before us, being washed and dried, weighed 10.5; therefore equal to 21 lb. in a hundred weight.

This method of determining the quantity of argillaceous earth, is equally accurate and convenient. And, when a hundred weight of pure crystaline alum, dissolved in sixteen times its weight of distilled water, and deprived, in a temperature of 90 degrees, of the excess of acid, by means of aerated magnesia, deposits 36 lb. of argillaceous earth exactly saturated with the vitriolic acid, by calling the given weight of the precipitate *a*, the quantity of the earth will be found $= \frac{18.100\, a}{36.100} = \frac{a}{2}$. After the point of saturation is attained, the solution must be evaporated to a third of its bulk before the sediment is collected on the filtre. The precipitation may be effected likewise by small plates of zinc, extended very thin under the hammer. The solution of alum, though slowly evaporated, deposits no sediment until reduced to nearly an eighth part; but if the water carried off in vapour

vitriolated magnesia without any admixture of alum, and a small quantity only of gypsum that had remained undissolved in the water of the solution. If the experiment is properly instituted in this manner, he will not be in the least influenced by any opinions that may be advanced to the contrary.

vapour is replaced by an equal quantity, the whole ſolution immediately becomes turbid, and the argillaceous earth exactly ſaturated, falls to the bottom. This proceſs, however, is liable to objection: For as the vitriolated zinc alſo requires an exceſs of acid, the proper criterion for regulating the operation is yet to be aſcertained.

From what then has been ſaid, we may conclude, that a centenary of Lemnian earth contains 47 parts of ſiliceous earth, 5.4 of aerated calcareous earth, 6.2 of aerated magneſia, 10 of argillaceous earth, 5.4 of calcined iron, and 17 of a moiſt volatile ſubſtance. The ſum of the experiments taken ſeparately, amounts to 102; but this ſmall exceſs is owing to the difficulty of rendering the argillaceous earth perfectly dry.

§ III. *Of the Oſmundic Earth.*

THIS earth is the produce of Mount Oſmund, in the pariſh of Rattvik, in Eaſt Dalecarlia, where it forms a ſtratum of three feet thick. The rock of the mountain is calcareous, hard, and interſected with ſtrata of argillaceous matter and ſchiſtus. Petroleum is found in ſeveral places of it, but eſpecially in the ſchiſtus. But a more particular deſcription and delineation of the

the mountain will be ſeen in the Tranſactions of the Stockholm Academy *.

The colour of the earth is more or leſs completely cineritious; its ſurface ſomewhat rough, and feels as if greaſed. It is compoſed of irregular particles. Though it appears ſtratified, yet it cannot be ſeparated into regular lamellæ, but breaks always into large pieces with acute angles, reſembling almoſt the concave and convex fractures of ſiliceous ſubſtances. It excells in hardneſs the Lemnian earth. When a ſolid piece of it is applied to the lip, it adheres very ſtrongly. Old fiſſures in it are covered with a yellow ochre. It has an earthy ſmell; no taſte; but feels between the teeth more ſiliceous than the Lemnian earth.

When immerſed in water, it ſeparates in the ſame manner as the Lemnian earth, but rather into ſmaller particles. Being moiſtened and rubbed between the hands, it creates no froth, but it is notwithſtanding detergent.

When pulveriſed, and boiled for half an hour in diſtilled water, it paſſes perfectly clear through a double filtre, and does not affect the papers employed as reagents. The nitrous ſolution of ſilver occaſions a ſmall precipitation, which blackens by expoſure to the light of the ſun.

If

* D. Tilas in Actis Stockh. 1739. tab. 2.

If expoſed in powder to the fire raiſed gradually to a white heat, it emits aqueous vapours, and an empyreumatic odour. The papers of reaction indicate the preſence of an acid. Juſt before ignition the maſs becomes of a black colour, but afterwards this colour diſappears. When cooled, the centenary is found to have loſt 18 pounds.

A ſmall piece placed on a coal, and receiving the flame of the blow-pipe, decrepitates, turns black, and melts with ebullition, leaving a white frothy ſlag. With the microcoſmic ſalt, it exhibits the ſame phœnomena as the Lemnian earth; but a grain of it thrown into a ſolution of the ſalt becomes white. It efferveſces leſs with the ſalt of ſoda.

We purſued the ſame method of analyſis as with the Lemnian earth. From the ſmall experiments, indeed, a triffling quantity only of magneſia was diſcovered; but, that its proportion might be more accurately aſcertained, we examined half of the ſolution with the powder of chalk, and the reſult was not more than a quarter of a pound of magneſia.

Collecting all theſe circumſtances then together, it appears, that a centenary of Oſmundic earth contains about 60 parts of white ſiliceous powder, 5.7 of calcareous earth, 0.5 of magneſia, 11.1 of argillaceous earth, 4.7 of calcined iron, and 18 of a moiſt volatile matter.

The

The experiments taken ſeparately gave 14.1 of argillaceous, and 5.7 of calcareous earth; but this exceſs of 3.8 ſeems to ariſe chiefly from the imperfect drying of theſe ſubſtances.

§ IV. *Of the Hampſhire Earth.*

THIS earth is a native of the county of Hampſhire in England; but, as the exportation of it is prohibited, it cannot be procured in larger quantities than are required for mineralogical collections. Fullers have long uſed it in their trade, although in ſeveral manufactories in England, the proceſs of fulling cloths is carried on by treading them under feet with the dung of ſwine and warmed human urine.

The colour of the Hampſhire earth is dark, a little inclined to green, and faintly marked with yellowiſh veins. In ſubſtance it is opaque, and appears in ſome degree ſtratified, although it does not ſeparate in ſtrata. As to hardneſs, it is not equal to thoſe already deſcribed. Its particles are without ſhape, but capable of being poliſhed by the nail. Its fractures are rather rough, with dark pointed eminencies. It has an earthy ſmell, but no taſte; adheres to the lip; and between the teeth feels a little ſiliceous.

When immerſed in water, it falls to pieces like the other earth. Rubbing it in water produces

duces no froth; but it is exceedingly detergent.

Being pulveriſed, and boiled for half an hour in diſtilled water, it will paſs through a filtre of ſeveral folds, ſtill turbid, with many ſubtle particles floating in it, that diminiſh its tranſparency. If to this water a few drops of the ſolution of muriated terra ponderoſa be added, no precipitation is obſerved; from which it may be inferred to contain neither vitriolic acid, gypſum, or any ſalt combined with that acid. But if the nitrous ſolution of ſilver be poured into it, a milky ſediment ſoon makes its appearance, which, on being expoſed to the rays of the ſun, immediately becomes black; an undoubted proof of the preſence of the muriatic acid.

If ſubjected, in its pulveriſed ſtate, to a fire gradually raiſed to a white heat, it becomes black juſt before ignition, but afterwards reſumes its natural appearance as the fire increaſes. While in this ſituation, it emits aqueous vapours, a little acid. On being cooled, it is found to be $15\frac{1}{2}$ lb. in the centenary lighter than before.

A ſmall bit expoſed to the flame of the blowpipe, on a piece of coal, decrepitates, but not in ſo great a degree as the Oſmundic earth; it turns black, and melts with ebullition into a dark coloured ſpongy maſs. With borax, microcoſmic ſalt, and mineral alkali, it exhibits the ſame character as the Lemnian earth.

Its analyſis was obtained in the ſame way as that

that of the two former earths; and, in a centenary of it was found 51.8 of a ſiliceous powder, tinged yellow with iron; 3.3 of calcareous earth; 0.7 of magneſia; 25 of argillaceous earth; 3.7 of calcined iron, and 15½ of moiſt volatile matter.

An exceſs of one pound only we attributed to the argillaceous earth.

By a volatile matter is underſtood here, as well as in the preceding experiments, not only the deſtruction of an oily ſubſtance, but alſo the expulſion of the muriatic acid from its baſe, by means of the vitriolic. What this baſe may be is not eaſy to determine with ſuch ſmall quantities; but certainly traces of ſea ſalt appear, however faint, in ſome of the varieties examined by boiling in water, and filtration. We diſcovered no ſal ammoniac. Perhaps, indeed, it would be neceſſary to employ larger maſſes of earth to procure a more perfect ſublimation than has been yet attained.

§ v. *Corollary.*

From a compariſon of the foregoing deſcriptions and analyſis the following concluſions may be drawn:

That, as to the *external character*, the varieties examined are ſo perfectly ſimilar, that they differ in degree only. The greateſt diſparity ob-

vious

vious to the ſenſes, is in the colour, and ſmooth ſhining ſurface of the Lemnian earth.

The ſame obſervation may be made on their properties, either in fire or water.

With regard to their compoſition, the difference in that reſpect alſo is triffling. They have all the ſame proximate principles, and vary in nothing but the proportions of them. But that we may preſent a clearer view of their ſeveral qualities and relations, we have drawn up the following table in which the weights of each principle are expreſſed, in hundred parts, under the head of its particular earth.

T A B L E.

A Centenary contains of	Lemnian earth.	Oſmundic earth.	Hampſhire earth.
Siliceous Powder	47.0	60.0	51.8
Aerated Lime -	5.4	5.7	3.3
Aerated Magneſia	6.2	0.5	0.7
Argillaceous Earth	19.0	11.1	25.0
Calcined Iron	5.4	4.7	3.7
Moiſt volat. matter	17.0	18.0	15.5

In the natural ſyſtem therefore, of Cronſtedt, the lithomargæ are ranked as a particular diſtinct ſpecies of clay; although the proportion of magneſia in two varieties in exceedingly ſmall. But

this

this name of Lithomargæ does not ſeem to be an important diſtinction. The character of this ſpecies bears a ſtrong reſemblance to the zeolite; nor do they differ in compoſition, except in the ſmall portion of magneſia which the zeolite wants. There is ſome analogy between it and marles alſo. But in the lithomarge the combination of the different principles is not merely mechanical, as in the marle, which efferveſces more readily with acids, although it contain leſs calcareous and magneſian earth than the lithomarge now under conſideration.

Notwithſtanding, in the varieties examined, the greateſt proportion of argillaceous earth does not equal a fourth part of their weight, and that the ſiliceous earth generally exceeds the half; yet neither Cronſtedt, nor any other mineralogiſt, have thought proper to refer them under the head ſiliceous; and for the very beſt reaſon; as ſuch is the intenſity and prevailing quality of clay, that though it were ſtill in a much leſs proportion, it would yet determine the character of the whole maſs.

As the clay of Hampſhire is much uſed in the trade of fullers, we may learn from this analyſis what are the properties it is required to poſſeſs. In the operation of fulling, two things chiefly are neceſſary; firſt, the waſhing away all impurities; and ſecondly, the thickening and conſolidating

of

of the web by the curling or intermixture of the fibres on its ſurface. Any kind of clay will anſwer theſe purpoſes, provided it is free from qualities poſitively noxious. The ſiliceous part of it muſt be very finely divided; for large particles would wear the threads with their angles, or even cut them under the hammers: The argillaceous proportion alſo muſt not be too ſmall, that it may readily diſſolve in water, form the neceſſary conſiſtence, and be eaſily waſhed away when the operation is finiſhed. It muſt not be combined with any colouring matter, either vitriolic, or any other that is capable of affecting the dye of the cloth. It ſhould contain a ſmall proportion of chalk; but if that proportion is encreaſed, the maſs becomes too thin, looſing not only its tenacity, which is neceſſary to form the pile or map, but its greaſineſs alſo, by which the threads are preſerved againſt all external violence. Nothing of the kind of pyrites ought to be in it. But that it may contain the calx of iron not combined with any menſtruum without prejudice, is evident from the Hampſhire clay, which is an excellent fullers earth.

We have no doubt but the Oſmundic likewiſe might be very ſerviceable, if it could be procured in ſufficient quantity, and of the ſame quality as that examined here. Soaps would indeed be preferable to earths for the bufinefs of fulling, if they did not generally affect the colour of the cloths.

For cleaning linen, clay free from every colouring matter may be fuccefsfully ufed. It is true it creates no froth like foap, but it does not the lefs remove impurities.

OF

OF THE

ASBESTINE EARTH.

Non possunt oculi naturam noscere rerum.
LUCRETIUS.

CRONSTEDT, in his mineralogy, reckons nine species of earths, which, as he had never analysed, he considered as simple and primitive substances. By analysis, however, we have learned that the most of them are compounded, as the *Granatic*, *Micaceous*, *Zeolitic*, and *Fluoratic*, and that the *Magnesian* is to be altogether excluded from the class of earths, and ranked among metals. Our knowledge of the asbestine earth has been hitherto uncertain and superficial. Some of the varieties have been resolved by menstrua into more simple principles; while others, that seemed the purest, have not undergone the least alteration. In hopes therefore to throw ſome light upon a ſubject hitherto not well underſtood, we have inſtituted many and various experiments, which we ſhall now offer to your attention.

According to Cronſtedt, the Aſbeſtos is diſtinguiſhed by ſeven different characters. Firſt, When pure, it is very difficult to be fuſed. Second, The flexibility of its fibres. Third, Its ſurface. Fourth, It becomes brittle by ignition. Fifth, It is not ſufficiently hard to ſtrike fire with ſteel. Sixth, Is inſoluble in acids. And Seventh, It melts eaſily with borax. How far we may truſt to this deſcription, relating almoſt to its external properties only, we ſhall now proceed to determine.

§ IV. *Of the Tarentaiſian Aſbeſtos.*

This ſpecies, called Tarentaiſian, is the produce of Savoy in Italy. As to its outward character, it is of a pure white colour, and can be divided into the ſofteſt threads of a tolerable length, ſhining and opaque.

When expoſed to the fire, it exhibits the following qualities:

Exp. 1. By a long continued calcination, it ſcarce loſes ſome hundred parts of its weight. In an intenſe heat it liquefies, and, when cooling,

ing, and, when cooling, concretes into a filamentous mass; but, if this is melted much longer, it becomes a greenish glass, easily penetrating the crucible.

Exp. 2. When the extremity of a thread is exposed to the flame of the blow-pipe, it melts into an opaque globule, that grows dark coloured, if the flame continues to act upon it. It dissolves with borax and the microcosmic salt, and effervesces with the mineral alkali.

Though reduced to so fine a powder that it cannot be mechanically further divided, yet it is but little soluble in any menstrua.

Exp. 3. A hundred docimastic pounds were gently boiled in ten times the weight of aqua regia, until a small quantity only of the liquor remained. The menstruum dissolved no more than 12, and the residuum had undergone no change. The solution being precipitated by fixed alkali, yielded an earth similar to the terra ponderosa, some calcareous earth, and the rest magnesia.

Exp. 4. An hundred pounds, treated in the same way, with eight hundred of concentrated vitriolic acid, four only were dissolved, and which appeared to be calcareous earth and magnesia.

Exp. v. As it was poſſible too great an abundance of ſiliceous earth might prevent its being more ſoluble, one hundred pounds, with four hundred of vegetable fixed alkali, were kept in a red heat for two hours, but were not brought into fuſion. After this operation, the vitriolic acid extracted twelve, but the reſiduum was not in the leaſt affected by it. It ſeemed, therefore, to be owing to the preſence of the vitriolated terra ponderoſa that it ſtill reſiſted all attempts to decompound it. Accordingly the following method was purſued, with a view to ſeparate all the primitive earths it might contain.

Exp. 6. 100 lb. of aſbeſtos, well mixed with 100 of veg. alkali, and 100 of powdered charcoal, were ignited for two hours; and then being boiled for ſome time in 1000 of aqua regia, afforded a complete ſolution.

What remained undiſſolved was tranſparent, like jelly; and, being collected, and thoroughly waſhed in diſtilled water, and afterwards dried, weighed 64. It was now white and opaque, and not to be affected by any acid menſtruum, except the fluoric; but melted with effervеſcence with half its weight of veg. alkali, and exhibited a perfect glaſs.

The clear liquor being concentrated by evaporation, the vitriolic acid was dropped into it, and occaſioned a precipitate of 6 lb. of a white

powder,

powder, which proved to be the *ſpatheum ponderoſum.*

The evaporation being carried ſtill further, 12 of vitriolated lime were obtained, of which 6.9 were aerated chalk.

By means of the phlogiſtic alkali, 7 of Pruſſian blue were precipitated, which anſwers to nearly 1.2 of calcined iron.

From the liquor yet remaining, the fixed alkali produced 18.6 of aerated magneſia. It ought to well obſerved, that the water poured off from the precipitate ſhould boil near an hour, as it always holds a portion of magneſia, and ſometimes of lime diſſolved in the aerial acid. This volatile menſtruum being diſſipated, the aerated lime falls almoſt immediately, but the ſeparation of the magneſia is ſlow, and not completed until the whole is evaporated to dryneſs. The ſediment, containing magneſia alone, diſſolved in the vitriolic acid, being inſpiſſated, and afterwards ignited for a quarter of an hour, is ſtill wholly ſoluble in water; whatever alum may be in it remains burnt and deprived of its exceſs of acid; if gypſum, that alſo remains; unleſs waſhed away by a large quantity of water. To diſcover the argillaceous earth, the aerated magneſia, as elſewhere explained, is moſt ſucceſsfully employed as a precipitant of the ſolution already deprived of its

iron.

iron*. This method is very convenient: For, ſhould the magneſia be added in too large a quantity, the exceſs will ſubſide to the bottom whiter and heavier than before, ſo that the alum, which is neither ſo heavy or ſo light coloured, may eaſily be ſeparated from it by waſhing. In the experiment that was made in this manner, we obtained 3.3 of argillaceous earth.

In the analyſis of the following varieties this method was continued.

§ III. *Of Aſbeſtos of Swartvik.*

MANY remarkable varieties of this aſbeſtos occur at Swartvik, in the pariſh of Swerdſio in Dalecarlia; two of which we ſhall now proceed to conſider.

The firſt is white, and diviſible into the fineſt flexible fibres. Mixed with which are found little bundles harder and ferruginous, that were however ſeparated from them, as more impure, and more charged with iron.

Cronſtedt's Mineralogy, § 106. 2.

Its character on being expoſed to the fire.

EXP. 7. By calcination it becomes rather whiter in the crucible.—With a greater heat it runs into a general maſs of a martial colour.

EXP.

* Analyſis of Lithomarge.

Exp. 8. In the flame of a blow-pipe, whether alone or mixed with alkali, microcoſmic ſalt, or borax, it exhibits the ſame appearances as the Tarentaiſian; except that it diſcovers a greater proportion of iron in its compoſition.

Exp. 9. Purſuing the method of analyſis deſcribed before, Exp. 6, the centenary produced, of terra ponderoſa nothing; but 13.9 of chalk; 17.2 of aerated magneſia; 27 of clay; 64 of ſiliceous earth; and 2,2 of calx of iron.

§ IV. *Of the Aſbeſtos of Swartvik reſembling Steatites.*

We are now to give our attention to another variety of the Swartvik aſbeſtos, which forms as it were a link between the aſbeſtos already deſcribed, and the ſteatites which is found in the ſame place. It reſembles the ſteatites in its green colour, but which is rather a little paler; its ſurface is ſmooth and ſhining; can be ſcraped with the nail into a white powder; it differs however in the arrangement of its parts, being ſtriated parallel and longitudinally, and capable of diviſion into the fineſt white threads, which were before ſo cloſely united, that their joining was not perceptible.

Exp.

Exp. 10. In a violent heat, in a crucible, it hardens and becomes white.

Exp. 11. The flame of the blow-pipe produces the ſame effect upon it as on the foregoing.

Exp. 12. Treated in the ſame manner as the former experiments, we procured by analyſis,—of terra ponderoſa, 0; calcareous earth, 7.7; aerated magneſia, 13.6; argillaceous earth, 2.7; ſiliceous earth 74; and calx of iron, 2.

§ v. *Of the Steatites of Swartvik.*

As the ſteatites of Swartvik reſembles in many circumſtances the aſbeſti found at the ſame place, we have thought it would be attended with ſome advantage to determine by analyſis the extent of this ſimilitude.

The ſteatites is of a green colour, with a ſurface ſmooth and ſhining; forms a compact ſolid maſs, here and there interſected with irregular fiſſures, that are frequently concealed. Its conſiſtence is ſuch, that it can be ſcraped with the nail; and it turns into a white powder.

Cronſtedt's Mineralogy, § 81. 2 β.

Exp. 13. A ſmall thin lamella, weighing

355 lb. being expofed to a white heat for two hours in a crucible, was found, when thoroughly cold, to weigh no more than 333 lb. fo that in this operation a lofs was fuftained of 22 lb. which accounted for feveral pounds of humidity as well as aerial acid.

The whole of it became white, and though fomewhat harder than before, yet could ftill be fcraped with the nail.

In a fevere fire of many hours, it changes a little from yellow to a darkifh colour, and acquires a degree of hardnefs capable of ftriking fparks of fire from a flint. If a folid piece of it could be obtained free from chinks, of a proper fize, nothing would excel it for the purpofe of fculpture, and efpecially for the carving of heads and fmall figures. For it may be eafily wrought with a chizel ever fo blunt; and when finifhed, being properly hardened in the fire will defy the keeneft tooth of time.

To melt it requires the ftrongeft poffible degree of heat.

Exp. 14. The powder of fteatites roafted in a pneumatic apparatus gives out about 6 lb. of aerial acid in a centenary.

Exp. 15. In the flame of a blow-pipe it becomes white, but is not melted;—unites with effervefcence with the falt of foda;—diffolves with borax, but not with the microcofmic falt.

Exp. 16. 100 lb. of it being reduced to a fine powder, were boiled in 1200 lb. of aqua regia. To the folution filtrated, and concentrated by evaporation, vitriolic acid was added, but no muddinefs appeared in it, nor was any gypfum depofited, although the evaporation was carried farther. But that it might not efcape by being defended by the filicious earth, as much vitriolic acid was poured into the folution as would be more than fufficient to take up the foluble earths; and the whole was then evaporated to drynefs.

Being afterwards thoroughly wafhed in water, there ftill remained a refiduum of filiceous earth equal to 80.

Phlogifticated alkali difturbed the liquor, and produced 4 of Pruffian blue; which anfwers to 0.9 of calx of iron.

The remainder, when filtrated was found to contain magnefia. But that it might be afcertained whether it held any argillaceous earth, a precipitation of 4 was obtained by means of the aerated magnefia; and it was obferved, that the greateft part of the precipitate fell before the excefs of acid was completely deftroyed. The fediment was faturated exactly with vitriolic acid; and the

the proper excess of which being restored, a genuine alum was produced.

It appears, therefore, that a centenary of steatites contains, of terra ponderosa, 0; of calcareous earth, 6; aerated magnesia, 17.1; argilaceous earth, 2; siliceous, 80; and calx of iron, 0.9.

§ VI. *Of the Asbestos of Bastnæs.*

In the mine called Bastnæs, at Riddarhyttan, is found an asbestos of a greenish grey, with very fine, soft threads, easily broken; mentioned by Cronstedt in his Mineralogy, § 105, A. 2. and which often serves as a matrix of copper pyrites.

Exp. 17. Roasted in a crucible, in a fire it exhibits the same character as the asbestos in general.

Exp. 18. Nor does the blow-pipe occasion any extraordinary phenomena.

Exp. 19. By the usual analysis, from the centenary was obtained, of terra ponderosa, 0; chalk, 6; aerated magnesia, 16.8; argillaceous earth, 6; siliceous, 67; and calcined iron, 4.2.

§ VII.

§ VII. *Of the Aſbeſtos of Corias.*

This kind is found at Corias in Auſtria, reſembling very much the aſbeſtos of Tarentaiſe, is white, ſoft, and diviſible into the fineſt threads.

Cronſtedt's Mineralog. § 105. 1.

Exp. 20 and 21. In the crucible, and with the blow-pipe has the ſame qualities with the other aſbeſti.

Exp. 22. By analyſis, the centenary produces, of terra ponderoſa, 0; aerated chalk, 10.5; aerated magneſia, 12.9; clay, 3. 3; ſiliceous earth, 72; and calx of iron, 1.3.

§ VIII. *Of the Aſbeſtos of Crete.*

This ſpecies of aſbeſtos, brought from Crete, is white, of a rough irregular texture, with ſhort broken threads, laid over each other like tiles on the roof of a houſe.

Cronſtedt's Mineral. § 106.

Exp. 23 and 24. In the fire it exhibits nothing different from the others.

Exp.

Exp. 25. Its analyfis yielded, of terra ponderofa, 0; aerated chalk, 14.3; aerated magnefia, 28.8; clay, 1; filiceous earth, 53.9; and calx of iron, 2.

§ IX. *The Afbeftos of Sahlberg, commonly called, Mountain Cork.*

This is dug out of a filver mine at Sahlberg; it is white, compact, and elaftic like cork, and with its fibres varioufly interwoven.

Exp. 26 and 27. It has the ufual character in the fire: But it is worthy of remark, that when properly heated in the flame of a blow-pipe, it affords a tranfparent globule, which feldom happens to the other afbefti.

Cronftedt's Mineral. § 104. 1. *a.*

Exp. 28. By analyfis the centenary produced, of terra ponderofa, 0; aerated chalk, 10; aerated magnefia, 22; clay, 2.8; filiceous earth, 62; and calx of iron, 3.2.

§ X. *Of the Afbeftos of Sahlberg, known by the Name of Mountain Leather.*

It differs from the foregoing variation in its lamellated maſs only, and its conſiſtence, which is not ſo firm.

Cronſtedt's Miner. § 103. 1.

Exp. 29 and 30. It agrees perfectly with the former aſbeſtos in its appearance in the fire.

Exp. 31. A centenary of it yielded by analyſis, of terra ponderoſa, 0; aerated chalk, 12.7; aerated magneſia, 26.1; clay, 2; ſiliceous earth, 56.2; and calcined iron, 3.

§ XI. *Of the faſciculated Aſbeſtos of Grænge.*

This ſpecies is found in the pariſh of Grænge in Dalecarlia, and conſiſts of grey parallel fibres, rather rigid, not very diſtinct, and collected into little bundles, which are not parallel in relation to each other, but croſs in various directions.

Cronſtedt's Mineralogy, § 106.

Exp. 32 and 33. In the fire it appears as uſual.

Exp. 34. Analyſis diſcovers in the centenary, of terra ponderoſa, 0; aerated chalk, 12.8; aerated magneſia, 16; clay, 1.1; ſiliceous earth, 63.9; and calx of iron, 6.

§ XII.

§ XII. *Of the Aſbeſtos of Pehrſberg.*

At Pehrſberg in Vermeland, we meet with an aſbeſtos of a dark colour, with rigid parallel fibres, that can ſcarce be ſeparated, or admit of being further divided.

Cronſtedt's Mineralogy, § 105.

Exp. 35 and 36. In the flame of a blow-pipe it becomes white, and leaves a white ſcoria; which is rather extraordinary, as it contains above $\frac{10}{100}$ of iron.

Exp. 37. By analyſis we obtain, of terra ponderoſa, 0; aerated chalk, 12; aerated magneſia, 13.7; clay, 1.7; ſiliceous earth, 62; and calcined iron, 10.6.

§ XIII. *The fibrous Schorl of Grænge.*

As the fibrous Shorls very often bear ſo ſtrong a reſemblance to the aſbeſti, that they are with difficulty diſtinguiſhed from them by their external appearances, it may not be improper to examine the compoſition of both the one and the other variety, which, from their outward character, ought naturally to be referred to the claſs of ſchorls. In the pariſh of Grænge, ſuch a ſpecies occurs of a greeniſh white, with ſlender parallel threads, tranſparent, and brittle like glaſs, and in other reſpects very ſimilar to the aſbeſtos of Baſtnæs already deſcribed.

Cronſtedt's Min. § 74. *a.*

Exp. 38. It is converted by fire, in a crucible, into a white ſcoria.

Exp. 39. In the flame of a blow-pipe, it melts with ebullition into a ſlag; diſſolves with borax and with the microcoſmic ſalt, but with the latter more ſlowly; and efferveſces in its union with the mineral alkali.

Exp. 40. The analyſis of it produces in a centenary, of terra ponderoſa, 0; aerated chalk, 6; aerated magneſia, 12.7; clay, 2; ſiliceous earth, 72; and calx of iron 7.3.

§ XIV. *The fibrous Schorl of Zillerthal.*

At Zillerthal in Tyrol is found a beautiful ſchorl of a green colour, with priſmatic fibres, brittle, tranſparent, not quite parallel, but combined in ſeveral little bundles, diverging from a centre. Small pieces of it cut glaſs.

Cronſtedt's Min. § 74. *b.*

Exp.

Exp. 41. and 42. Whether tried by fire in the crucible, or by the blow-pipe, it diſcovers the uſual qualities of ſchorl.

Exp. 43. By analyſis, the centenary produces of terra ponderoſa, 0; aerated chalk, 9,3; aerated magneſia, 20; clay, 2.7; ſiliceous earth 64; and calcined iron, 4.

Having proceeded thus far, it may perhaps be not altogether uſeleſs to deſcribe more particularly the method by which the different analyſes were conducted. The ſtones intended for examination being firſt reduced to the fineſt powder, and exactly weighed, were thoroughly mixed with fixed vegetable alkali and powdered charcoal, and then ignited for two hours in a covered crucible; at which period the cover being removed, they were calcined until the charcoal was completely dephlogiſticated. The ſteatites alone was not expoſed to this proceſs, as its ſolubility was ſufficiently proved by other experiments. The alkali employed was the pure ſalt of tartar. In all the trials, both the quantity and quality of the charcoal being the ſame, there was no reaſon to apprehend the admixture of any foreign ſubſtance. A centenary of this coal yielded no more than 1½ of aſhes. After the calcination, the powders became more or leſs blue or green, and communicated directly to a ſmall quantity of water poured upon

 them

them, a green, or bright red. If an acid was poured upon the green liquor, it was changed to a red; if upon the red liquor, the colour was at firſt much heightened, but afterwards aſſuming a yellowiſh tint, became gradually fainter, and at length wholly diſappeared. To the ſmall portions of magneſia, which almoſt always adheres to the charcoal, we may attribue all theſe phenomena, as will be found explained elſewhere *.

The powder thus prepared was boiled in aqua regia, until all the ſoluble part of it was diſſolved. The ſiliceous part remaining was collected in a filtre, and waſhed in warm water. To the ſolution concentrated by evaporation, ſome drops of ſtrong vitriolic acid were added; and, if after a quarter of an hour there were no ſigns of terra ponderoſa in it, a quantity of the ſame acid ſufficient to ſaturate the calcareous earth was then poured in, and, by a gentle evaporation, almoſt the whole of the gypſum was ſeparated. This being collected, the ſolution was again diſturbed by aerated alkali, and received on a filtre: The precipitate was then waſhed; and, while yet moiſt, vitriolic acid was gradually added to it, until none of it remained except perhaps a ſmall portion of gypſum that ſometimes eluded the firſt ſeparation. On boiling the water of the precipitation, it depoſi-

ted

* Eſſays, 2 vol. page 220.

ted ſome magneſia diſſolved in the aerial acid; and, if there was ſtill any quantity of aerated chalk, it would be eaſily ſeparated by means of the vitriolic acid. The two precipitations above related were found uſeful ſolutions in the vitriolic acid, for the purpoſe of expelling the aqua regia, and depoſiting the alum in its turn. The new ſolution in the vitriolic acid is therefore firſt to be precipitated by the phlogiſtic alkali, and then, the Pruſſian blue being collected, the alum may be depoſited in the remaining clear liquor, by means of the aerated magneſia.

§ XV. *Corollary.*

In order to leſſen the difficulty of comparing together the ſeveral varieties examined, we have exhibited here at one view the proportional contents of a centenary of each of them.

	Terra pond. vitriolata.	Calcar. earth.	Magnesia.	Clay.	Siliceous earth.	Calx of iron.
Steatites	0.0	0.0	17.1	2.0	80.0	0.9
Asbest. Steatiform	0.0	7.7	13.6	2.7	74.0	2.0
—— Swartvik	0.0	13.9	17.2	2.7	64.0	2.2
—— Corias	0.0	10.5	12.9	3.3	72.0	1.3
—— Crete	0.0	14.3	28.8	1.0	53.9	2.0
—— Corium	0.0	12.7	26.1	2.0	56.2	3.0
—— Cork-like	0.0	10.0	22.0	2.8	62.0	3.2
—— Bastnæs	0.0	6.0	16.8	6.0	67.0	4.2
—— Grænge	0.0	12.8	16.0	1.3	63.9	6.0
—— Pehrsberg	0.0	12.0	13.7	1.7	62.0	10.6
—— Tarentaise	6.0	6.9	18.6	3.3	64.0	1.2
Schorl Grænge	0.0	6.0	12.7	2.0	72.0	7.3
—— Zillerthal	0.0	9.3	20.0	2.7	64.0	4.0

Having well considered these circumstances, it is plain,

That no such earth exists as a peculiar simple asbestine earth. For every one of these varieties contains, besides a small portion of iron, other known principles, four of which are primitive, as the calcareous, the magnesian, argillaceous, and siliceous; and, although the second is by no means in so great a proportion as the last, yet it still determines the character and genus. As in the Sciagraphy of the Mineral Kingdom, digested and arranged according to proximate principles, the genera of compounded substances are not defined by the excess in quantity of any one particular ingredient; so, in the case now before us, certainly

certainly no one, from the character of a ſtone, ſoft, fibrous, and flexible, would be led to apprehend ſuch an abundance of ſiliceous matter.

In the compoſition of the nine ſpecies, reckoned, with the conſent of all mineralogiſts, under the name of aſbeſti, which have hitherto been chemically examined, the ſiliceous earth is found to conſtitute the greater part, making never leſs than the half, and ſometimes three fourths of the whole. In relation to quantity, magneſia holds the ſecond place between the limits of 12.7 and 28.8 in the centenary. Then follows the aerated chalk, fluctuating from 6.0 to 14.3. Argillaceous earth is in the ſmall proportion of 1.6 in the centenary. Calcined iron is found in all of them from 0.9 to 10.6. The ſpecific difference therefore ſeems to be thus determined:

Aſbeſtos—compoſed of ſiliceous, magneſian, calcareous, and argillaceous earth, with ſome admixture of ferruginous matter. Metallic ſubſtances are indeed extraneous; but, as earths of the pureſt kind are ſeldom entirely free from iron, it muſt ſtill be conſidered as a ſpecies of alloy. In this order the materials of the compoſition being enumerated, according to their ſeveral proportions, illuſtrate clearly the ſpecific differences.

As to what relates to thoſe ſubſtances that bear different degrees of reſemblance to the aſ-

beſti,

beſti, the Tarentaiſian approaches ſo near to the genuine, that it is a queſtion whether it ſhould be ſeparated from it. It has the ſame principles, arranged in the ſame order, with the addition of vitriolated terra ponderoſa only, and which does not ſeem to have been combined by the hazard of neighbouring ſituation, but by a more intimate and perfect union with all the parts, as it eſcapes the penetration even of aſſiſted viſion. The aſbeſtos of Tarentaiſe, then, conſtitutes the ninth ſpecies of the Magneſian genus; to which perhaps the inſignificant name of amianthus applies, that would otherwiſe be ſuperfluous. But we will now attend to a ſpecific difference.

The *amianthus*—compoſed of ſiliceous, magneſian, and calcareous earth, terra ponderoſa vitriolata, argillaceous earth, and a portion of iron. Whoever has had an opportunity of examining this ſubſtance in large quantities, on the ſpot where it is found, ſhould have inveſtigated whether the mixture of the terra ponderoſa is merely mechanical. For were it no otherwiſe united, it would ſcarcely remit ſo much the action of acid menſtrua, as we find by experience that it does. The progreſſion from the ſteatites, through the ſteatiform aſbeſtos, to the ſofteſt variety of aſbeſtos, deſcribed under the third and fifth heads, is ſomething remarkable. The firſt differs ſolely by its wanting the calcareous earth; which ſeems in ſome meaſure to imply a conſiderable power in this earth to form

form its fibrous texture. On the other hand, again, it not only diſcovers an obvious reſemblance to the fibrous ſchorl, but a ſpecific agreement even is demonſtrated by analyſis. But this cannot be affirmed of all the varieties of the fibrous ſchorl, as hitherto two only of them have been examined; though, with regard to the reſt, the probable conjecture is very great.

From the corroborating teſtimony, therefore, of theſe experiments, we may correct the ſpecific differences laid down in the Sciagraphia of the Mineral Kingdom. For, at the time that this paper was written, no perfect analyſis of the aſbeſtos had as yet been made, and two only of its principles were known. We would, however, hope to flatter ourſelves, that we have determined the ſpecific difference of the aſbeſtos among eleven varieties, both as to their agreement in external characters as well as inward compoſition.

The aſbeſti have been hitherto applied to little or no uſe. Formerly, indeed, cloths made of the ſofteſt kinds were employed to wrap up the bodies of the dead, that, by its qualities of reſiſting fire, their aſhes might be preſerved. But on the abolition of funeral piles, the utility of the aſbeſtos ceaſed. And as to its being calculated for garments for the living, the continual and intolerable irritation of its harſh and ſhort fibres would render it certainly not very deſirable.

Paper

Paper made of aſbeſtos is both brittle and abſorbent; and ſo little adapted to the purpoſe of writing, that as yet it has never been otherwiſe conſidered than as a curious phenomena in phyſics.

Perpetual matches, or wicks for lamps not conſumable by fire, may indeed be formed with the proper kind of aſbeſtos; but they require to be occaſionally cleaned, otherwiſe the oily matter, that nouriſhes the flame, depoſits a carbonaceous reſiduum on the top of the match, and accumulates in ſuch quantity as finally to extinguiſh it. Beſides, ſeveral of the varieties whoſe fibres are ſufficiently detached, to draw up the oil or fatty ſubſtance, run ſo cloſely together in the hotteſt part of the flame, as to prevent the neceſſary ſupply.

Various ſtories are related of ruffles made of the aſbeſtos, by the Chineſe, and worn at the end of their linen ſleeves; that they were finely wrought, and, when dirty, were readily and thoroughly cleaned by throwing them into the fire. But the ſpecimen ſent to the collection of minerals in the academy, a few years ſince, does by no means anſwer this deſcription: For on examining it, it was found to be nothing elſe than a ſlight open cloth made of ſome vegetable ſubſtance, and therefore eaſily deſtructible in the fire.

THOUGHTS

THOUGHTS

ON A

NATURAL SYSTEM

OF

FOSSILS.

Res ardua, vetustis novitatem dare, novis auctoritatem——dubiis fidem, omnibus vero naturam et naturæ suæ omnia.

PLINIUS.

PART I.

ARRANGEMENT OF FOSSILS.

NATURAL BODIES IN GENERAL.

§ I. *Principal Division of Natural Bodies.*

ALL bodies which nature spontaneously produces upon the surface of the earth may be properly divided into *organised* and *unorganised.*

§ II. *Organised*

§ II. *Organiſed Bodies.*

These are poſſeſſed of a number of internal veſſels, by which, from the nouriſhment they take in, the particles neceſſary to the increaſe, ſupport, and propagation of ſuch bodies, are extracted, prepared, conveyed, and diſtributed.

§ III. *Claſſes of organiſed Bodies.*

These bodies are diſtinguiſhed by the epithet *living*; and, whether they poſſeſs ſenſibility or not, they conſtitute two immenſe claſſes, the *animal* and the *vegetable*, which are commonly conſidered as two diſtinct kingdoms in nature.

§ IV. *Unorganiſed Bodies.*

Those bodies are termed unorganiſed that are entirely without any organic ſtructure, and ſeem to be formed by the accumulation of particles united ſolely by the external force of attraction.

§ V. *Various*

§ V. *Various Confiftencies of unorganifed Bodies.*

THESE differ in many refpects, but we fhall here take notice of the degrees of *denfity* only, which has commonly been defigned by the name of confiftence.

§ VI. *Solid Bodies.*

CONSIDERING thefe, then, according to this rule, we find fome bodies fo *folid*, that their particles are fo firmly united as not to be feparated but by a very confiderable force. Of this kind are moft of the foffils.

§ VII. *Liquid Bodies.*

SOME again are *liquid*, whofe component parts adhere fo loofely, that they may be feparated by the fmalleft impulfe; but being left undifturbed, they, by the force of gravity, arrange themfelves in fuch mutual equilibrium, as to prefent a furface parallel always to the horizon.

§ VIII. *Fluid Bodies.*

OTHER bodies are reckoned *fluid*, whofe particles are not only eafily feparable, but feem in fome degree to repel each other. It is true, they feek an equilibrium; but, as they are not lefs influenced by elafticity than by gravity; they oftener appear with the unequal furfaces we daily fee in clouds and vapours.

§ IX. *The Utility of this Diftinction.*

ALTHOUGH the fame body, as occafion requires, may undergo every variation of confiftence, yet this diftinction is not the lefs to be regarded; for peculiar qualities, with a confiderable difference in their proportions belong to each condition. But the plan we have propofed to follow, will not admit of a further explication of this matter.

§ X. *The continued Series of Natural Bodies.*

THE great Leibnitz, by that law to which he gave the name of *continuity*, denied formerly that there could poffibly be any interruption between

tween phyfical caufes and effects; and maintained, with fuch confidence, its invariable operation and influence, that he predicted, that fome time or other a fpecies of animals (as the zoophyta) would be difcovered, partaking more or lefs of the nature of vegetables.—The celebrated Trembleyus, by the difcovery of the Polypi, afterwards confirmed the truth of this prefage. Daily experience alfo convinces us of the exiftence of fuch a connecting chain in the order of natural bodies; fo that, though we are acquainted with feveral links fingly, yet it may feem fcarce poffible to afcertain thofe that fhould be immediately united to them.

§ XI. *The Neceffity of a Syftem in Natural Hiftory.*

As natural bodies may in various ways be rendered ufeful to man, a thorough knowledge of them becomes highly neceffary; and it will, indeed, in general be found, that their utility encreafes in proportion to the extent of that knowledge. Their great number and variety require fyftematic arrangement; without which the neceffary diftinctions could not be made, and which, in fome cafes, where the difference is very minute, would be productive of great inconvenience.

§ XII. *Criteria of Natural Bodies.*

In order to discriminate with safety and precision, even where bodies are united in the greatest affinity, it is an object of the first importance to establish proper *criteria*.

§ XIII. *Constant and perpetual Forms of Organic Bodies.*

In the egg, or in a fecundated germ, the little body, the rudiment of the future fœtus, lies wholly concealed, until by proper heat and nourishment it is gradually evolved, increases, and arrives at maturity. In all organic bodies, therefore, the form is predetermined from their very origin, which the power of their internal and peculiar structure is calculated to develope; so that between these two qualities the relation is invariable; and therefore criteria are not improperly collected from that external figure which is derived from, and rooted in the essential character of the species.

§ XIV. *Monstrous Productions.*

Among these, indeed, we sometimes find deviations from the general laws of nature, producing *monsters*; but such events which are rare, and

and arifing from particular caufes, are almoft always unlike each other.

§ XV. *Foffils.*

All unorganic bodies, as well folid as liquid, which are either altogether without any organic ftructure, or difplay the ruins only of organization, are denominated *foffils*, or more commonly *minerals.*

§ XVI. *The Mineral Kingdom.*

The term *foffil*, or *mineral kingdom*, is generally applied to an arrangement of fuch foffils as are found in the earth.

§ XVII. *Generation of Foffils.*

In this third kingdom of nature, the procefs of generation is carried on in a manner widely different from that of organized bodies. Here is no egg, no feed, to cherifh and fupport the future foffil, confined and reftrained within the narroweft limits; no fecundation; no eftablifhed circulation of the nourifhing fluids; nor any evolution. Molecules uniting, by the fole power of attraction, form at once the growth and perfection of fossils.

§ XVIII. *Variable and inconstant Form of Fossils.*

FORM, and other external qualities, of which the senses only can determine, depend upon circumstances that are perpetually varying, but which do not in the least affect the intrinsic nature of the fossil.

The position may possibly need the illustration of an example. Let us take a quantity of water, charged with aerated calcareous particles, and we shall see arise various figures, textures, and cohesions, according to the different modes in which the concretion was performed. By the subsidence only of the atoms a crust is generated, parallel to the bottom, if the distribution of them has been made equally throughout the whole mass; if otherwise, the greater part forms tubercles farther from the surface of the bottom, than in the supposition of equality. Water impregnated with aerial acid acts like a menstruum; and, though it does not at all affect the saturated particles in this hypothesis, yet it nevertheless has considerable influence in forming their concretions. Such water oozing through subterraneous vaults, generates calcareous drops, hanging from the roof, while pointed

pointed cones are produced by the falling fluid upon the floor, and both increaſing in length, meet at laſt, and form one continued column.—If the ſame water purſues its trickling courſe along the walls, we find them covered with a ſtalagmitic cruſt; which according to the diverſity of the protuberances exhibits a great variety of figures, that, with the aſſiſtance of a warm imagination, may be made to reſemble complete animals, or their ſeveral members, and a thouſand other forms and appearances.—From this water ſuffered to remain long at reſt, ſpataceous cryſtals are ſeparated, that aſſume various ſhapes; as the granatic, the ſchoerlaceous, hyacinthic, dodecaedric, and thoſe pyramidal on both ſides, named ſwines teeth,—and many others.

The internal texture likewiſe admits of conſiderable variation. The moſt ſubtle particles unite into a denſe and equal maſs: Thoſe that are granulous, and of many angles, form combinations more rough and uneven; ſuch as are produced by chryſtallization appear ſpataceous; and others that are alternately depoſited in ſtrata, or lamellæ, preſent a divided ſtructure.

The degrees of coheſion alſo vary according to circumſtances. Water charged with fine particles of aerated chalk, and quickly evaporated, leaves a powder ſcarcely cohering, and which ſoils the fingers, like the mineral known by the name of Agaric. Larger maſſes however of calcareous powder, expoſed for many years to the preſſure of a conſiderable weight, acquire at length ſuch a degree of conſiſtence, that diſtinct lines can be drawn with ſmall pieces of them; indeed this property is found in calcareous chalk likewiſe.—Hitherto the greater degree of hardneſs has been produced by cryſtallization, as we find that calcareous cryſtals make no mark whatever, a circumſtance owing to the firm union of their particles, by which the friction on a painter's canvaſs has no effect upon them, at leaſt ſo as to be viſible.

What has been thus briefly ſtated may be ſufficient to ſatisfy us, that, from the external qualities of foſſils, no proper judgement can be formed of their internal compoſition.

OF THE SEVERAL CRITERIA OF FOSSILS.

§ XIX. *Oryctology.*

ORYCTOLOGY, or Mineralogy, are names given to that ſcience, which ſo arranges all the known foſſils, that they may be accurately diſtinguiſhed from each other.

§ XX. *Various*

§ XX. *Various Syſtems of Oryctology.*

As zoologiſts, in their arrangement of animals, have choſen different parts; ſome the feet, others the teeth, the becks, and other parts, according to the agreement or diſagreement of which their different ſyſtems were eſtabliſhed; and, as botaniſts have differed in the principles of their ſcience, one preferring a leaf, another the petals, a third the ſtamina and peſtillum, while a fourth maintains the ſuperiority of the fruit;—even ſo is it with mineralogiſts, who have often purſued very different paths, in their endeavour to illuſtrate and confirm the ſame object. Such a view of natural bodies, taken as it were from many different points, has however its advantages, as it increaſes the number of accurate compariſons. But, as every method cannot equally anſwer the end propoſed, it becomes neceſſary to ſelect that which is the moſt perfect and convenient.

§ XXI. *The beſt Arrangement.*

As, in order to underſtand the nature of foſſils, and apply them to purpoſes of utility, it is neceſſary to arrange them in ſome kind of ſyſtematic order, the preference is certainly due to that method, by which both their internal character and compofition may be made equally evident. Effential properties depend on the quality of the parts that enter into compofition, and their mutual proportion; and, unlefs we are well aquainted with thefe parts, we fhall labour to little purpofe, in our attempts to mould them to our own defires: Nay, we often meet with difappointments, becaufe we have not confidered that our views are inconfiftent with the very nature of the materials fubjected to experiments.

§ XXII. *In what manner the Compofition of Foffils may be afcertained.*

HAVING fettled thefe points, it remains yet to be determined in what manner we are to judge of the *compofition* of foffils: Whether the connexion between fuperficial marks, and the intrinfic character, is fo intimate and confequent, that the former cannot be known, without the other being revealed? whether it may be neceffary to proceed by a chemical analyfis in the dry way? or, fhould this not be fufficient, are we to have recourfe to the moift way? We will confider thefe queftions feparately.

§ XXIII. *External Criteria.*

IF, through the means of criteria collected from

from the external appearance, and obvious to all, we were able to obtain the object of our research, no method could certainly be more simple; for, with the affiftance of our fenfes only, we might difpenfe with the tedious proceffes of experiments: But we have already difcovered the fallacy of relying on many of thefe marks, even the moft principal, as they are liable to be affected by various circumftances of fituation, and diverfified without end, (§ xviii.). It may be proper, therefore, to enter a little more minutely into the confideration of this queftion.

§ XXIV. *Uncertain and deceitful Size of Foffils.*

In no criteria can we poffibly have lefs faith than in that of magnitude; and we cannot fufficiently exprefs our aftonifhment at the violence offered to nature, when a larger piece of ftone, referred to its proper genus, if reduced to a powde, is not only exiled to fome other, but is not even permitted to remain under the fame clafs.

§ XXV. *And Colour.*

The vulgar proverb, that cautions us againft belief in colour, is not inapplicable to oryctology. It is well known, that there are feven primitive colours; and, in order that a body appear coloured, it is requifite that fome particular

cular kinds of rays be reflected; would we enquire into the cause of this phenomenon, we must seek it in the quality of the surface, which is indeed often so transient, that the colour may be changed, or entirely destroyed by the heat of boiling water, or even by the influence of solar light.

A transparent colour arises from transmitted rays, and seems to indicate a species of attraction; while, on the other hand, an opaque colour implies repulsion. Both without doubt suggest the idea of some relation between the light and the given body; but which is of such subtlety, that though it alone were varied, the character of the matter remains altogether unaltered; at least the difference is not obvious to the senses. We have seen, that transparency depends upon the disposition of the particles; and this once disturbed, the transparency vanishes, and with it all the effect produced by transmitted rays. These several appearances seem to arise from the phlogistic molecules, which vary either as to quantity, magnitude, or elasticity. Velocity even determines the difference of colours.

§ XXVI. *Internal Texture and Form.*

We have already touched on *internal texture and form* in the foregoing divisions, (§ xviii.)

Determinate

Determinate figures bear a reſemblance to geometric bodies, and it is not without ſome degree of probability that they are ſaid to be derived from the nature of the matter: An opinion that has long influenced many to believe, that certain figures were proper and eſſential to different ſubſtances. The folly of this doctrine I have elſewhere demonſtrated at large *. If therefore regular figures, and thoſe beſt defined, are fallacious, we are ſurely not to rely on any ſuperficial characters which are very often common to ſubſtances of the moſt oppoſite qualities, and never uniformly conſtant in the ſame ſpecies.

§ XXVII. *Phyſical Marks of Earths.*

Nor are we wholly to neglect the *phyſical marks*, which, though they cannot be fully eſtimated by the external ſenſes alone, yet may be aſcertained by eaſy experiments, without the trouble of decompoſition. Such, in the firſt place, are hardneſs and ſpecific gravity; to which, indeed, we may add the relation to the magnet.

§ XXVIII. *Hardneſs.*

Degrees of hardneſs may be determined in various ways, by the nail, the knife, or by ſteel; and,

* Eſſays, vol. 2.

and when they are more intenſe, by a ſeries of gems, cut expreſsly for this purpoſe. But this property indicates leſs the matter, and its mixture, than the various exſiccations ariſing from different circumſtances, the ſubtlety and coheſion of particles, denſity, and ſuch like. Soft clay dried gradually, and afterwards expoſed to an encreaſing fire for ſeveral hours, until it is brought to a white heat, becomes harder and harder, and is at length capable, like a flint of ſtriking ſparks from ſteel. In all this proceſs, however, the matter is no otherwiſe affected than by a contraction of its bulk, which is diminiſhed about one half.

§ XXIX. *Specific Gravity.*

SPECIFIC gravity is determined by the hydroſtatic balance, which properly indicates nothing elſe than the denſity or quantity of matter in a given volume. A knowledge of this property is of conſiderable utility, eſpecially in the examination of metals, whether pure, or of known mixture; but with reſpect to other foſſils, the difference is ſo very triffling, that their nature and compoſition can ſcarcely ever be this way aſcertained.

§ XXX.

§ XXX. *Examination by the Magnet.*

IRON, unleſs it is dephlogiſticated below a certain point, is ever obedient to the magnet; but this mark is particular. Various phenomena likewiſe authoriſe a ſuſpicion that many other ſubſtances are attracted by it; therefore no reliance can be had upon this as a diſtinguiſhing character.

§ XXXI. *Real Utility of external and phyſical Marks.*

ALTHOUGH ſuperficial criteria contribute nothing to the true knowledge of foſſils, and that the obſervation of Juvenal, *fronti nulla fides*, may be well applied to them, even though the phyſical properties be at the ſame time underſtood, (§ xxviii. xxx.) yet we are not altogether to paſs them over in contempt. By ſuch accurate determinations as the celebrated Werner ſo ſucceſsfully attempted, they are rendered very proper for diſtinguiſhing varieties; and when the eye is once habituated to them, they often lead it directly to diacritic experiments. Perhaps the compoſition being thoroughly aſcertained by analyſis, an exact compariſon may aſſiſt conſiderably in drawing a juſt inference.

§ XXXII. *Nature of Foſſils diſcoverable by the Aid of Chemiſtry.*

IN order to diſcover the proximate principles of foſſils, it is neceſſary to have recourſe to chemical experiments. But will not the ſimpler kinds be ſufficient, in which the foſſils, whether alone, or with the addition of proper fluxes, are melted in the fire and treated in various ways? This indeed is the path purſued with indefatigable zeal by the celebrated Pott, and which no one ſince him has extended with more ſucceſs than the renowned Monſieur D'Arcet. How far it is connected with our deſign we ſhall preſently have occaſion to obſerve.

§ XXXIII. *Their Character in the Fire.*

A THOROUGH knowledge of the effects produced by fire upon foſſils is of the greateſt importance in the cultivation of many arts. For if we recollect that bricks, tiles, crucibles, glaſs, amauſa, earthen and china veſſels, eliquation of metals, and other works, can neither be carried on nor completed without the aſſiſtance of fire, we ſhall ſee that this knowledge is equally neceſſary and extenſive.

§ XXXIV. *Use of the Blow-Pipe in Oryctology.*

Nor can we paſs over in ſilence the great utility of the blow-pipe in oryctology, by its ſpeedy and conciſe mode of operating. With it a few minutes are ſufficient to examine the nature of a foſſil, upon a piece of coal, or in a ſpoon of gold, and to obſerve all the changes from beginning to end; which for the moſt part is not poſſible in a crucible; notwithſtanding in this way, it requires ſeveral hours before the reſult of the proceſs can be known*.

§ XXXV. *Moſt of the Principles of Foſſils are diſcovered by Fire.*

It muſt, however, be acknowledged, that, in many caſes, the principles of foſſils may be aſcertained by the proper application of fire; unleſs, by the number or delicacy of ſuch principles, the compoſition of the foſſil is rendered too complex and intricate.

§ XXXVI. *But not every Principle.*

There are many circumſtances that will prevent us from conſidering fire as the ſupreme arbiter of compoſition, though ſupported with all the

* Eſſays, 2d vol. page 455.

the aſſiſtance of the dry way; and it may be ſufficient to enumerate ſome of the moſt conſiderable.

§ XXXVII. *Why Inveſtigation by Fire is ſometimes fallacious.*

FIRE tends to confound all principles together, except thoſe of metallic bodies which are ſeparated from their matrices; it is therefore not at all calculated to extricate the ſeveral ingredients of compoſition.

§ XXXVIII. *The Efficacy of Fire cannot be defined with any certainty.*

AN accurate and eaſy meaſure of the power of this element is yet wanting. A foſſil reſiſts a certain degree of heat, that will yield to one more intenſe; and there are perhaps a very few that are deemed altogether refractory.

§ XXXIX. *And it is variable alſo.*

IT is not uncommon for the ſame degree of fire to melt ſome varieties of the ſame ſpecies, while upon others, it ſeems not to have the ſmalleſt influence. The petroſilices, feltſpat, and other foſſils, afford examples of this kind.

§ XL.

§ XL. *Does not determine the Proportion of the different Principles.*

AND laſtly, if ſometimes it is competent to diſcover ſingle principles, yet it always conceals their mutual proportions. This imperfection is of the greater moment, as it is evident, that the proportions of the ſame materials being varied, both the appearence in the fire, and the other qualities of the foſſil, are often conſiderably altered.

§ XLI. *Merit of Cronſtedt.*

THE celebrated Cronſtedt, in his excellent ſyſtem of foſſils, has eſtabliſhed the ſuperiority of principles, and has therefore conceived the genuine method; and if, notwithſtanding, he has occaſionally fallen into errors, they muſt be attributed to the want of proper experiments.

§ XLII. *The beſt Method of examining Foſſils in the Humid Way.*

THE illuſtrious Margraf had no ſooner diſcovered the true method of decompoſition, the humid and menſtrual, than he endeavoured, by his own exertions to render it eaſy and practicable. The new road into which he ſtruck, was beſet with thorns and briars; but it is certainly the only one that leads to a knowledge of principles, both as to quality and quantity; and therefore indispensably necessary in every enquiry into composition.

§ XLIII. *The Difficulty of founding a System of Fossils.*

It was the opinion of the celebrated Lehman, whose judgement in such matters was unquestionable, that a thousand years would not be sufficient for the construction of a system of fossils, arranged according to proximate principles, on account of the immense number of various fossils, and the daily augmentation it is receiving; the variety and expence of the necessary experiments, and the want of a more general spirit of adventure and industry requisite for such an undertaking.

§ XLIV. *Internal and external Characters.*

A collection of those properties on which the leading principles depend, is called the *internal character;* and the chief superficial marks of any fossil taken together, constitute the *external character.*

Of

OF THE CLASSES OF FOSSILS.

§ XLV. *Enumeration of the Claſſes.*

AVICENNA, an Arabian phyſician of the eleventh century, divided foſſils into the four claſſes, of ſalts, earths, metals, and phlogiſtic bodies. In this diviſion, all ſubſtances agreeing either in external or internal character, are properly enough combined; and, as hitherto no general arrangement has been propoſed preferable to this, it is no doubt worthy of being continued.

§ XLVI. *Order.*

THE order of the claſſes may in a great meaſure be treated as a matter of indifference; however, I think it right to begin with Salts, as being the only ſubſtances ſoluble in water, and which ought to be thoroughly underſtood, in order to develope the nature of the other claſſes; and perhaps, becauſe they are radically united with each of them, though the moſt conſiderable number of them have as yet in this ſtate eſcaped diſcovery.

Phlogiſtic bodies I place the laſt in order; for theſe by their prevailing principle approach nearer than any of the other claſſes to organiſed bodies, charged with inflammability, and to which principle foſſils perhaps are indebted for their exiſtence. Earths and metals, according to their character, hold with propriety a middle ſtation.

§ XLVII. *Diſtinguiſhing Marks of each Claſs.*

For the preſent it may be ſufficient to mention the following criteria of the claſſes, which ſhall afterwards be more fully explained.

Salts very finely pulveriſed, and diſſolved in a thouſand times their weight of water, are more or leſs ſenſible to the taſte. With reſpect to diſtilled water 2 is the common limit of their ſpecific gravity.

Earths have neither taſte nor ſolubility. They are however taken up by proper ſimple ſalts. Though for the moſt part heavier than ſalts, they are not reducible to a metallic ſtate. When compared with water, their ſpecific gravity fluctuates between 3 and 4½, which it has never yet exceeded.

Metals are not ſoluble in water; have a peculiar ſplendour; and ſurpaſs all other known bodies in ſpecific gravity. They are at leaſt ſix times heavier than equal bulks of water, commonly much more; but never exceeding twenty times.

Phlogiſtic bodies are almoſt always lighter than

than the ſalts; but have this peculiar quality of being combuſtible.

§ XLVIII. *Taſte.*

TASTE, depending upon the ſenſibility of the tongue, differs ſo much in different perſons, that what will excite powerful ſenſations in one man ſhall not be at all perceptible to another. It is evident, therefore, we are to place but little dependance on this quality.

§ XLIX. *Solubility in Water.*

SOLUBILITY in water, conſidered generally, is an *unlimited property*. In order to define it, it will be neceſſary to attend to the ſtate of diviſion of the body to be diſſolved, and the quantity and temperature of the menſtruum employed.

Pulverization encreaſes the extent of ſurface; and in proportion as it does ſo, the menſtruum, by coming into contact in a greater number of points, acts with more efficacy. For this reaſon large maſſes immerſed in a menſtruum, are ſometimes very little, if at all corroded: When divided into ſmall pieces they offer leſs reſiſtance; and, if pulverized are entirely diſſolved. It happens occaſionally, however, that mechanical diviſion does not anſwer the end effectually, and therefore recourſe is had to the more ſubtile powers of chemiſtry; and the precipitation of a ſolution made in a ſtronger menſtruum, is taken ſucceſsfully for this purpoſe. For a precipitate yet moiſt and recent is ſo open and ſpongy, that it far exceeds all mechanical diviſion.

In like manner, though a ſolution cannot be effected in an equal weight of water; yet, if that weight is doubled or tripled, or ſufficiently encreaſed, there would be no doubt of producing it.—If water of a moderate temperature avail nothing, tepid or warmer water may ſucceed; and ſhould this degree alſo of heat be ineffectual, it may yet be raiſed to ſuch a height in a cloſe veſſel, as will generally overcome all reſiſtence, and even produce effects ſcarce to be expected.

Hence, then, I apprehend it is evident, that the very nature of ſolubility will not admit of any certain or determinate criteria, but that it may be ſaid rather to proceed in an infinite ſeries: For if, on inſtituting an experiment, nothing is diſſolved, a ſuſpicion will always ariſe that if the reſiſting matter were either more minutely divided or immerſed in a greater quantity of water, or in water of a higher temperature, it would neceſſarily be diſſolved. In this manner, therefore, all certainty is deſtroyed, and every concluſion rendered merely conjectural.

§ 4.

§ L. *Artificial Limits of Solubility.*

If ſolubility ever becomes an uſeful criterion, it muſt be by aſſigning to it certain neceſſary artificial limits. Having duly conſidered this idea, I have pronounced thoſe to be the beſt, that can be found moſt eaſily every where. I have ſelected therefore for this purpoſe mechanical pulverization, a weight of water a thouſand times heavier than the ſubſtance to be diſſolved, and a degree of heat equal to boiling, as boundaries more proper than any others.

§ LI. *Great Extent of Solubility.*

We are very far from believing that this limit is to interrupt one link in the great connecting chain of nature. Our ignorance and weakneſs have rendered it neceſſary; and, whatever ſubſtances beyond it a more improved ſtate of ſcience may diſcover, we ſhall refer them to the claſs of earths, though we give them the appellation of ſaline, as an indication of their character. As examples of ſuch ſaline ſubſtances, we may take the ſiliceous earth, which is found abſolutely diſſolved at Geyſer in Iceland *; and the zeolithic, at Laugarnaes in the ſame iſland †.

 Vitriolated

* Eſſays, vol. 3d. p. 251.

† Ibid. p. 255.

Vitriolated ponderous earth, commonly called *ſpatum ponderoſum*, aerated lime *, fluorated lime, impregnated with the acid of the *lapis ponderoſus* †, are all ſaline earths, by the force of compoſition, and are even without doubt ſoluble, though to what extent experience has not yet determined.

§ LII. *Diſtinguiſhing Marks of Earths.*

The characters of earths are of the negative kind. An earth is that ſubſtance, which is not ſoluble; not ſo heavy as metallic bodies, nor is capable of combuſtion. Criteria ſuch as theſe betray our very limited and imperfect knowledge. Cronſtedt indeed mentions another mark, the malleability of earths; but this obſervation may be applied to ſalts, phlogiſtic ſubſtance, and the brittle metals. As to their form not being changed by a red heat, the ſame can be ſaid of the vitriolated vegetable alkali, of metals that require a much greater degree of heat for their fuſion, and of other foſſils. Any expanſion of their bulk is ſcarce perceptible to the eye, though a red heat is always ſure to produce it, unleſs counteracted by the diſſipation of ſome volatile matter, as in clay, aerated lime, and other ſubſtances.

§ LIII.

* Vol. i. p. 26.

† Vol. iii. p. 228.

§ LIII. *Metals.*

PERFECT metals are eafily diftinguifhed by their opaque fhining furfaces and fpecific weight. Their malleability, which Cronftedt confiders as their peculiar character, is no general criterion; for we reckon almoft as many brittle as ductile metals.

§ LIV. *Phlogiftic Subftances.*

A CERTAIN degree of levity, with as much phlogifton, loofely combined, as will occafion inflammation, is neceffary to the conftitution of all bodies denominated phlogiftic. Solubility in oil is not a diftinguifhing property of this clafs; as that menftruum, though producing no effect on plumbago, yet acts violently on lead, copper, arfenic, and other metals.

§ LV. *Mixed Foffils.*

WHILE we are giving our attention to the diftinct arrangement of the feveral claffes, it will be eafily feen that we mean to confider fuch foffils only as are in a ftate of purity; that is to fay, free from every corruption by combination with the fubjects of other claffes, not neceffary to their compofition. Sulphurated metals, for example, belong to two claffes; and we are to to determine from other data, to which they ought in preference to be adjudged. In like manner, aerated and fluorated lime, muriated ſilver, and ſome others are to be conſidered.

§ LVI. *Affinity of Foſſils.*

By the law of continuity, we may obſerve a great affinity among the ſeveral claſſes of foſſils.

§ LVII. *Affinity of Salts with Earths and Metals.*

We have already taken notice of the connexion of ſalts with earths, and we may add further to our remarks on this ſubject, that burnt lime, by the intermedium of the matter of heat, acquires a ſolubility perfectly ſaline. The ſame thing happens to ponderous earth, but not to magneſia. In all metals there lurks a certain acid peculiar to each, the nature of which we have as yet explored in arſenic only. Theſe metallic acids differ from all others in this reſpect, that, when taken with proper proportions of phlogiſton, they become metallic calces; but if ſaturated with that principle they are reduced to a perfect metallic ſtate *, generating at the ſame

* Eſſays, vol. 3. p. 124.

ſame time ſulphur and aeriform fluids *. Moſt phlogiſtic bodies likewiſe, perhaps indeed all, contain an acid united in their very conſtitution.

§ LVIII. *Affinity of Earths with Metals.*

Earths reſemble the calces of metals in many of their properties; but in reſpect to ſpecific gravity, the faculty of colouring glaſs, and their reduction to the metallic ſtate, they are eſſentially different.

§ LIX. *Sulphureous Character of Metals.*

Metals in their perfect ſtate are either metallic acids ſaturated with phlogiſton, or a ſpecies of metallic ſulphur, which are ſometimes very evidently ſuſceptible of inflammation, as zinc and arſenic. Gold and copper, when in fuſion, afford ſome appearance of flame, though faint, in a greeniſh vapour; bright ſparks are emitted from iron in a white heat; and tin alſo may be inflamed by a proper manner of operating.

§ LX. *Stones.*

In the claſſes already enumerated, all foſſils are by no means included. Such as are compoſed

* Eſſays, Vol. ii. p. 352.

ſed of heterogeneous ſubſtances, mechanically mixed, and united in a viſible manner, and which, for the moſt part, conſtitute the entire ſummits of mountains, are comprehended under one name of *Petræ* or *Saxa*. Cronſtedt has, with great propriety, treated theſe ſeparately in an appendix. The knowledge of theſe ſubſtances is doubtleſs highly neceſſary, and tends much to the illuſtration of phyſical geography; but they are not therefore to be confounded with bodies more homogeneous, whoſe combination reſting on chemical principles, is effected in the way of ſolution.

§ LXI. *Organic Foſſils.*

ORGANIC foſſils are conſidered by Cronſtedt in another appendix. Theſe ſubſtances are to be treated as ſtrangers from the animal or vegetable kingdom. They are diſtinguiſhed by an organic ſtructure, more or leſs imperfect; of which, as long as they bear any marks, we are to reckon them as foſſils of a foreign ſpecies. The conſideration of them is however in various points of view, highly uſeful. They reſemble a ſeries of ancient coins in the teſtimony they bear to the convulſions and revolutions of our globe, on which hiſtorical monuments are wholly ſilent. From them we may learn the wide extended ſovereignty of the ſea; the changes that

that ſucceſſive ages have wrought upon the ſurface of the earth; and they diſcloſe to us what animals inhabit the deep abyſſes of the ocean, and many other circumſtances moſt worthy the attention and enquiry of philoſophy.

§ LXII. *Volcanic Productions.*

THOSE burnt ſubſtances thrown out from the mouths of volcanos, by a greater or leſs degree of ſubterraneous fire, Cronſtedt has thought fit to arrange in a third appendix. A general view of them no doubt would be uſeful; but there are not wanting many reaſons why, in my opinion, volcanic productions will not admit of a ſeparate claſſification. We know there are many who ſtrenuouſly ſupport the hypotheſis, that the whole foſſil kingdom owes its origin to fire; for ſuch as theſe, therefore, any diſtinction will be unneceſſary. We have learned alſo, that marks burned by fire into foſſils are gradually obliterated by the injuries of time; becoming firſt obſcure, then equivocal, and at length being wholly deſtroyed. Whatever limits, therefore may be drawn, they are in their very nature tranſient and periſhable. It is, and muſt be often exceeding difficult to determine whether foſſils have derived their exiſtence from ſolution, or from the effects of fire. Accordingly, to me it ſeems proper, to inſert homogeneous volcanic productions into classes agreeable to their principles; and that all those heterogeneous substances, whose combination is visibly mechanical, should be the subject of the first appendix.

Of Genera.

§ LXIII. *Arrangement of Genera.*

By the assistance of classes, all those fossils are connected, whose composition, character, and properties are perfectly similar. Genera require a nearer affinity; species a resemblance still closer; and varieties must correspond in their internal habitudes only.

Fossils entirely homogeneous are of very rare occurrence; as, for the most part, two, three, or more principles, enter into their composition.

The more simple their composition, it follows, they will be the easier reduced to their natural genera.

Let A and B be the proximate principles of any fossil, let A be heavier than B, the compound A B, will be then referred to the genus of A; but this admits of various exceptions.

Suppose B possessed of a generic difference, and that it is no where found in a single state, (for we do not here speak of artificial separation,) on); but always united to A, or ſome other matter, and ever inferior in weight in ſuch combinations. According to the rule propoſed above, the genus B ſhould diſappear entirely, and be altogether wanting in the genera of its own claſs, which is by no means conſiſtent with a natural ſyſtem.

Again, let us ſuppoſe B excels A in the intenſity of its properties, ſo that B is only equal in weight to $\frac{A}{N}$, yet notwithſtanding the qualities of B are clearly predominant in the compoſition A B, that is, are much more conſpicuous than thoſe of the leſs ingredient A. Here again, unleſs I am deceived, we are to admit another exception.

If the caſes propoſed under B and C obtain at the ſame time, the exception receives a double confirmation.

Sometimes it ſeems neceſſary to give a preference to the price of particular ſubſtances. Suppoſe A B C an ore, whoſe metal C, though of leſs weight than any other part of the mixture, yet in value ſurpaſſes both B and A, ſo that they are entirely neglected, and C only thought worthy the expence of metallurgic operations. In this caſe A B C is in fact the ore of C; but if the proportion of quantity were regarded, it ſhould belong to the genus of A, and with great propriety, if a natural ſyſtem only is required.

We

We are not here to have any reſpect to fictitious valuation. But as the arrangement of foſſils is made with a view that our knowledge of them may be eventually uſeful and advantageous, it may ſeem to militate againſt this deſign, if we were to ſeek among the baſer kind for all thoſe noble minerals, whoſe intrinſic value can defray the labour and coſt of eliquation.

The ſeveral caſes propoſed ought not to be conſidered as imaginary, as they each of them occaſionally occur, and will be rendered more clear and intelligible by application in the following ſections.

§ LXIV. *Genera of Salts.*

In ſalts, we diſcover two genera, by no means ambiguous; the acid, and the alkali. Chemiſtry has not yet been able to extract their proximate principles; but, that they are different from, and oppoſite to each other, there is not the leaſt room to doubt.

§ LXV. *Acids.*

An acid is eaſily diſcoverable by the taſte, by its property of changing to red the blue vegetable colours, and of effervеſcing with aerated alkalis.

§ LXVI. *Alkalis.*

Alkalis are diſtinguiſhed by a burning taſte, by their converſion of blue vegetable colours to a green, and by their powerful attraction for acids.

§ LXVII. *Salts not ſaturated.*

Unsaturated combinations of acids and alkalis, enter the genus of the prevailing ſubſtance, unleſs any one ſhould chuſe to refer them rather to the imperfect neutral ſalts; which might be done not altogether without reaſon, as the moſt of them betray an exceſs of either the one or the other ingredient.

§ LXVIII. *Whether neutral Salts are to be referred to a diſtinct Genus.*

It may be queſtioned whether an acid exactly ſaturated with an alkali ſhould conſtitute a diſtinct and ſeparate genus? Or ought rather ſuch a combination to be ranked under the acid, or the alkaline ſalts? If there is evidently an exceſs of either of theſe principles, as in § 75, then, without doubt, it may be properly aſſigned to the genus of the exceeding principle; but, in all perfect neutral ſalts, the properties of acid and alkali are blended ſo intimately by ſaturation, that all diſtinction between them ſeems entirely to have diſappeared. In this ſtate of equilibrium, then, it becomes a matter of indifference whether the preference be given to the acid or the alkali. To the latter however I ſhould rather incline, as the moſt convenient; but I would not violently oppoſe any one who might think proper to refer them to the acid, or to a diſtinct genus. Quantity may in this caſe, in ſome meaſure, aſſiſt our determination; but not without irregularity: For, as the pure fixed alkali is ſaturated with a weight of acid leſs than its own; ſo, on the other hand, the volatile alkali requires the acid to be heavier than itſelf.

§ LXIX. *Mixed Neutral Salts.*

It may happen, that the ſame acid is partly ſaturated with one alkali, partly with another; and yet neverthele ſs, theſe three are ſo ſtrongly united by cryſtallization, as to conſtitute but one peculiar ſalt. The ſalt of Seignette affords an inſtance of this ſpecies of compoſition; the cream of tartar likewiſe ſaturated with volatile alkali. That the ſame alkali may be combined with two acids, the union of cream of tartar with the acid of borax ſufficiently demonſtrates. In the foſſil kingdom, indeed, we find none of theſe triple ſalts; but they inform us what may be done towards eſtabliſhing a general arrangement. The ſalt of Seignette, with the acid of borax

borax, produces a quadruple ſalt; and it is not unlikely, but that the induſtry of future ages will diſcover combinations of five principles, and perhaps of ſtill more; the diſpoſition and order of which may be determined by the character and quantity of the ſeveral ingredients.

§ LXX. *Analogous Salts.*

FOSSILS of the ſecond and third claſs become true ſaline ſubſtances, by combination with any ſalt; and in this condition they are baniſhed from their original claſſes. Salts, ſuch as theſe, are called, analogous; and according to the character of their baſes, are of two kinds, either earthly or metallic. Whatever imparts the ſaline nature ought to determine the genus.

§ LXXI. *Other Combinations of Salts.*

ALL earths almoſt as well as metals are not only taken up by acids, but ſeveral foſſils beſides, of both claſſes, are diſſolved by alkaline ſalts, and ſome even by neutral ſalts; nay, it happens occaſionally, that two double ſalts will unite into one, and form a ſalt of four principles. From ſuch multiplied and various combinations proceed, alkalis and acids charged with earths and metals; double neutral ſalts, or ſalts of more principles, containing earths and metals; double earthy ſalts united with double metallic ſalts,

 which

which, according as the ſaline matter is either the ſame or different in each, generate triple or quadruple compounds.

§ LXXII. *Doubtful Genera of Salts.*

In the claſs of ſalts it often happens, that ſome principles are never found in a ſingle and independent ſtate, but united always with others. Such are, for example, the nitrous, the muriatic, and arſenical acid. It may be doubted, therefore, whether theſe ſubſtances are to be conſidered under their ſimple genera. As, however, it does not ſeem improbable, that they were once free and uncombined, we are hardly authorized to exclude them; though it may be, at the ſame time, obſerved, that they have never yet been found otherwiſe than in this ſtate of combination. At all events, the inveſtigation of ſimple ſubſtances will throw light upon the ſeveral compoſitions.

§ LXXIII. *Genera of Earths.*

Some genera of earths have hitherto reſiſted all attempts to reduce them into ſimpler principles; while others, by a proper analyſis, have diſcovered two or more. The former are called *primitive*, the latter, *derivative* earths.

§ LXXIV. *Primitive Earths.*

CRONSTEDT has eſtabliſhed nine primitive earths, but accurate experiments have ſince ſhewn that the greater number of them were compounded, ſo that the account is reduced to three only; the calcareous, ſiliceous, and argillaceous. We have however to add new earths, with which he was not acquainted, the terra ponderoſa and magneſia. We reckon therefore five primitive earths.

§ LXXV. *Of the common Origin of Earths.*

ALTHOUGH the powers of chemiſtry have not yet been able to decompoſe theſe five earths, the reduction of them all to one ſpecies, or, at leaſt, to a ſmaller number than the preſent, may poſſibly be the reward of future induſtry. I acknowledge myſelf of this opinion, and I think with ſome foundation. Clay, for example, is nothing elſe than calcareous earth, ſo ſtrictly combined with ſome unknown acid, that the ſeparation of them has hitherto been attempted in vain. No one certainly could have ſuſpected the calcareous baſe in the *lapis ponderoſus*, which has been demonſtrated by analyſis. In like manner, other ſubſtances may be inveſtigated. But until proper experiments ſhall have fully developed the nature of ſuch compoſitions, they muſt be, in reſpect to our knowledge of them, conſidered as primitive ſubſtances: For it is wholly inconſiſtent with the caution and diffidence of natural philoſophy to advance any poſition upon a bare poſſibility. Daily experience ſufficiently teaches, that thoſe things which at one time appear highly probable, may at another be diſcovered to be entirely unfounded.

§ LXXVI. *Reaſons why the Terra Ponderoſa ought to be referred to a diſtinct Genus.*

THE ponderous earth, on account of its great ſpecific gravity, is deſerving of particular attention, and leads us naturally to apprehend it to be of metallic origin. Other arguments alſo ſupport this hypotheſis. It is admitted, with the force of an axiom, that phlogiſticated alkali precipitates metallic ſolutions only: But if this alkali is dropped into a ſolution of acetated ponderous earth, it is immediately diſturbed, and a white powder is precipitated; which, on examination, is found to conſiſt of that earth vitriolated, from the vitriolic acid inherent in the Pruſſian blue. If the powder is ſeparated by means of a filtre, and a new portion of acetated ponderous earth added to the liquid, on expoſing it to the fire, the ſolution, though clear before, depoſits another white powder, containing the ponderous earth united with the phlogiſtic alkali. The reſult is the ſame if the ponderous earth

earth, ſaturated with the nitrous acid is treated in a ſimilar manner: Therefore it ſeems rather to reſemble a metallic calx than an earth, by theſe properties.

Among the metallic calces, that which ariſes from lead correſponds with the ponderous earth in its weight, its white colour, and peculiar attraction for the vitriolic acid, by which that acid is torn away from alkaline ſalts; but there is notwithſtanding a remarkable difference between them. Acetated lead is diſturbed wholly in the cold by phlogiſticated alkali, and depoſits a ſediment, which neither is ſoluble in water, nor in the vitriolic acid; but the acetated ponderous earth yields its genuine precipitate by heat only, and which is ſoluble both in the vitriolic acid and in boiling water. Beſides, this earth has hitherto reſiſted all efforts to reduce it to a metallic ſtate.

Therefore, although there may appear a conſiderable affinity between the ponderous earth and a metallic calx; yet, as long as it is incapable of reduction, its metallic nature is certainly not ſufficiently demonſtrated, and it muſt ſtill retain a place among the earths.

§ LXXVII. *Five Genera ſhould be conſtituted of the five primitive Earths.*

As we have enumerated already five primitive earths, they naturally become the heads of five diſtinct genera. It is very rare, if ever, that they are found in a ſimple ſtate, being either combined with one or more of the other earths. The moſt eaſy method, therefore, would be to determine the genus of every ſuch compoſition, according to the heavieſt principle; but the caſes before ſeparately ſtated, in § lxiii, are often objections to this plan.

§ LXXVIII. *Exceptions.*

WERE this rule once admitted, we ſhould loſe altogether the magneſian and argillaceous genera; for, in the compoſitious hitherto examined, into which thoſe earths enter, the ſiliceous has been always found to outweigh the others, although, from their character and properties, they had both the ſuperiority. Common clay contains above half its weight of ſiliceous earth, ſometimes above three fourths, and yet the argillaceous qualities are ſo diſtinct, that theſe compoſitions are unanimouſly denominated argillaceous. The ſame richneſs and pre-eminence of quality, with reſpect to the ſiliceous earth, are found in magneſia, and other ſubſtances.

All earthy compoſitions, therefore, may be determined by the genus of that ingredient, which exceeds the others in weight, unleſs it be ſiliceous, and not equal to ſeven-eights of the whole. In ſuch caſes, the genus ought to be aſcertained

aſcertained by whatever ingredient aproaches neareſt in weight to the ſiliceous.

§ LXXIX. *Compounded Earths are not united mechanically only.*

BUT perhaps, all earthy compoſitions are nothing elſe than many ſubtle mechanical mixtures? At the very firſt view indeed there ſeems ſome foundation for ſuch an opinion; but a more minute inveſtigation furniſhes evidence of a cloſer union conſtructed on other principles. The earth of alum immerſed in lime-water, and entering into ſo ſtrict a combination with the lime as not to be ſeparable but by chemical art, teaches us, that among primitive earths mutual attraction has a real exiſtence. Beſides, as almoſt all theſe mixtutes generally form cryſtaline concretions, we have another proof, not only of the minuteneſs of their particles, but of an union perfectly homogeneous.

§ LXXX. *Genera of Metals.*

IN the third claſs we are to conſtitute as many genera, as we have known diſtinct metals.

§ LXXXI. *Encreaſed within a few Years.*

AT the beginning of the preſent century, eleven

eleven metals only were known; but it had ſcarce grown forty years older, before the diſcovery was made of platina, a noble and ductile metal, and of three or four others, that were not malleable, as cobalt, niccolum, magneſium, and ſiderum, which laſt has hitherto appeared to differ from all the reſt *. The fifth in molybdena is not yet ſufficiently explored, to determine whether it ſhould be reckoned among thoſe already known, or conſtitute a new ſpecies; and to the ſixth, in the acid of the lapis ponderoſus, we may apply the ſame obſervation. Of theſe two, however, we are in hopes the character of the firſt will be ſoon diſplayed by the induſtry of Mr Hielm. The genera of metals, therefore, of which we can be certain, amount to ſixteen, or fifteen at leaſt; and it is not unlikely that this number will be increaſed by future diſcoveries.

§ LXXXII. *Arrangement of mixed Metals.*

In ſection lxiii. we have a queſtion reſpecting the genera of minerals containing two metals, the one of which is more valuable than the other, but in leſs quantity. Examples of ſuch minerals we find in the golden pyrites, which hold

* Meyer and Klaprothius have proved it to be iron joined to the phoſphoric acid; and our author, convinced by their arguments, changed his opinion.

hold a ſmall proportion of gold united with a large proportion of iron; among the galenæ, that are far richer in lead than in ſilver; among the copper pyrites, always producing more iron than copper; and ſo on of many others. According to ſyſtematic rules, the more valuable and ſcarcer metal, although it defray the expence of eliquation, ſhould yet be referred to the genus of the more abundant, though of leſs eſtimation. But if the uſe and aim of any ſyſtem is conſidered, there can be no doubt that the preference ſhould be aſſigned to the metal of the higheſt value. In ſome degree, however, the determination of this point may be a matter of indifference, provided no diſtinct genus is thereby deſtroyed; a circumſtance that would probably affect the ſiderite, in caſe it were decided in favour of ſuperiority in weight, as that metal has never yet been found ſeparate from iron ores, to which it always bears the ſmalleſt proportion.

§ LXXXIII. *Genera of Phlogiſtic Bodies.*

THE fourth claſs contains the feweſt genera, ſulphur, petroleum, amber, and perhaps diamond.

§ LXXXIV. *Sulphur.*

Sulphur is an inftance of the moft fimple compofition, confifting of two principles only, acid faturated with phlogifton.

§ LXXXV. *Petroleum.*

In petroleum we difcover an union more complex; a fmall portion of water combined, by means of an acid, with the principle of inflammability.

§ LXXXVI. *Amber.*

The origin of amber is evidently from the vegetable kingdom, for, befides its peculiar acid and oil, we obtain the acetous acid by diftillation. The earthy refiduum may be confidered as a matrix.

§ LXXXVII. *Diamond.*

With regard to the diamond, I have hitherto found no place fo proper for it as this clafs. In a fufficient degree of fire, it is entirely confumed, and with an appearance of cloud or flame; and, in the focus of a burning lens it difcovers figns of a footy matter.

§ LXXXVIII. *Pyrites and Molybdena do not constitute peculiar Genera.*

I HAVE referred pyrites, or ſulphurated iron to the genus of iron. In like manner, molybdena, which is nothing elſe than a metallic calx mineralized by ſulphur, provided its genus were known, ought to be aſcribed to the claſs of metals. As to the foſſil conſidered by Cronſtedt as fixed phlogiſton, and which he calls *brandertz,* its compoſition has not as yet been ſufficiently inveſtigated.

§ LXXXIX. *Properly ſpeaking, there is but one Genus of phlogiſtic Subſtances.*

IN the ſtrictneſs of language, all the genera of this claſs might be reduced to one, as the ſame principle of inflammability prevails in each of them.

§ XC. *Firſt Appendix.*

IN the firſt appendix to the claſſes, are treated thoſe foſſils of various and mechanical combination, and which for the moſt part is obvious to the ſight.

§ XCI.

§ XCI. *Four Genera of Foſſils mixed mechanically.*

ANSWERING this deſcription, we have four genera only, which are denominated according to the claſs of the moſt predominant ingredient in their compoſition.

§ XCII. *Firſt Genus.*

THE firſt genus in which the ſaline character prevails occurs ſometimes in the neighbourhood of volcanoes. In gypſum alſo other foſſils intimately mixed are occaſionally found. The ſubſtances likewiſe contained in natural waters may perhaps be referred to this genus. They are indeed held by water in ſolution, but their union is generally merely mechanical, of which the fixed principles are collected in the reſidua, after the evaporation of the liquor.

§ XCIII. *Second Genus.*

To the ſecond genus we aſſign all thoſe foſſils in which the earthy principle abounds. Such are thoſe placed by Cronſtedt in his firſt appendix under the name of *ſaxa*. Under this genus may be arranged ſeveral matrices of metals as well as of inflammable ſubſtances; for lithanthrax,

thrax *, aluminous ſchiſtus, aluminous ore of La Tolfa, and many others, contain ſome extraneous earthy matter, and in conſiderable quantity.

§ XCIV. *Third Genus.*

In the third genus, the metallic nature is predominant. It has been long obſerved, that ſome metals affect a diſpoſition to aſſociate with each other; ſo that if one is diſcovered, it may be properly conjectured that the other is not very far diſtant. Relations ſuch as theſe, as are obvious in this genus, are worthy attention and enquiry, as they promiſe no ſmall advantage to the inhabitants of mountainous countries.

§ XCV. *Fourth Genus.*

In the fourth genus we meet with various mixtures of foſſils, of which this ruling principle belongs to the laſt claſs.

§ XCVI. *Diſtinct and mixed Particles of Foſſils.*

To this appendix likewiſe, the diſtinct and mixed particles of foſſils may conveniently be referred, inſerting them under their proper genera, according to circumſtances. Such, for example

* Pit coal.

example are the marles, moſt of the common clays, mixed ſands, and ſeveral others.

§ XCVII. *Four Genera of organic Foſſils.*

LASTLY, Organic foſſils are divided into four genera, as the diverſity of their nature ſuggeſts, whether they are found impregnated with and compoſed of ſalts, earth, metals, or phlogiſton.

§ XCVIII. *Fifth Genus of Cronſtedt.*

CRONSTEDT adds a fifth genus, and perhaps with great propriety, in which are included all the dead remains of once living ſubſtances, which, by gradual putrefaction, have loſt their original ſtructure, though they ſtill retain ſuch ſtrong marks of it as are not obliterated entirely but by the lapſe of many years. To this genus belongs the earth of deſtroyed animals or vegetables.

§ XCIX. *Organic Bodies mineralized by Salts.*

THIS operation muſt vary according to the nature of the ſubſtance. Bodies immerſed in a ſalt ſolution are ſometimes penetrated by it, and indurated. In this manner the entire bodies of men, that had fallen by accident into the vitriolated water of the mine of Fahlun were found

after

after ſeveral years, ſo little changed to the eye, that the individual could be remembered by his countenance: In other reſpects however they were rigid like a ſtatue, formed of ſaline matter. When expoſed to the free air they began to crack. By a ſimilar proceſs, no doubt, even ſofter ſubſtances may be ſo hardened, as to preſerve their ſtructure a long time, exempt from putrefaction.

§ c. *Bodies impregnated with Bitumen.*

In like manner organic bodies, impregnated with bituminous matter are enabled to preſerve themſelves from decay, and retain their figure and ſtructure.

§ ci. *Petrifaction of organic Bodies.*

Neither the bodies of animals nor of vegetables can be wholly penetrated by ſtony particles. The harder parts only, as the bones, ſhells, external covering, roots, woods, fruit, and ſimilar ſubſtances, are liable to this change; which, if I miſtake not, proceeds in the following manner: At firſt, the parts of ſofteſt texture putrefy, and leaving ſeveral empty ſpaces, through which water loaded with earthy particles paſſes, and in its courſe depoſiting them, the vacuities are at length filled by their gradual accumulation. Then follows the deſtruction of the more firm conſiſtence, to be penetrated in the ſame order.

If the later depoſitions differ in their colour and properties from thoſe of an earlier date, yet the original organic ſtructure is beautifully diſplayed by ſmooth and poliſhed ſections of the different bodies. All the particles, however, of the bodies ſo deſtroyed are not always carried off; for it often happens in diſtillation, that ſuch are expelled as ſhew ſigns of an organic conſtruction.

§ CII. *Organic Bodies penetrated with metallic Particles.*

The moſt ſubtle metallic molecules, that can poſſibly be carried along by water, may in the ſame manner penetrate and change the harder organic parts.

§ CIII. *Nuclei.*

From the ſubſtances already deſcribed, nuclei have, with great propriety, been conſidered as quite diſtinct. They are produced by two different proceſſes. Any body poſſeſſing a ſhell or firmer covering, and depoſited in a ſoft ſtratum, is gradually attacked in its fleſhy parts and ſoft inteſtines, which are either wholly deſtroyed, or contracted by exſiccation; ſo that room being made in this manner for the particles flowing in, the ſhell is at length filled with a nucleus, bearing the marks of its internal ſurface. If a body is involved in ſediment, and after the exſiccation of the ſtratum is any way deſtroyed

destroyed or carried off, a nucleus will be formed in the cavity, describing its external features.

§ CIV. *Remaining Impressions of organic Bodies.*

In any soft substance, impressions are left by cockles, snails, insects, fishes, and other small animals of the firmer kind, either of their external surface, their bones, or skeletons.

CV. *Osteocolla.*

In particular soils, living roots are by degrees covered with so hard a crust, as to prevent the absorption of the necessary juices. When a vegetable attracts moisture every where in the neighbourhood of its root, the subtile, calcareous, argillaceous, siliceous, and even ochreous molecules, that accompany it, produce this effect. The fluid in which they were borne being absorbed by the roots, they fix themselves on the surface, and there forming a covering impervious to water, the roots decay, putrefy, and leave this crust, which is commonly called *osteocolla.*

§ CVI. *Incrustated organic Bodies.*

Waters loaded with earthy particles frequently cover with a crust, reeds, small branches, and other ſubſtances immerſed in them, without any alteration of their original form.

Of the different Species.

§ cvii. *Specific Characters of Salts.*

Specific characters are to be determined by the difference in the nature of thoſe ſimple ſalts, which art has not been able to compoſe from their principles. Of theſe, two diſtinct genera only are known; the acid and the alkali already mentioned.

§ cviii. *Species of Acids.*

The genus of acids is very extenſive. The vitriolic, nitrous, and muriatic, have been extracted from foſſils for many ages paſt; but the diſcovery of others differing evidently from theſe has been made within a much later period. The acid of fluor, borax, arſenic, ſiderite, molybdena, and lapis ponderoſus, are of this deſcription *.

§ cix. *Vegetable Acids.*

We have the proſpect as yet of a more extenſive field in the acids of the vegetable kingdom. Beſides,

* For metallic acids, ſee Eſſays, v. iii.

Besides the acetous, which was the only one formerly known, it has produced to us already the acids of ſugar, ſorrel, tartar, benzoin, citron, amber, and ſeveral others.

§ CX. *Animal Acids.*

THE animal kingdom is the pooreſt of the three; for except the acid of ants, and of fat, we know of none other proper to it, although, without doubt, it contains many highly deſerving of notice. As for example, the acid which the larva phalænæ vinulæ of Linnaeus throws out in its defence, clear as water, and colourleſs, which reſembles the concentrated acetous acid in ſmell and taſte, coagulates blood, and thickens ſpirit of wine; reddens blue paper for a ſhort time; but the original colour returning afterwards, affords proof of its great volatility *. The ſcarcity of this very ſingular liquor has perhaps delayed ſo long its further inveſtigation.

§ CXI. *Acids common to ſeveral Kingdoms of Nature.*

OTHER acids are common to all the kingdoms of nature, as the *phoſphoric*, which had been falſely aſſigned to the animal kingdom alone; but which has been found, though rarely, in the foſſil †, and in great plenty in the vegetable kingdom.

* Oeuvres de M. Bonnet, v. iii. 8vo. p. 28.

† Eſſays, vol. ii. page 426.

kingdom. Under this head we may arrange the aerial acid.

§ CXII. *Great Number of Acids.*

If we consider, that probably the existence of all metals depend upon their peculiar radical acids; that vegetables evidently contain a number of unknown acids; and that, perhaps, the same may be said of animals also; we have reason to wonder at the abundance and variety of this substance, and to set a high value on its utility and importance in the œconomy of nature.

§ CXIII. *Species of Alkaline Salts.*

The extent of the other genus is confined within very narrow limits. For a long time three species only of alkaline salts were known; two of which could bear a slight ignition, and were therefore denominated fixed; while the other was distinguished by its volatility.

§ CXIV. *Fixed Alkalies.*

Of the fixed alkalies the one seems to prevail in the vegetable, and the other in the mineral kingdom; from which they both derive their names.

§ CXV.

§ CXV. *Neutral Salts.*

SALTS formed by the exact ſaturation of acids with alkalies amount to ſixty double ſpecies, on the ſuppoſition that the acids do not exceed twenty in number. A conſiderable part, however, of the combinations of theſe are as yet unknown, or at leaſt but imperfectly examined.

§ CXVI. *Imperfect double Salts.*

MANY imperfect double ſalts have been diſcovered. The acids of vitriol, arſenic, tartar, and ſorrel unite in exceſs with the vegetable alkali; and the acids of vitriol and tartar with the mineral alkali. The labours of poſterity will probably add a greater number. Borax retains an exceſs of alkali; and the arſenicated mineral alkali likewiſe is capable of a ſimilar combination.

§ CXVII. *Triple Salts.*

THE ſalt of Seignette, and tartar ſaturated with volatile alkali, furniſh examples of the neutral triple ſalts.

§ CXVIII. *Imperfect Triple Salts.*

AMONG the triple imperfect ſalts, we know of the union of tartar with the acid of borax. Here is an exceſs of acid.

§ CXIX. *Quadruple Salts.*

TARTAR and borax combined, are an inſtance of the quadruple ſalts.

§ CXX. *Species of analogical Salts.*

EARTHS and metals, although ſingly they refuſe every combination with water, yet by the admixture of a ſalt they become for the moſt part ſoluble, and are then called analogical ſalts.

§ CXXI. *Species of double perfect earthy Salts.*

FOUR primitive earths uniting with twenty acids, produce eighty double perfect earthy ſalts; that is ſalts compleatly ſaturated. The fifth earth, the ſiliceous, is ſoluble in the fluor acid only.

§ CXXII.

§ CXXII. *Double imperfect earthy Salts.*

Of all the double imperfect earthy salts, with an excess of acid, the salt of alum is the most conspicuous.

§ CXXIII. *Triple earthy Salts.*

The principle triple compounds, are the volatile alkali, either vitriolated or muriated, and magnesia, with which even nitrated lime readily unites.—Vitriolated magnesia combines with clay; and both the vegetable and mineral alkali saturated with the acid of fluor, admit an union with siliceous earth.

§ CXXIV. *Earthy alkaline Salts.*

Fixed caustic alkalis, I know for certain affect no other earths than the argillaceous and siliceous. No triple alkaline salts have as yet been discovered.

§ CXXV. *Species of metallic salts.*

Analogical metallic salts are by far the most numerous. From a combination of the sixteen metals with the twenty acids, we obtain three hundred and twenty double salts; but

but which can be ſcarcely ſo perfectly ſaturated, as that there ſhould not be ſome ſmall exceſs of acid.

§ CXXVI. *Metallic Salts, with an Exceſs of the metallic Baſe.*

THERE are ſome inſtances alſo of the union of metals and acids, highly deſerving of notice, in which the exceſs is on the part of the metal. To this head we refer the turpith mineral, and red precipitate of Mercury, which though ever ſo well waſhed, yield a ſmall quantity of acid on diſtillation. The ſame remark applies equally well to the pulvis algarothi. Mercurius dulcis retains its metal partly calcined and partly perfect *; and nitrated ſilver, in like manner can take up a portion of ſilver, without dephlogiſticating it. Muriated copper, deficient in its acid, conſtitutes a peculiar ſalt hitherto undiſcribed.

§ CXXVII. *Triple metallic Salts.*

WE have long been acquainted with a conſiderable number of metallic triple ſalts, that are not ſeparable but by decompoſition. Of this deſcription are the combinations of tartar with iron and antimony; of the vitriolated vegetable

* Scheele in Actis Stockh.

getable alkali with iron; of the muriated vegetable alkali with platinum; of the vitriolated volatile alkali with copper; of the muriated volatile alkali with platinum, quickſilver, copper, and iron; of vitriolated and acetated quickſilver with iron; of vitriolated iron with magneſium, with copper, and with zinc.

§ CXXVIII. *Quadruple metallic Salts.*

THE quadruple metallic ſalts are formed by the union of ſal ammoniac with nitrated iron, with nitrated copper, and with boracic quickſilver; of the vitriol of iron, likewiſe, with the vitriols of copper and zinc together.

§ CXXIX. *Alkaline metallic Salts.*

MOST of the alkalis alſo combine readily with metals, eſpecially the volatile alkali; which ſometimes forms beautiful cryſtals, with a metallic baſe, as with ſilver and copper. The numerous family of theſe ſalts are deſerving of much greater attention than has ever yet been paid to them.

§ CXXX. *Synopſis of Salts.*

FROM what has been ſaid, I am of opinion there can be no doubt of the extenſive influence

and

and variety of the claſs of ſalts, in which we have here conſidered all thoſe prepared by art, as well as thoſe produced by nature. In favour of the halurgic ſyſtem, I ſhall ſubjoin a table, preſenting at one view all the chief varieties, with which I am acquainted. A greater number of proper experiments would certainly add many more to the account.

SALTS.

Properly ſo called	Simple	Acid
		Alkali.
	Double	Neutral
		Imperfect.
	Triple	Neutral
		Imperfect.
	Quadruple	Neutral
		Imperfect.

Analogic	earthy	with an acid	double, triple	Perfect
				Imperfect
		with an alkali	double	
	metallic	with an acid	double, triple, quadruple	Imperf. with exceſs of acid
				Imperf. by defect of acid.
		with an alkali	double	

§ CXXXI.

§ cxxxi. *Species of Earths of a double Character.*

In the claſs of earths different ſpecies frequently occur, poſſeſſing two characters. To the firſt belong the ſaline earths; which, on account of the limits before aſſigned to them, are not reckoned in the claſs of ſalts, although they reſemble them in their nature, and conſtitute but an imperfect ſpecies of earths. Of theſe ſubſtances, however, a few only are known, § 51.

§ cxxxii. *Mixed Species of Earths.*

Genuine ſpecies of mixed earths are produced by the intimate union of two or more. Of the exiſtence of ſuch an union we have clear evidence, in § 90.

§ cxxxiii. *On what Arguments their Diverſity is founded.*

Not the quality and number only of the ingredients, but even their relative weights imply a ſpecific diverſity.

§ cxxxiv. *The Neceſſity of conſidering the Proportion of every Part.*

In the Sciagraphia Regni Mineralis, lately publiſhed

published, I have overlooked the mutual proportions; but, on further reflection, I find the consideration of them absolutely necessary.

§ CXXXV. *Method of investigating the several Species of Earths.*

In order to determine with accuracy the species of earths, which hitherto seem to have rested on no very certain foundation, it will be requisite to explain carefully this doctrine. Let the five primitive earths be indicated by five initial letters, the ponderous by *p*, calcareous by *c*, magnesian by *m*, argillaceous by *a*, and siliceous by *s*.

§ CXXXVI. *Continuation.*

At first we will attend to the character only and number of principles; and, by means of the doctrine of combinations, it will be easy to ascertain how many specific consociations can arise from these five letters.

For example, *p*, *c*, *m*, *a*, and *s*, can produce no more than ten double species—

pc, *pm*, *pa*, *ps*,
cm, *ca*, *cs*,
ma, *ms*,
as.

Of

Of triple ſpecies we have as follows :—

pcm, *pca*, *pcs*, *pma*, *pms*, *pas*,
cma, *cms*, *cas*,
mas.

Quadruple :—

pcma, *pcms*, *pcas*, *pmas*.

Laſtly, One quintuple only :—

pcmas.

In this manner, from the whole claſs of earths, beſides the five ſimple ſpecies, containing the primitives alone, we can obtain but twenty-ſix different combinations; which, together with the five ſimple, amount in all to thirty-one.

§ CXXXVII. *Why this Method is imperfect.*

In this plan, however, the number of the ſpecies is too much limited, and our concluſions liable to error. It will eaſily appear that *pa*, for example, muſt be ſeparated; for the character of the maſs, with an exceſs of ponderous earth, will be by no means the ſame as with an exceſs of clay. In like manner *pac* ſhould be referred to three diſtinct genera, according as the firſt, the ſecond, or the third principle bear the greateſt ſhare in the compoſition, (§ 78.). The ſame, indeed

indeed, will be obſerved in whatever formula is employed. Therefore it is neceſſary, together with the number of the principles, to conſider the weight of each.

§ CXXXVIII. *In what Manner can this Defect be ſupplied or corrected.*

THAT they may be all ſymbolically deſigned, and rendered obvious to the ſenſes, a certain local value muſt be aſſigned to every letter; ſo that whatever principle occurs firſt in combination, that ſhould be underſtood to be the heavieſt of the whole maſs: Every intermediate principle will yield to the preceding one, but exceed thoſe that follow it, and the laſt of all will be of the leaſt importance.

§ CXXXIX. *Enumeration of double Species.*

ACCORDING to this ſyſtem then we ſhall have twenty double ſpecies:

pc,	*pm*,	*pa*,	*ps*.
cp,	*cm*,	*ca*,	*cs*.
mp,	*mc*,	*ma*,	*ms*.
ap,	*ac*,	*am*,	*as*.
ſp,	*ſc*,	*ſm*,	*ſa*.

§ CXL.

§ CXL. *Enumeration of triple Species.*

EACH of the five letters in forming triple compoſitions, may be arranged in twelve different ways. Five multiplied by twelve, therefore produce ſixty ſpecies as follows:

pcm, pca, pcſ, pma, pmſ, pmc, paſ, pac, pam, pſc, pſm, pſa.
cpm, cpa, cpſ, cmp, cma, cmſ, cap, cam, caſ, cſp, cſm, cſa.
mpc, mpa, mpſ, mcp, mca, mcſ, map, mac, maſ, mſp, mſc, mſa.
apc, apm, apſ, acp, acm, acſ, amp, amc, amſ, aſp, aſc, aſm.
ſpc, ſpm, ſpa, ſcp, ſcm, ſca, ſmp, ſmc, ſma, ſap, ſac, ſam.

§ CXLI. *Quadruple Species.*

As the double ſpecies amount to twenty; and theſe, with the remaining three letters can be combined in ſix different ways, in the quadruple ſpecies, it will be eaſily ſeen, that ſix times twenty, or one hundred and twenty, will expreſs the amount of this diviſion.

S *pcma,*

*pcma, pcam, pcmſ, pcſm, pcſa, pcaſ, pmac,
pmca, pmaſ, pmſa, pmcſ, pmſc, pacm, pamc,
pacſ, paſc, pamſ, paſm, pſcm, pſmc, pſac,
pſca, pſam, pſma.*

*cpma, cpam, cpmſ, cpſm, cpaſ, cpſa, cmpa,
cmap, cmpſ, cmſp, cmaſ, cmſa, capm, camp,
capſ, caſp, camſ, caſm, cſpm, cſmp, cſpa,
cſap, cſma, cſam.*

*mpca, mpac, mpaſ, mpſa, mpcſ, mpſc mcpa,
mcap, mcpſ, mcſp, mcaſ, mcſa, macp, mapc,
macſ, maſc, mapſ, maſp, mſcp, mſpc, mſap,
mſpa, mſac, mſca.*

*apcm, apmc, apmſ, apſm, apcſ, apſc, acpm,
acmp, acmſ, acſm, acpſ, acſp, ampc, amcp,
ampſ, amſp, amcſ, amſc, aſpc, aſcp, aſpm,
aſmp, aſcm, aſmc.*

*ſpcm, ſpmc, ſpam, ſpma, ſpca, ſpac, ſcpm,
ſcmp, ſcam, ſcma, ſcpa, ſcap, ſmca, ſmac,
ſmpa, ſmap, ſmcp, ſmpc, ſapc, ſacp, ſacm,
ſamc, ſamp, ſapm.*

§ CXLII. *Quintuple Species.*

THE triple ſpecies being ſixty in number, (§ 140.) and each of theſe admitting of two changes only with the other two letters, it fol-lows

lows, that, under this head, we may reckon one hundred and twenty ſpecies.

pcmaſ, pcmſa, pcamſ, pcaſm, pcſam, pcſma,
pmcſa, pmcaſ, pmaſc, pmacſ, pmſca, pmſac,
pamſc, pamcſ, paſmc, paſcm, pacſm, pacmſ,
pſcma, pſcam, pſmca, pſmac, pſamc, pſacm.

cpmaſ, cpmſa, cpaſm, cpamſ, cpſam, cpſma,
cmpaſ, cmpſa, cmapſ, cmaſp, cmſpa, cmſap,
camſp, campſ, capmſ, capſm, caſpm, caſmp,
cſmpa, cſmap, cſpma, cſpam, cſapm, cſamp.

mpcſa, mpcaſ, mpacſ, mpaſc, mpſca, mpſac,
mcpaſ, mcpſa, mcapſ, mcaſp, mcſpa, mcſap,
mapcſ, mapſc, macpſ, macſp, maſcp, maſpc,
mſpca, mſpac, mſcap, mſcpa, mſacp, mſapc.

apcmſ, apcſm, apmcſ, apmſc, apſcm, apſmc,
acpmſ, acpſm, acmpſ, acmſp, acſpm, acſmp,
ampcſ, ampſc, amcpſ, amcſp, amſpc, amſcp,
aſpcm, aſpmc, aſcpm, aſcmp, aſmpc, aſmcp.

ſpcma, ſpcam, ſpmca, ſpmac, ſpacm, ſpamc,
ſcpma, ſcpam, ſcmpa, ſcmap, ſcamp, ſcapm,
ſmpca, ſmpac, ſmcpa, ſmcap, ſmacp, ſmapc,
ſapcm, ſapmc, ſacpm, ſacmp, ſampc, ſamcp.

§ CXLIII. *Amount of the Species.*

If the primitive earths are five in number, then the preceding paragraphs exhibit the formulæ of all thoſe ſpecies that can poſſibly ariſe from their various combination; and to which, adding the five ſimple earths, we ſhall find the amount to be thus, $5+20+60+120+120=325$, the amount of the whole.

§ CXLIV. *Further Explanation of the Formulæ.*

I have ſo contrived theſe formulæ as to make it evident to what genus every combination is to be referred.—The firſt letter determines the character of that genus, *s* only excepted; as, though it exceeds in weight, yet its other qualities do not always prevail, (§ 89.)

If at any time the number of the primitive earths is diminiſhed, whether by decompoſing them into others more ſimple, or by diſcovering them to be of a metallic nature, yet the ſame formulæ may be preſerved after making the neceſſary correction.

For example, Suppoſe *p* were referred to the third claſs, the quintuple formulæ, (§ 142.) would then become quadruple, that ſeries being deſtroyed entirely where *p* begins, and from all the others would it be taken away. In this caſe, we we loſe the whole of the firſt genus, and the ſame formulæ are repeated four times in each of the remaining genera, and conſtitute one ſpecies only; ſo that $\frac{24}{4}=6$ ſpecies is of each genus and $4\times6=24$ the number of all the quadruple ſpecies.

Let us take another example, and remove altogether *a*, the formulæ of that genus are immediately annihilated, and the eighteen in the three other genera are reduced to $2\times3=6$.

In the ſame manner, that the corrections are made in the formulæ of the laſt order, can they be applied to thoſe preceding. For it is evident that in reducing quadruple to triple ſpecies, it is impoſſible when *p* is deſtroyed, that the remaining ſeries ſhould be quadruple, and are therefore to be removed entirely.

Let *n* repreſent the number of primitive earths, and the number of the double ſpecies be expreſſed by $n. n.-1.$ of triple ſpecies by $n. n-1. n-2,$ of quadruple ſpecies by $n. n-1. n-2. n-3,$ and that of the laſt order by $n. n-1. n-2.-n-n-2.$

§ CXLV. *Species of Metals.*

Having determined theſe points, we now proceed to the third claſs, in which, on account of the greater number of genera, we ſhall find the ſpecies alſo to be far more numerous.

Metals occur generally either complete, mineralized, or deprived of their phlogiston.

§ CXLVI. *Native Metals.*

Whatever possesses a complete metallic form, is denominated native.

Into this state no heterogeneous substances are admitted, unless they are perfectly metallic. Hence arise various species;—the metal native and simple;—combined with some other;—or with several together. Native simple metals are very rare, and, as far as I know, have never yet been discovered perfectly pure.

Most metals are occasionally found native, as gold, platinum, silver, quick-silver, copper, bismuth, niccolum, arsenic, cobalt, and antimony; but scarce any one of them occurs quite pure. Gold is mixed with silver or copper; silver with gold or copper; platinum with iron; niccolum and cobalt with arsenic as well as iron; antimony with iron or zinc; and further experiments will without doubt discover other combinations.

The existence of native lead, iron tin, and zinc has been always much questioned by many.

Magnesium and siderite have never yet been found in a native state.

§ CXLVII.

§ CXLVII. *Mineralised Metals.*

A MINERALISED metal appears to me to be a metal intimately united with some foreign substance that destroys more or less the genuine metallic form.

§ CXLVIII. *Mineralising Substances*

SUCH are sulpher and acids.

CXLIX. *Metals mineralised by Sulphur.*

SULPHUR can be directly united with all the metals, except gold, platinum, and zinc; and these mineralisations are found in the bowels of the earth. Sulphurated tin also occurs in Siberia *.

Some mineralizations are affected, both as to character and appearance, according to the quantity of sulphur. Tin, combined with twenty hundred parts of sulphur, forms a mineralisation, white and fibrous; but, with twice that proportion, the compound is micaceous, and of the colour of gold.

Sulphur acting on perfect metals separates a portion of their phlogiston; and is even capable of uniting with many calces likewise.

 The

* Essays, vol. iii. p. 158.

The combination of gold with ſulphur, by the intermedium of iron; is not yet made ſufficiently evident; for that which is found in pyrites ſeems to be rather mixed than diſſolved; as in a ſolution of pyrites, in the nitrous acid, the gold is depoſited in molecules, not in powder, but differing from each other both in ſize and figure *.

As to zinc, that metal appears in the pſeudo galena to be joined † with ſulphur by means of iron.

§ CL. *Mineraliſing Acids.*

Of mineraliſing acids there are ſeveral, as the vitriolic, muriatic, phoſphoric, aerial, and probably the arſenical.

§ CLI. *Vitriols.*

Vitriols of copper, iron, and zinc, are the ſpontaneous productions of nature. Combinations of the ſame acid with lead, niccolum, and cobalt, are likewiſe ſometimes found; and they ſeem generally to be the reſult of decompoſed mineraliſations.

§ CLII.

* Eſſays, vol. ii. p. 412.

† Ibid. p. 329, and 336.

§ CLII. *Metals mineralised by the Muriatic Acid.*

THE muriatic acid is more rarely found united with metals. As yet it has not been discovered in any other than silver, quicksilver, and copper. The two first contain with it the vitriolic acid likewise *.

§ CLIII. *Metals mineralised by the Aerial Acid.*

THE aerial acid is often present in calciform metals. We meet with it in lead, copper, iron, and zinc. Of its connexion with other metals we have no certain intelligence.

§ CLIV. *Metals mineralised by the Phosphoric Acid.*

OF all the acids, that of phosphorus is the scarcest, and has hitherto been found with a spataceous kind of lead only.

§ CLV. *Metals mineralised by the Arsenical Acid.*

THE arsenical acid, if I mistake not, is the true menstruum of the red cobalt, that is sometimes beautifully crystallised. It is certain, that a red colour is owing to an acid, and that, from all the experiments as yet made, no other has been discovered.

§ CLVI.

* Woulfe, Philos. Trans.

§ CLVI. *The different Species of Metals admit of almost numberless Variations.*

Whoever considers, that we are acquainted already with sixteen metals, and that of these the greater number of the perfect can be in several ways combined together, as well as those mineralised by sulphur and various acids, will naturally expect that, by means of accurate analyses, many more species might be discovered, which have as yet probably escaped the researches of the laborious philosopher. Were we to pursue the plan applied to the earths, (§ cxliii.) the number would be really astonishing; but I am almost of Pliny's opinion, who somewhere confesses: "Mihi contuenti sese persuasit rerum natura nihil incredibile existimare de ea." Formulæ, indeed, point out to us what may be done; but whether, and where, they are employed, must be learned from a faithful analysis; which assists us, besides, better to understand those of them that prescribe the true limits to our investigations.

§ CLVII. *Spiecies of Phlogistic Substances.*

The fourth class is exceedingly poor both in genera and species.

§ CLVIII.

§ CLVIII. *Species of the Diamond.*

We are acquainted with many differences of the diamond, but with none that are ſpecific.

§ CLIX. *Species of Sulphur.*

The ſpecies of ſulphur are diſtinguiſhed by the diverſity of their acids, and we know of two only; the common formed by the vitriolic acid, and plumbago, containing the aerial acid ſaturated with phlogiſton.

§ CLX. *Species of Petroleum.*

The varieties of petroleum, in colour and tenuity, depend for the moſt part on the degree of exſiccation, and on the matrix or heterogeneous ſubſtances mechanically mixed with it; ſo that they can be conſidered but ſeldom as ſpecific. Exſiccation produces a maſs thick and tough, or ſolid and dry.

§ CLXI. *Amber.*

The ſame obſervations nearly will apply to amber. In reſpect of tranſparency and colour, we meet with many varieties in the European ſpecies.

The

The Indian ſpecies agrees in all thing with the European, except its being ſofter, and wanting the volatile ſalt *, which laſt circumſtance ſeems to eſtabliſh a ſpecific difference. Copal, commonly ſo called, is to be diſtinguiſhed from the gum reſin of that name ſold by the apothecaries.

§ CLXII. *Origin of Phlogiſtic Subſtances.*

DIFFERENT opinions are maintained by philoſophers, reſpecting the origin of phlogiſtic ſubſtances. Some contend, that theſe bodies are proper to the foſſil kingdom; while others, probably with more reaſon, aſcribe them to thoſe organic ſubſtances which abound in various oily and fat juices, and are not ſo much affected by time, as they are gradually changed in the bowels of the earth by neighbouring pyrites and other foſſils, until they acquire a bituminous quality. Heterogeneous ſubſtances encloſed within them are evident proofs of original fluidity. The different degrees of purity of naptha, coagulation performed by time, acids, or other media, and various circumſtances beſides in the great laboratory of nature, all influence the denſity, colour, clearneſs and other properties.

As to ambergriſe, Aublet inſiſts, that it is the juice of a tree growing in Guiana, and there called

* Lehman, Chem. Schrift.

called Cuina. He ſays, that after heavy rains, large maſſes of it are waſhed into the rivers. The ſpecimens examined by Roſſelle are ſaid to reſemble ambergriſe in their odor and principle qualities *. Long ago, Rumphus makes mention of a tree called nanarius, containing a juice ſimilar to ambergriſe. Lately, however, in England an opinion has obtained, that this ſubſtance is the excrement of a cetaceous fiſh. Obſervations made on the phyſeter macrocephalus, (the ſpermaceti whale) have given riſe to this Idea, as the excrement in the inteſtines of that animal, is found on diſſection perfectly hardened, and containing the beak of the repia octopodia, on which it feeds, and in every reſpect reſembling the ambergriſe of commerce.

§ CLXIII. *Species of Foſſils mixed mechanically.*

Of foſſils mechanically mixed, that fall under conſideration in the firſt appendix, we have conſtituted four genera only, (§ 91.) their ſpecies, however, are numerous.

§ CLXIV. *The ſeveral Species expreſſed by the Formulæ of Letters.*

Let *s* denote ſalt, *t* earth, *m* metals, and *i* phlogiſtic ſubſtances; and let the ſame local value

* Hiſt. des plantes de la Guyane, 1774.

value be aſſigned to theſe letters as in the foregoing examples, (§ 138.) and we ſhall obtain the following double ſpecies.

st, *sm*, *si*.
ts, *tm*, *ti*,
ms, *mt*, *mi*.
is, *it*, *im*.

Triple ſpecies.

stm, *sti*, *smt*, *sit*, *smi*, *sim*,
tsm, *tsi*, *tms*, *tis*, *tmi*, *tim*,
mst, *msi*, *mts*, *mis*, *mti*, *mit*,
ism, *ist*, *ims*, *its*, *itm*, *imt*.

Quadruple ſpecies.

stmi, *stim*, *smti*, *smit*, *sitm*, *simt*,
tsmi, *tsim*, *tmsi*, *tmis*, *tims*, *tism*,
msti, *msit*, *mtis*, *mtsi*, *mits*, *mist*,
istm, *ismt*, *itsm*, *itms*, *imst*, *imts*.

§ CLXV. *Continuation.*

We are, however, not raſhly to conclude that all the ſpecies are exhauſted in theſe formulæ; for every letter may be varied in many ways, according to the diverſity of the ſeveral ſpecies. For example, *t* can be multiplied more than 325 times, (§ 131, 143). *I*, indeed, preſents but

but few variations, and *s* likewiſe; as the number of the ſalts proper for theſe mixtures, is exceedingly limited; but *t* ſurpaſſes even *m*, (§ 156); ſo that we have here another occaſion of admiring the exhauſtible ſtories of nature.

§ CLXVI. *The Poſition and ſituation of mixed Foſſils.*

IT is by no means to be expected; that every ſpecies of theſe mixed foſſils, which to me appear to be *petræ*, ſhould be equal to the production of huge mountains. The greateſt number of them have hitherto been found in veins or ſmall ſtrata only; many of which, though of different characters, when combined, give birth to rocks. The ſame may be ſaid of the ſeparate particles, which, in the aggregate, form large and continued ridges of hills. But theſe almoſt always ſpring from the ruins and decompoſitions of mountains.

§ CLXVII. *Species of organic Foſſils.*

ORGANIC foſſils conſtitute four genera, (§ 97.); but the ſeveral ſpecies of foſſils, whether poſſeſſing an organic form only, or with it an organic ſtructure, are diſtinguiſhed by ſpecific marks.

§ CLXVIII.

§ CLXVIII. *Species of organic Foſſils mineraliſed by Salts.*

ORGANIC foſſils, penetrated with ſaline matter, are but ſeldom found. Gypſum, indeed, ſometimes contains the leſs periſhable remains of animals and vegetables; but theſe ſubſtances are ſcarce ever found quite gypſeous. Entire animals are occaſionaly to be met, filled with vitriol, (§ 99.) and ſtill oftener the harder parts of vegetables, or their roots, ſeem to reſiſt putrifaction by the means of this ſalt.

§ CLXIX. *Earths.*

THE ſecond genus, comprehending earthy foſſils, is by far the richeſt. Innumerable calcareous nuclei of ſhell fiſh and marine inſects daily occur in calcareous ſtrata. Sometimes, an animal covering, or ſhell, which was before calcareous, being changed in its internal texture only, become ſpataceous.

Argillaceous nuclei of marine animals are common in aluminous ſchiſtus, but very rare in any other bed. Frequently the covering of the animalcule ſtill remains.

Marine exuviæ are obvious in marle alſo. If lime predominates, often the ſkeletons alone of the fiſh are ſeen. Of Oſteocolla we have already ſpoken ſufficiently, § 105.

Siliceous

Siliceous nuclei frequently fill entirely the internal cavity of organic foſſils, and ſometimes even the ſame matter ſurrounds their external ſurface. I am in poſſeſſion of an echnites, the ſhell of which is filled with common flint, and ſhews upon the ſurface of the nucleus all its natural inequalities; the ſhell itſelf, however is calcareous and ſpataceous, although it was imbeded in ſiliceous earth on both ſides. Small ſhells occur ſometimes in jaſper, but very rarely *, and are not more frequent in petroſilex.

Organic bodies, themſelves alſo are found penetrated with ſiliceous matter. Siliceous petrefactions of the trunks of trees are often diſtinctly marked with the growth of every year. Siliceous muſcles and cockles alſo frequently occur, and ſmall corals even are ſometimes clearly to be diſtinguiſhed in common flints.

I have ſeen the marks of leaves accurately expreſſed in quartz, and the epitomium of Blankenburg is often quartoſe.

Nuclei of ſand are ſometimes to be met with; but the figure of their ſurface is generally ſo obſcure, that it is very difficult to determine from what organic body they were produced.

In the ſand pit at Maeſtricht was found not long ago the ſkeleton of a crocodile, ſome teeth of which were ſent to me.

* Ferber in Epiſt. de Italia.

§ CLXX. *Species of organic Foſſils impregnated with metallic Particles.*

VERY few metals aſſume an organic form. The calx of iron, but ſlightly cohering, or concreted like a ſtone, penetrates roots, wood, and even whole trees, preſerving ſtill the fibrous texture, which may ſometimes be ſcraped with the nail.

Pyrotaceous iron, indeed, now and then forms nuclei; but it commonly adorns the organic ſtructure with lines or little ſpots, and ſeldom occupies it entirely.

Copper, in the form of a calx is ſuppoſed frequently to enter into bones and teeth, giving them a blue colour, eſpecially after they are calcined. This colour, however, is often owing to iron.

Pyritaceous copper alſo reſembles the anomia in the magnet of Iarlſberg in Norway, and fiſhes in ſeveral places.

Spots of native gold or ſilver are ſometimes ſeen on the ſurface of foſſil ſhells.

The grey ore of ſilver at Frankenthal in Heſſe is found in the form of ears of corn, and commonly called *kohrn-ahren*; and under the appearance of leaves and ſtalks of ſome granife-rous vegetable.

Cinnabarine ſhells are exceedingly rare.

I

I have in my poſſeſſion ſome pſeudogalena of a blackiſh yellow, united to millepores.

§ CLXXI. *Species of Phlogiſticated organic Foſſils.*

Wood impregnated with petroleum frequently occurs. There is a trunk of a tree in the collection of the academy at Upſal, indurated with petroleum, black and ſmooth, and yet eaſily diſtinguiſhed to be of a beech. The Icelandic foſſil wood alſo comes under this head, of which I have ſpoken more fully in another place *.

Bones penetrated with aſphaltus are ſometimes found.

As is foſſil wood likewiſe, whoſe pores are filled with amber, and even with inſects and other ſmall animals; which this ſubſtance does not only penetrate, but even ſurrounds, as a ſplendid monument covering their remains.

Turf and mould contain organic bodies, eſpecially of vegetables reduced in the greateſt part by putrefaction to duſt; but which diſplay ſigns of their original ſtructure and character, more or leſs obſcure. The firſt ſcarce differs from the latter but in the greater decompoſition and denſity of its maſs.

 VARIETIES.

* Eſſays, v. iii. p. 239

VARIETIES.

§ CLXXII. *Ordinary Confuſion of Varieties with Species.*

THAT many varieties have been obſerved in ſpecies properly determined is the more evident, as they have, for the moſt part, been conſidered as different ſpecies. A miſtake to which the practice of the mineralogiſts in determining ſpecific differences from external marks undoubtedly gave riſe.

§ CLXXIII. *Criteria of Varieties to be taken from external Appearances.*

IN the foregoing, we have ſhewn that ſpecific marks were to be taken from the particular compoſition; but although ſuperficial criteria do not affect the intimate nature of theſe bodies, yet they are not by any means to be neglected; they are well calculated to determine varieties, and are even uſeful, not only in leading often a ſkillful eye to proper diacritic experiments, but in throwing light upon the mode of production, and other intereſting circumſtances.

§ CLXXIV. *Illuſtration of external Marks.*

THE chief external marks are thoſe taken from the form of the outward ſurface; the texture, in the appearance of its particles by a recent fracture; the colour, hardneſs, and gravity.

§ CLXXV. *Amorphous Foſſils.*

FOSSILS that have no determined ſhape are denominated amorphous.

§ CLXXVI. *Chryſtalline Foſſils.*

BUT thoſe whoſe circumference is included within plain ſides meeting each other at various angles are called cryſtalline.

In the foſſil kingdom, we have five regular geometric figures, of plain, equal, and ſimilar ſides; as the tetraedra, cubes, octaedra, dodecaedra, and icoſaedra; beſides many others diſtinguiſhed by their priſmatic columns and pyramidal terminations. In what manner the great number of derivatives ariſe from a few primatives, and differing from each other at the firſt view, I have related elſewhere *.

Salts, indeed, on account of their ſolubility in

* Eſſays, vol. ii. p. 1.

in water, more readily acquire a ſubtilety and freedom of their particles, which, through the means of attraction, is neceſſary to form them into cryſtalline concretions; but this property is not limited to them, as cryſtalline foſſils are found in almoſt every genus of earths, metallic, and phlogiſtic ſubſtances.

§ CLXXVII. *External Marks taken from the Texture of Foſſils.*

THE texture of foſſils is not eaſily determined by the form of the particles; as when they are intimately combined with each other they are always mutilated by fractures; we may, however, diſtinguiſh many varieties. The moſt ſubtile, ſhapeleſs molecules uſually called impalpable, give riſe to an equal texture: while others larger, and more diſcernable produce a granous, filamentous, ſcaly, and ſpataceous compoſition.

§ CLXXVIII. *From the Colour.*

COLOURS, eſpecially the gradual ſhades of them, can ſcarce be ſo deſcribed by language, as to convey any clear idea, Hardly any other method, therefore, than that of compariſon can be uſed by always referring to thoſe colours ſufficiently underſtood.

§ CLXXIX.

§ CLXXIX. *Physical Marks.*

PHYSICAL marks alſo, as hardneſs and gravity, are to be employed for aſcertaining varieties, whenever they are found to throw any light.

§ CLXXX. *Varieties of organic Foſſils.*

THE varieties of organic foſſils are to be determined from the ſpecies of vegetables or animals, which ſerve as guides to our judgement. And all living bodies being defined by their external appearance, the ſame rule may be obſerved in this as in the other claſſes.

§ CLXXXI. *Epilogue.*

A SYSTEM of foſſils, arranged according to the foregoing method, I think is to be recommended for its variety, order, and utility; for the number of ſpecies and varieties, the manyfold combinations of principles, the ſeries of agreement and diſcrepancy, the harmony and oppoſition of internal and external characters, and many other important reaſons: And I hope it will be found to anſwer better, not only on account of its extenſive view, but alſo becauſe the riches and phenomena of the organic kingdoms are in it more properly diſplayed than in any other.

LATTER PART.

Of giving Names to Fossils.

§ CLXXXII. *The Utility of Names properly adapted in Mineralogy.*

If foſſils are rightly and juſtly arranged and denominated, agreeably to the nature of things, we find a harmony in them not leſs grateful than advantageous.

§ CLXXXIII. *Hiſtory of Names in Natural Philoſophy.*

The ſciences cultivated during the early ages, as chemiſtry, and all thoſe depending on it, had unhappily adopted certain ſchemes and modes of ſpeech, of which the greater part were not only puerile and abſurd, but often altogether falſe, and leading to erroneous concluſions. Many circumſtances contributed to the ſupport of this mummery. At firſt, in thoſe days of darkeſt ignorance, names were required to deſcribe new diſcoveries and phenomena, adapted to the unſkilfulneſs of their authors. By degrees the knowledge of natural bodies, as well as of artificial, being extended, the profeſſors of chemiſtry began to entertain ſuch lofty ideas of their

their ſkill, that they did not heſitate to promiſe themſelves the miracles of an univerſal medicine, and the making of gold. Hence aroſe the ridiculous ſtruggle betwixt the immoderate boaſtings, through which they were endeavouring to diſpoſe advantageouſly of their diſcoveries, and the moſt ſolicitous attention with which they wiſhed to keep them concealed. What the names they employed could be, when depending on the moſt abſurd theories, the ſlighteſt appearances, and moſt abſtruſe metaphors, we are at no loſs to apprehend. To theſe were added afterwards others produced by any fortuitous ſlight occurrence; and we perceive in ſome meaſure a language peculiar to the early operations of chemiſtry.

§ CLXXXIV. *Of reforming the Names of Foſſils.*

THE inſtitution of academies of ſcience gave riſe to the gradual introduction of a ſounder theory, founded upon more accurate experiment, which tended conſiderably to limit the barbarous and myſtical affectation of ſecrets; and occaſioned a more rational denomination of new diſcoveries, though as yet not built upon general principles. Beſides, the rude and indigeſted maſs of antiquity was ſtill preſerved for the greateſt part, and chiefly for the following reaſons. From the reformation of names and

phraſes

phrafes, it was apprehended that the whole fcience would be involved in great confufion, and that their number would create confiderable difficulties; and it was likewife alledged, that the moft ancient writings would, by this means, be rendered unintelligible, and all the fcience they contained condemned to oblivion. But fuch evils, at leaft not all of them, feem not to be a neceffary confequence. The oldeft writings, efpecially thofe on alchemy, are almoft all of them incomprehenfible: Whatever therefore will anfwer to probable conjecture, or will admit of a certain and determinate explication, might be more eafily underftood, if tranfpofed according to the nature of the fubject,—and the fenfe of this or that denomination being once extracted, it might be preferved in a book appropriated to the purpofe. As to what relates to the dread of the introduction of new names, it would undoubtedly be well grounded were not all writers to fuffer them to be regulated in the fame manner. In this cafe the new names adapted to the nature of things would readily infinuate themfelves, and be univerfally received.

Surely, it is highly improper that the nobleft fcience, which conftitutes, as it were, the very effence of natural philofophy, fhould deliver truths of the greateft importance in the moft abfurd of all languages. Every country in Eu-

rope

rope has thought the cultivation and perfection of its peculiar language an object highly worthy of attention; and ſhall the ſciences alone be diſtinguiſhed for rudeneſs and barbarity of ſtile, while they are daily requiring new names to expreſs new diſcoveries conſtructed upon rational principles; and which, if they are not all wiſely and methodically ordered, would ſometimes by their number occaſion the deſtruction of thoſe very diſcoveries they were intended to preſerve. In botany, ſuch a reformation has long taken place; and what is there that ſhould prevent ſo ſalutary a plan from being extended to the other ſciences?

But notwithſtanding the obvious neceſſity of reform, as well as of ſome fixed ſtandard, according to which all the new names ſhould be regulated, there are ſtill many difficulties that oppoſe their free introduction into the republic of letters. From the very nature of the propoſal it is expoſed to the influence of particular opinions; and every one, partial to his own, and chuſing different data, it will be impoſſible in the beginning at leaſt, to unite, in one common conſent, ſentiments ſo adverſe and contradictory. We are not however to deſpair; for, if the voices of all do not combine, perhaps the greater number will, to ſtifle the clamour of perſiſting cavillers. Every real friend to chemiſtry, therefore, ſhould wiſh for a happy iſſue to the

the plan of Monſ. Morveau, to be attempted in the new Encyclopædia. In the mean time, it may be permitted me to offer a few curſory remarks, which I think are relating particularly to mineralogy, and ſubmit them to the judgement of the public. The end of the whole ſyſtem is doubtleſs to expreſs with truth, perſpicuity, preciſion, and brevity, every thing of which an idea can be conveyed by words. New names, therefore, become neceſſary to new things; and to render theſe the moſt convenient is the chief aim and object of this undertaking.

§ CLXXXV. *Names that are evidently abſurd, and ought to be expunged.*

I AM of opinion, that all abſurd names, and ſuch as betray oſtentatious vanity, are to be entirely ſet aſide. Of theſe we have examples in the ſal mirabile Glauberi, ſal ſecretum Glauberi, ſal polychreſtum Glaſeri, arcanum corralinum, arcanum duplicatum, ſal de duobus, and ſeveral others.

§ CLXXXVI. *And falſe Names likewiſe.*

IN like manner, names that are falſe ought to be removed. Of this deſcription are the following, ſuggeſting ideas that are erroneous:

Oleum

Oleum vitrioli	For	Concentrated vitriolic acid.
Spiritus vitrioli		Diluted vitriolic acid. Spirit indicates properly an inflammable liquor miſcible with water.
Oleum tartari		Vegetable alkali diſſolved by deliqueſcence.
Sal tartari		Alkali of tartar.
Terra foliata tartari		Acetous acid ſaturated with the vegetable alkali.
Butyrum antimonii		Muriatic acid ſaturated with antimony.
Semi-metallum		Fragile metal.

§ CLXXXVII. *What then are the names to be adopted?*

Those names which indicate ſome eſſential property or compoſition are of all others the beſt.

§ CLXXXVIII. *What are the Names to be tolerated?*

Those which admit a more extenſive ſignification may be ſuffered, if others evidently better cannot be ſubſtituted. And theſe indeed are

are true names; for although, from the power of the words, they will apply to many fubftances, nothing prevents them from being κατ' ἐξοχὴν applied to the one or the other. In this way acidum aerium was ufed in the year 1772, for aer fixum; which is not abfolutely advancing a falfehood, as it poffeffes a proper acid, and in an aerial form; but it is objectionable, becaufe thefe qualities are difcoverable in other fubftances. Let therefore fome other denomination be fubftituted more exact and determinate, as, gas, or acidum mephiticum, or elfe there will be no end to the various changes. But if it be impoffible to find one more accurate, it will be attended but with little inconvenience, to apply it to that fubftance which we know for certain to be the acidum aerium of the antients.

§ CLXXXIX. *Names fignifying lefs than the Thing defined ought to be abolifhed.*

WHATEVER names exprefs too limited a fenfe fhould certainly be expunged, if a choice can be made among thofe that are fynonimous, efpecially thofe recommended by long time; as they convey falfe and inadequate ideas. Thus *mineral* indicates properly an ore; but in the vulgar fenfe it fignifies every inorganic body found in the bofom of the earth; although this idea is more accurately expreffed by the word *foffil.* In

In like manner, *oryctologia* implies a more exact denomination of the ſcience of foſſils than *mineralogia*. *Petrefactum* or *petrificatum*, falls nearly under the ſame criticiſm. But as here we have no better ſynonimous word to ſubſtitute, we muſt be contented with ſuch as cuſtom has eſtabliſhed. Words, like coin, owe their currency to preſcription.

§ CXC. *How we are to proceed without proper emphatic Names.*

As it is not eaſy to apply names exactly expreſſive of the thing defined, we are to adopt ſuch as having no determinate meaning may have their ſenſe aſcertained by definition.

§ CXCI. *Names derived from the Authors of new Diſcoveries.*

Among botaniſts and anatomiſts the memory of diſcoverers is perpetuated in particular denominations; it may, therefore, be a queſtion, whether among chemiſts, where the reward of new facts is attended with greater inconvenience, it would be proper in the ſame manner to teſtify a grateful ſenſe of obligation? To me, indeed, it ſeems to be practicable, and without any impropriety; but as it often happens, that the ſame diſcovery has been made by different individuals

individuals at the ſame time, it might, upon the whole, be better to truſt the fame of all, to the impartial records of the hiſtoric page. This exception, however, need not extend to names of little importance in chemiſtry.

§ CXCII. *By what Means are the Claſſes of Foſſils to be defined?*

Each claſs of foſſils ſhould, if poſſible, be defined by one ſingle word. Such as,—Salts, Earths, Metals, and Phlogiſtica. True, indeed, the laſt is an adjective; but on this account ſolely it is not to be rejected, as we ſhall preſently ſhew: Nor, indeed, have we reaſon to apprehend ambiguity from the uſe of it, as the context will always determine whenever it refers to foſſils. If any one ſhould think the word *bitumina* preferable, I can have no objections; although it may appear extraordinary to many to conſider diamonds under this definition.

For want of a more proper appellation, I diſtinguiſh foſſils mixed mechanically under the name of Petræ. My reaſons for this diſtinction I have given already in § 166. Thoſe, however, that form the ſubject of the other appendix, as organic foſſils, can ſcarce be defined under one title, and we muſt therefore either employ two, or call them in general Petrefactions, § 189.

§ CXCIII. *Denomination of Genera.*

Each genus ſhould be expreſſed in one word, for the ſake of brevity and convenience.

Among the ſalts there are, ſtrictly ſpeaking, but two genera; the acid and the alkali. And we ſhall ſee by and bye the great advantage this produces, that the combinations of every acid conſtitute proper genera. An acid may be conſidered ſubſtantively without the neceſſity of having the word Salt prefixed to it, as every acid is a ſalt.

In the ſecond claſs we have found five genera. One of which, but lately diſcovered, has, on account of its ſpecific gravity, obtained the name of Terra Ponderoſa. But in order to render it more conciſe and convenient, the firſt word might be eaſily omitted, though always underſtood, and the laſt employed alone as a ſubſtantive; or we would, with Monſ. de Morveau, adopt Barites from βαρυς with great advantage. The remaining earths are all expreſſed with ſubſtantive names; but for the ſake of perſpicuity, I would yet recommend ſome alteration in them: As for example, Calx, Magneſia, Argilla, and Silex, are deſcriptive of foſſils, ſuch as they occur on the ſurface of the earth, blended more or leſs with heterogeneous matter; and therefore the words Calcareum, Magneſium, Argillaceum and Siliceum, might be properly ufed to fignify thefe fubftances pure and unmixed.

The names of the fixteen metals are all fubftantives, and except one, are of the neuter gender. The υδραργυρος of the Greeks was tranflated into Latin by Pliny *hydrargyrum*, and why may not the *platina* of the Spaniards be adopted into the fame language, with a neutral termination? According to this propofal, we fhall have the following generic names, *aurum*, *platinum*, *argentum*, *hydrargyrum*, *plumbum*, *cuprum*, *ferrum*, *ftanneum*, *vifmutum*, *niccolum*, *arfenicum*, *cobaltum*, *zincum*, *antimonium*, *magnefium*, and *fiderum*, if this laft differs at all from iron. Each of them are to indicate the metal in its complete ftate. Dephlogifticated metals, commonly called calcined, or metallic calces, refemble indeed, in fome meafure, burned chalk, from their attraction of the aerial acid, from their becoming cauftic with the volatile alkali, their fufceptibility of pulverifation, and other properties.

Of phlogiftic bodies, the generic names are fo well conftructed that we have no remarks to offer upon them: *Adamas*, *fulphur*, *petroleum*, and *fuccinum*, are received with propriety.

The four genera of *petræ* I define by the following names. The firft, abounding in faline matter, I call *falfamentum*; the fecond, loaded with earthy matter, appears to me to be properly ly *faxum;* the third, containing metals in their matrices, I denominate *minera;* and the fourth, from the mixture of petroleum, or other phlogiftic bodies more plentifully found in it, takes the name of *bitumen;* or, if this name be given to a clafs, *picarium* may be fubftituted.

Of the organic foffils, that which is penetrated with any falt may be called *falitura;* with earthy particles, *lapidofum;* with metallic, *metalliferum;* and with phlogiftic, *pollinctum.* Should names more proper than thefe occur to any perfon I fhall have no objection to withdraw them.

§ CXCIV. *Of applying Names to the fimpler Foffils, and efpecially to the Salts.*

All bodies, whofe proximate principles have never yet been afcertained by art, require fimpler names; the primitives efpecially fhould be expreffed by one word; and thofe of a known compofition fhould be defined by derivatives having a reference to their principles; if not of one or two words, confifting at the moft of three. To denote each body by a peculiar fimple name would be productive of great inconvenience, and be an ufelefs burden to the memory. It might however be of confiderable advantage to the fyftem of nomenclature, in the clafs of falts, if every one of the fimple falts could be indicated by a fingle word. Would it not therefore be admiſſible, by ſuppoſing the acid to conſtruct the names as ſubſtantives? As for example, *vitriolicum*, *nitroſum*, *muriaticum*, *regalinum*, *fluoratum*, *arſenicale*, *boracinum*, *ſaccharinum*, *oxyalinum*, (inherent in the acid of the wood ſorrel) *tartarum*, *benzoinum*, *citrinum*, *ſuccineum*, *galacticum*, *formicale*, *ſebaceum*, *phoſphoreum*, and *aereum*. Phlogiſticated vitriolic acid might be named *ſulphureum*, and phlogiſticated nitrous acid *nitreum*. In like manner, in the genus of alkalies, the vegetable will be *potaſſinum*; the mineral *natrum*, a name by which it has ſometime been already known; and the volatile will be *ammoniacum*. The great advantage of this ſimplicity, as we ſhall ſee preſently, will be obvious in giving names to compounded ſubſtances; which, if they conſiſt of more than two or three words, will give riſe to a diffuſe and circuitous ſtile, both in ſpeaking and writing. All names certainly proceeding from the definition of ſeveral words are by far the moſt improper.

§ CXCV. *Names of Species demonſtrated in the Caſe of Salts.*

Specific differences, that can ſerve as diſtinct names, are uſed with conſiderable advantage. Admitting what has been already propoſed in the preceding paragraph, this very eaſily

ſily obtains in the claſs of ſalts, as to all the ſpecies perfectly ſaturated. That earthy and metallic ſalts ought to be arranged under the head of their menſtrua, we have ſeen in § 70.; but, with reſpect to the perfect neutral ſalts, it is not ſo clear, § 68. It ſeems indeed more convenient to refer them to the genera of their ſeveral baſes; and in this way alſo I have proceeded. But we ſhall have more agreement with the analogical ſalts, moſt of which are properly aſſigned to the acid, if the neutral ſalts are ſubjected to the ſame arrangement. According to this method we ſhall have names ſufficiently apt by combining the acid with the adjective of the baſis. As for example,

Vitriolicum potaſſinatum,	for	Tartarus vitriolatum.
Nitroſum natratum,	—	Nitrum cubicum.
Muriaticum ammoniacum,	—	Sal ammoniacus.
Acetum potaſſinatum,	—	Terra foliata tartari.
Vitriolicum calcareatum,	—	Gypſum.
——— magneſiatum,	—	Sal catharticus amarus.
——— argillatum,	—	Alumen.
Nitroſum barytatum,	—	Barytes nitratus.
——— argillatum,	—	Calcareum nitratum.
Muriaticum barytatum, &c.	—	Barytes muriaticus.

Metallic double ſalts alſo may be treated in *the ſame manner; as,*

Vitriolicum auratum, &c.

Nitroſum argentatum, &c.

Muriaticum plumbatum, &c.

Arſenicale cobaltatum, &c.

and many others.

No one can object to thoſe adjectives derived from the names of the metals, as Pliny uſes the word *ferratum;* and it is according to this plan that they are here applied.

Analogical ſalts, containing an alkali, may be eaſily arranged in the ſame manner.

Thus,

Potaſſinum —	Argillatum, Silicatum, &c.
Ammoniacum —	Argentatum. Cupratum, Zincatum, &c.

Double ſalts, in which either principle prevails can alſo be denominated in ſuch a manner as to expreſs an imperfect ſaturation, § 127. For example,—Tartar, with an exceſs of acid, can be defined by a combination of its generic name with the genitive of its baſe, as *tartareum potaſſini;* but, when perfectly ſaturated, may be called *tartareum potaſſinatum.* In like manner we ſhall have *oxalinum potaſſini*, but, when exactly ſaturated, it will be *oxalinum potaſſinatum; vitriolicum natri*, and *vitriolicum natratum; natrum boracini*, and *boracinum natratum;* and ſo on of others.

This

This method, however, is not applicable in other classes, not even to the double species. Saline earths, with such an excess of earthy matter as nearly to obliterate their saline character, ought thus to be expressed.

Barytes vitriolatus, for Spatum ponderosum.
Calcareum fluoratum, — Fluor mineralis.
Calcareum aeratum, — Calcareum vulgare.

The character of the remaining fossils differs more considerably from the salts, and requires auxiliary illustration.

§ CXCVI. *Trivial Names of Salts.*

FOSSILS, containing three or more principles appear capable of the clearest definition by means of the trivial names. The celebrated Linnæus first made use of such, in his Species Plantarum of 1753, by which every species could be conveniently expressed, without a repetition of the specific differences. The language of botany became thus remarkably easy and intelligible; and zooligists and mineralogists have to thank the same author for the happy introduction of them into their sciences.—But, although these names may be assumed from the inventor, some virtue, ancient appellation, property, or accidental circumstance respecting the species; yet should they be generally limited to one word, and very seldom indeed extend to two. They may be considered as surnames distinguishing

tinguiſhing the individuals contained in the ſame genus.

The triple ſalts are, by means of theſe trivial names, denominated with great facility. Of which we have the following examples:

Vitriolicum fallax —	Epſom ſalt united to the volatile alkali; eaſily producing an apparent inequality of attract.
——— epilepticum, —	Epileptic ſalt of Weiſman.
Muriaticum anti-epilepticum, —	Anti-epilepticum puerorum of Boerhaave.
——— alembrot, —	Sal alembrot.
——— dulce, —	Mercurius dulcis.
Galacticum Bartoleti, —	Sugar of milk, firſt deſcribed by Bartoletus.
Tartarum Seignetti, —	Sal polychreſtum Seignetti.
——— Laſonii, —	Tartar joined to the ſedative ſalt.
——— ſolubile, —	Tartar ſaturated with volatile alkali,—commonly called tartarus ſolubilis.
——— Mynſichti*, —	Tartarus emeticus.
——— martiale —	Globuli martiales.
Phoſphorum microſmicum, —	Sal microcoſmicus.

Compound

* Eſſays, vol. i. p. 340.

Compound ſalts, produced by regalinum (aqua regis) never become triple, at leaſt not all of them. The nitrous acid ſeems to be neceſſary for the purpoſe of dephlogiſtication only; and the muriatic generally exhibits the ſame combinations as the regaline, by which, if the muriatic is not in ſufficient quantity, a double ſalt is obtained, charged with the nitrous acid,

The ſame obſervation is equally applicable to the quadruple ſalts.

Tartarum Fevri,	—	Tartar united to borax,
Nitroſum Kunckelii,	—	Rubini Kunckelii.
——— ſympathicum,	—	Sal ammoniac with nitrated copper.

This ſalt exhibits cryſtals, that aſſume a yellow colour when heated, but become blue in a moderate temperature. If a ſolution of them ſufficiently diluted is uſed for writing, the letters will be found to diſappear entirely, by the application of heat; and, if expoſed to the vapour of cauſtic volatile alkali, to change to a beautiful blue colour.

Thus, then, I have pointed out a method, as I apprehend, both eaſy and ſimple, by which all the known ſalts, about fifty in number, may be each denominated in one or at moſt in two words.—According to the firſt diviſion, we have the genus only.—Of the ſecond, the double ſalts completely ſaturated are indicated by the adjective of their baſe ending in *atus*. In the third, the imperfect ſalts are known by the genitive

genitive of their bafe.—The fourth contains the triple falts and thofe of feveral principles, which are expreffed by the trivial names; and as in them we neither find the adjective of the bafe *atus*, nor the genitive, it is not poffible that any ambiguity can arife.—The whole compofition of the triple falts could not be fignified in two words, unlefs the double falts were defined in one only; and if the fame brevity were expected of the quadruple, the triple muft have neceffarily been denominated by one. But it may be a queftion, whether it is more difficult to invent fuch a number of new and fimple names, or, if invented, whether they could poffibly be retained by the memory.

§ CXCVII. *Of the fpecific Names of Earths, Metals, and Phlogiftic Subftances.*

If we confider every thing that has been faid in the foregoing fections on the fubject of the falts hitherto known and inveftigated, we fhall find, that we have in fome meafure laid the foundation of a general fyftem of mineralogy. With regard to the earths, and the following claffes, the denomination of the double and more compounded fpecies may be conveniently expreffed by the trivial names in two words. Thus, for example, under the genus magnefia, a fpecies occur, in the formula, *fmca*, compofed of of ſiliceous, calcareous, and argillaceous earth, with ſome admixture of iron *, which in ſyſtematic authors is denominated aſbeſtos, and treated as a peculiar genus. To this, indeed, the trivial name of aſbeſtos may be properly applied, as it ſeems to be ſo well underſtood, that the youngeſt mineralogiſt is in no danger of being miſled by it. The ſame may be ſaid of ſchoerl, granate, zeolite, and many others, that are diſtinguiſhed by names known to every body, and highly proper. In the compoſition of earths, iron is by no means a neceſſary ingredient, although it is generally found in them; and we therefore conſider it as an alloy, or heterogeneous ſubſtance.

§ CXCVIII. *Concluſion.*

I CANNOT finiſh my remarks on the denomination of foſſils more to my own ſatisfaction, than by pointing out what is yet wanting to the improvement of ſcience. I would wiſh that in the eſtabliſhing of new names, a preference ſhould be given to the Latin language. This is, or at leaſt was formerly the mother tongue of the learned; and being now not the living language of any nation, it is no longer liable to innovation or change. If therefore, the reform we propoſe is made firſt in Latin; it may be eaſily carried

* Diſſertation on the aſbeſtos.

carried into execution afterwards upon the ſame model in the modern languages, as far as their peculiar genius and conſtruction will admit.—In this manner, the language of chemiſtry will become every where uniform and conſiſtent, and conſiderable advantage will be derived not from the reading only of foreign publications, but the facility alſo with which they can be tranſlated. I have ſeen an excellent eſſay of Monſ. de Morveau on the reform of the French names*, and I am not a little flattered by the agreement I find between many of the alterations he propoſes and thoſe that I have offered on that ſubject. From this, perhaps, we may venture to hope, that by making it an object of further attention on both ſides, the differences yet ſubſiſting may be removed, to the great benefit of ſcience; and to the permanent eſtabliſhing and advancement of which all our views ſhould be directed.

* Diary of Monſ. Rozier.

OF

OF THE

COMBINATION

OF

MERCURY

WITH THE

MARINE ACID*.

Rejectis vanis speculationibus, et quicquid inane et sterile est, conservetur quicquid solidum est ac fructuosum.

BACO.

§ 1. *Introduction.*

A TREATISE on the preparation of corrosive mercurial sublimate in the humid way, and sent to me by the celebrated Monf. Monnet, and which I delivered to the Swedish academy of sciences, first suggested to me the idea of giving the history of the mercurial salts, arising from the mutual

* This dissertation was read in the Swedish Academy of Sciences, and published in the Acts of the said academy, 1769, in the Swedish language.

tual combination of mercury and the marine acid.

The relation betwixt menſtrua and the bodies they diſſolve, is eſtabliſhed by a conſtant and univerſal law of nature, in ſuch a manner, that they reciprocally ſaturate each other; that is, are mutually diminiſhed in their efficacy and acrid properties. From this combination, a new form of each mixt body ariſes; whoſe qualities, although they are generally to be attributed to the character of the conſtituent parts, and the confuſion of the properties of each, yet they ſometimes differ entirely from the character of the menſtruum, and of the body diſſolved. An exceſs of either principle gives birth to another genus of mixture, under which the true nature of the combined ſubſtance is often concealed. By taking away this exceſs of the one, or ſupplying the deficiency of the other principle, the obſcurity is removed and the mixt body aſſumes its proper character. This is commonly the caſe in the union of acids with lixivial ſalts, earths, or metals. But ſuch is the peculiar nature and condition of mercury combined with the marine acid, that it ſometimes unites with a leſs, ſometimes a greater proportion of acid; and can with great difficulty be forced from the mixture into which it has once entered, to make part of another. There are three forms under which theſe

theſe mixtures or combinations preſent themſelves, and which deſerve to be ſeparately conſidered.

§ II. *Corroſive Mercurial Sublimate.*

When mercury is completely ſaturated with the marine acid, the ſalt reſulting from ſuch an union is generally ſignified by the name of *corroſive mercurial ſublimate.* This name it derived from its corroding power; and it was called likewiſe the *malleus metallorum*, from its ſingular efficacy in the ſolution of metals.

Of the firſt inventor of this metallic ſalt we are entirely ignorant. The antients, however, ſeem to have had ſome knowledge of it. Avicenna, (who died, as it is ſaid, an. 1036, p. L. N.) makes mention of it; and, even a century before his time, it was known to Abubeker-al-Rhaſi, commonly called Rhaſes *. That the Chineſe were acquainted with the preparation of corroſive ſublimate, appears evident from a Chineſe manuſcript on the medical art, a tranſlation of which by C. A. Vandermonde into French is preſerved in the library of B. Juſſieu †. But whether the Chineſe and the Europeans derived their knowledge on this ſubject from the ſame ſource, or whether it was invented by ſeveral

* Memoire pour ſervir a l'hiſtoire de l'uſage interne du mercure ſublimé corroſif, par M. Le Begue de Preſle.

† Chemie medic. de Malouin, 1756.

veral in different parts of the world, is a queſtion I dare not venture to determine. It is well known, that the profeſſors of alchemiſtry ſought for the baſis and ſupport of their art in mercury, which, with that view, they made the ſubject of every poſſible experiment. While they were thus employed, therefore, it is not unlikely that chance made them acquainted with corroſive mercurial ſublimate; the preparation of which they ſeem, from the beginning, to have long reckoned among their ſecrets; or, at leaſt, to have diſcovered it in vague and enigmatical language. According to Junker, this metallic ſalt was called by the ancients Mercurium, and quickſilver was ſignified under the name of Argentum vivum.

§ III. *Whether Corroſive Mercurial Sublimate can be prepared by the ſole Mixture of the Marine Acid and Mercury?*

THE marine acid poured upon Mercury does not diſſolve it without the aſſiſtance of heat. Until the preſent day, therefore, corroſive mercurial ſublimate has always been prepared by the means of fire, in a tedious proceſs of ſeparations and compoſitions. It is not abſolutely certain, that J. C. Barchuſen poſſeſſed the art of combining mercury with the muriatic acid, without employing ſuch complicated proceſſes. The

The following words of the celebrated author ſeem to have ſome reference to this particular art: "Tandem fieri poteſt idem (mercurius) "corroſivus, ſi ſpiritu ſalis diſſolutus iterumque "coagulatus, cucurbitæ inditus ſublimatur." Margraaf has demonſtrated, that many metallic precipitates are ſoluble in thoſe acids, which have no effect upon perfect metals *. And long ago it was aſſerted by Stahl, that Mercury precipitated from aqua fortis, by a lixivial ſalt, could be diſſolved in the muriatic acid. On the credit of Junker, Stahl is ſaid likewiſe to have declared, that this laſt ſolution was not in the leaſt diſturbed by the addition of an alkaline ſalt; which if added to a ſolution of corroſive ſublimate would have produced conſiderable effect. I am at a loſs to conceive by what accident a circumſtance ſo unuſual ſhould occur in the experiments of Stahl. As often as I have repeated them myſelf, I have always obſerved a very different reſult; even when the acid was in exceſs; although a paler powder was then precipitated. From theſe accounts, however, it is manifeſt, that it has not been hitherto doubted whether corroſive mercurial ſublimate could be prepared without fire; the faith of experience, however, was wanting to eſtabliſh the truth of what as yet reſted only on conjecture. Great praiſe, therefore, is due to the diligence of Mo-

 net,

* Mem. de l'Acad. de Berlin, 1476.

net, which has thrown light upon a ſubject by no means certain, at leaſt not attempted by any one.

§ IV. *The various Proceſſes by which Corroſive Mercurial Sublimate is prepared. I. The Mixture of Bodies containing Mercury and Muriatic Acid.*

CHEMISTS have preſerved various meaſures in the preparation of corroſive ſublimate. Theſe can, however, be referred to four kinds only, and of which we ſhall now proceed to give ſome explanation.

I. The admixture of bodies containing mercury and muriatic acid. Lemery, Senior, was the firſt who followed this method, and of which he has given an account to the Pariſian academy *. He mixed together by friction four ounces of mercury, and as many of dried ſalt, and after he had expoſed the maſs to the fire for four hours, he obtained four ounces of a ſalt in all reſpects ſimilar to corroſive ſublimate; at leaſt all the difference that was found between them was, that this preparation was of a darker colour, a texture leſs cryſtalline, and of a milder nature.

I cannot help obſerving in this place, 1ſt, That the proceſs of extinguiſhing mercury completely by trituration with common ſalt, is exceedingly

* Mem. de l'Acad. R. des Sc. de Paris. a. 1709.

ceedingly difficult and tedious. 2d, That, by the method of Lemery, leſs corroſive ſublimate is procured than by the ordinary method, 3dly, It is neceſſary to employ the common white ſalt which always contains ſome muriatic magneſia and lime. If the experiment were made with common ſalt freed from theſe earthy ſalts, not a particle of corroſive ſublimate would be produced; as appears evidently from the attention Baume has paid to this queſtion *, as well as from the experiments made by Lemery. The latter, when he had diſſolved in water, the matter remaining after his operation, had filtrated it, and formed it into cryſtals, obtained the pureſt common ſalt; but which, when triturated again with mercury, and expoſed to the fire afforded no corroſive ſublimate. In this caſe the acid of the common ſalt was not expelled by fire as, it would have been from the earthy ſalts. Nor, indeed, does the experiment ſucceed better, if, inſtead of ſalt, its acid only is taken; as it does not act upon mercury, unleſs that metal has been previouſly divided minutely by precipitation or reſolved into vapours. Beſides, before the ſubliming veſſel is penetrated with a degree of heat ſufficient to raiſe the mercury to a ſtate of vapour, the acid of the ſalt has already aſſumed that form, as it poſſeſſes a greater proportion of volatility. It is therefore required, that the acid

 ſhould

* Dict. de Chemie de Macquer.

ſhould be able to reſiſt the action of the fire until they can be both converted at the ſame time into vapours. We are told that mercury and ſal ammoniac being mixed, and expoſed to the fire, will yield a ſmall quantity of corroſive ſublimate. The property of ſeparating acids from the volatile alkali, is common to mercury with other metals. On this principle are founded the experiments and modes of preparation ſuggeſted by the Count de la Garaye*.

Stahl has another experiment, in which he produces mercurial ſublimate by ſubliming together luna cornea and cinnabar. For, as by the aid of fire, the muriatic acid ſeparates from the ſilver to combine with the mercury of the cinnabar, the ſulphur likewiſe, being expelled from the mercury, diſſolves the ſilver, and forms with it ſulphurated ſilver, or artificial *minera vitrea*. This experiment deſerves to be repeated frequently and with attention; eſpecially as it is affirmed by Pott, that when mercurial corroſive ſublimate and ſilver filings are put into a retort, and expoſed to the fire, mercury will be found metallized in the receiver, and luna cornea remaining at the bottom of the retort. If this reſult is uniform and conſtant, it is a remarkable inſtance of the great affinity between ſilver and the muriatic acid. It will admit of explanation upon the principles of double elective attraction, by which the parts are

* Macquer in Mem. de l'Acad. des Sc. a. 1752.

are interchanged, which conſtitute cinnabar and luna cornea.

§ v. II. *What is the Importance of the nitrous Acid in the Preparations of mercurial Sublimate?*

As it is exceedingly difficult ſo to ſubdue mercury by trituration with common ſalt, as to deſtroy its fluidity; and as even when this labour is moſt ſucceſsful, the metal is ſtill raiſed too quickly by the heat; the nitrous acid has been employed by ſeveral chemiſts to reſtrain the volatility of the mercury, and to render it more diviſible, and eaſier to be mixed. But this is not the ſole reaſon for adding the nitrous acid. Some people pour it upon the mercury while it is triturating with the ſalt, in order to corrode the metal, and contribute to its extinction. Others again, following the ſteps of J. H. Cardiluccio, uſe the nitrous ſolution of mercury; into three pounds of which he orders a few handfuls of ſalts to be thrown, the fluid mixture to be gradually exſiccated, and the reſiduum to be diſtilled in a retort *. In this proceſs, a white precipitate of mercury, (of which we ſhall preſently give a fuller account,) is produced, which is raiſed by the fire in the form of a milder ſublimate. Some alſo pour the muriatic acid upon the

* R. Minderers Kriegſartzney.

the nitrated mercury ; but this method is but little profitable. On the other hand, there are ſeveral, who taking Barchuſen for their leader, inſpiſſate the ſolution by heat, to perfect dryneſs, and afterwards rub the reſiduum with an equal portion of ſalt deprived of its water of cryſtalliſation. The authors of the Edinburgh Pharmacopœia have adopted this method. G. Roth directs nitrated mercury to be triturated with a fourth part of common ſalt, the reſiduum of the ſolution to be poured into a retort, the fluid part of the mixture to be ſeparated by diſtillation, and what remains dry in the veſſel to be ſublimed by a ſtrong fire. If a milder preparation of corroſive mercury is deſired, he orders as much muriatic acid to be added, as will equal the quantity of the nitrous ſeparated by the diſtillation *. The ſame end may be obtained, and not leſs certain, at a ſmaller expence, if a greater proportion of common ſalt is added at the beginning.

§ VI. III. *How far is the Vitriolic Acid ſerviceable in this Preparation.*

THIS acid may be employed in ſuch a manner, that any ſubſtance in which it is contained, as for example, the vitriol of Mars, can be mixed with mercury and common ſalt. In order

* Anleitung zur Chemie, 1717.

der to forward the extinction of the mercury, which would be otherwise tedious and difficult, it is usual to add a small quantity of dried clay. Daily practice has sanctioned this process; and we find it recommended by N. Le Fevre, who directs four repeated sublimations *. Also, in the Brandenburg Dispensatory, by Blancard †; by J. F. Cartheuser ‡; H. F. Teichmeyer §; R. A. Vogel ||; Wallerius ¶, and others. We are told by Tachenius, that the Venetians prepare great quantities of the mercurial sublimate according to this method. They mix together 280 pounds of crude mercury, with 20 pounds of corrosive sublimate, and then, with great care, and variety of apparatus, they add 400 pounds of common salt, 200 pounds of vitriol, and 50 pounds of colcothar. Fifteen vessels are employed in this operation, and the fire being continued for fifteen days, they obtain at last 360 pounds of corrosive mercury**. Junker met with a Portuguese Jew at Amsterdam, using the same process; the theory of which may be very easily understood. The action of heat, and the mutual affinity between the vitriolic acid and the

* Cours de Chemie, 1660.
† Chemia.
‡ Pharmacologia, 1745.
§ Inst. Chem, 1729.
|| Inst. Chem. 1755.
¶ Chem. Phys. vol iii.
** Tachenius in Hippoc. Chem.

the mineral alkali, ſeparate the muriatic acid from the common ſalt, with which the mercury, raiſed into vapours, readily combines. The addition of the corroſive ſublimate aſſiſts in the extinction of the crude mercury. Inſtead of vitriol, the Chineſe ſometimes make uſe of alum*.

The pure vitriolic acid may be employed in different ways in a fluid form. If turpith mineral is preferred, (which is a mercurial calx according to Baume†, deprived of all acid by ablution in water), it is not ſufficient to have added the common ſalt, but it becomes neceſſary to add beſides the vitriolic acid, in order to expel the acid of the ſalt. The method invented by Kunkel ‡, has conſiderable merit. Equal weights of crude mercury and ſtrong vitriolic acid are diſtilled together; an exceeding volatile and fetid ſpirit paſſes over into the receiver, leaving behind in the retort a white ſaline matter, commonly named Turpethum album, but which would be more properly called, vitriolated mercury. This ſalt combined with the common ſalt exſiccated, and put into a ſubliming veſſel, produces mercurial ſublimate. If the operation is rightly conducted, it is not requiſite, as Kunkel would perſuade us, to diſſolve and ſublime repeatedly this ſalt in the muriatic

* Malouin, Chemie medic.
† Dictionnaire de Chemie.
‡ Laborat. Chem. 1716.

muriatic acid. Boulduc junior recommended this procefs to the Royal Academy of Sciences at Paris in the year 1730; not knowing, as it feems, that it had been already employed and made public by Kunkel.

§ IV. IV. *What are the Effects of the Vitriolic and Nitrous Acids ufed together to this Purpofe?*

The united powers of the vitriolic and nitrous acids may be varioufly directed to the preparation of the corrofive mercurial fublimate. And, in the firft place, the procefs may be inftituted with any acid united to its bafe; and mercury, vitriol, common falt, and nitre, may be triturated together, and the fublimation proceed afterwards very fuccefsfully. The object of this method is the expulfion of the nitrous acid from its bafe by the vitriolic; fo that being thus free, it may immediately corrode the mercury; and that the muriatic acid, unequal in force to the other two, may unite with the mercury, after the corrofion with the nitrous acid is complete. Tachenius *, Junker †, and others, recommend this preparation of corrofive mercury. For the fake of promoting the extinction of the mercury, Zwelfer ‡, Jac. le Mort §, and the

* Hippocr Chem.
† Confp. Chem.
‡ Pharm. Reg 1675.
§ Chem. Med. Phyf. 1688.

the authors of the London Pharmacopœia direct an addition to be made of one twelfth of corrosive ſublimate.

The pure and uncombined nitrous acid, with which Junkenius orders the mixture of mercury, vitriol, and common ſalt, to be moiſtened, is applicable to the ſame purpoſe. But he propoſed likewiſe another proceſs, viz. equal weights of common ſalt and vitriol are to be calcined together, ſome of the mixture to be ſpread on the bottom of a veſſel, and then mercury filtered through leather; and thus alternately to be placed layers of mercury and of the mixed ſalts. As much nitrous acid then, as is ſufficient to moiſten the maſs, is poured upon it; the liquid is expelled by diſtillation, and the dry matter remaining is ſublimed *.

When vitriolated tartar is added to a nitrous ſolution of mercury, a powder is precipitated, which, when expoſed to the fire with common ſalt, very eaſily produces corroſive ſublimate. Stahl ſeems to have mentioned this mode of proceeding, but in obſcure language †. Pott has explained it with more preciſion ‡; and has proved with the perſeverence of Baume, that vitriolic acid can be ſeparated, by means of the nitrous, from the ſalts to which it adheres. Accordingly,

* Lex Pharm. Chem. 1699.
† Von Salzen, 1738.
‡ Miſcell. Berolin. t. v.

cordingly, although the affinity of the nitrous acid is weaker than that of the vitriolic, there is nothing ſo wonderful in the circumſtance juſt now related. We are to conſider the propenſity of mercury towards the vitriolic acid, as operating to increaſe the influence of the nitrous, and from hence it proceeds that we obtain a vitriolated mercury but little ſoluble in water, and, on account of the ſmall quantity of the menſtruum, falling to the bottom of the veſſel in the form of cryſtals; while, on the other hand, the nitrous acid uniting with the lixivial ſalt produces a perfect nitre. ——Further, if this vitriolated mercury is mixed with common ſalt, and ſubmitted to the fire, a new exchange of parts takes place: for the mercury combining with the muriatic ſalt is ſublimed under the form of corroſive mercury, the matter remaining at the bottom of the veſſel being a Glauber's ſalt, generated by the acceſſion of the vitriolic acid to the mineral alkali.

The reſult is nearly the ſame, if you employ nitrated mercury, common ſalt, and vitriol. The uſe of this preparation is preferred by Beguinus *, Boerhaave †, Senac ‡, A. C. Ernſting §, J. H.

* Tirocin. chem. 1615.

† Elem. chem. tom. ii.

‡ Cours de chem. ſuivant les principes de Newton et de Stahl, tom ii. 1623.

§ Lex. chem. 1765.

J. H. Schulze *, Malouin †, H. Ludolf ‡, A. Rudiger §, Macquer ‖, J. R. Spielmann ††, Baume ‡‡, L. J. D. Suckow §§, and ſeveral others.

§ VIII. *What Mode of Preparation is the beſt.*

We have thus enumerated almoſt all the chief methods of preparing corroſive ſublimate; but, if we compare them with each other, in reſpect of profit and expence, we ſhall find them not all of equal merit and importance. We ſhall take no notice of the late boaſted diſcoveries of a Pariſian apothecary, in the preparation of this metallic ſalt with the acid of milk, as their inconſiſtency with known principles in nature is their ſtrongeſt condemnation. In Sweden, but a ſmall quantity of corroſive ſublimate is prepared, which is a circumſtance much to our diſadvantage, as we are not only obliged to purchaſe it from abroad, but alſo expoſed to the riſk of receiving it adulterated with arſenic, the moſt dangerous of poiſons, than which nothing can be

* Chem. Verſuche.
† Chem. medic.
‡ Einleit. in die chem. 1752.
§ Syſtemat. Anl. zur allgem. chem. 1756.
‖ Elemens de chemie pratique, tom. i.
†† Elem. chem. 1763.
‡‡ Manuel de chemie, 1763.
§§ Phyſiſche Scheidenkunſt, 1769.

be more fatal, whenever, for the purpofes of medicine, corrofive fublimate is diffolved in fpirit of wine, or a portion of crude mercury is added to moderate its corrofive quality. Of this cruel and diabolical fraud mention was made by the writers of the laft century; and we are therefore furprifed at the ill-judged and much too late delicacy of Doffie, who thought himfelf not permitted to reveal exprefly the poifonous fubftance with which corrofive fublimate might be adulterated. We fhall have occafion, a little futher on, to fay more upon this fubject; at prefent we have it in view to fhew, as far as we are able, in what manner corrofive mercurial fublimate ought to be prepared in our laboratories. It muft be acknowledged, however, that the greater number of methods for this purpofe are exceedingly tedious and expenfive, and replete with danger. The labour required to mix three or four fubftances is exceedingly great, and does not fucceed properly, except in very large veffels, which, during the progrefs of the operation, are very often broken. And add to this confideration, that the vapours of the nitrous acid are exceedingly noxious, and frequently produce hæmoptyfis, and other diforders, in thofe who infpire them. The danger is however not of fuch a nature, as that it muft always attend the preparation of mercurial fublimate. That method which requires the leaft

labour

labour is no doubt the beſt. Mercury diſſolved in the nitrous acid precipitates all thoſe ſalts containing vitriolic acid. Therefore turpeth mineral, or vitriolated mercury, can be prepared at a very ſmall expence, if vitriol is added to a nitrous ſolution of mercury, or if even the arcanum duplicatum is employed, which is obtained from the diſtillers of aquafortis at a very low rate. In this proceſs there is little ground for apprehenſion from the vapours of the nitrous acid, which may be entirely avoided by ſeparating the vitriolic acid from the mercury by means of diſtillation, (vide § 8.). When turpeth mineral is triturated with common ſalt, it throws off aſh-coloured vapours, highly offenſive to the lungs; but theſe may be borne much more eaſily than the nitrous vapours, and eſpecially if the mixture is made quickly and in ſmall quantity. If the maſs is now expoſed to the fire, corroſive ſublimate of the moſt perfect kind will be collected in the head of the ſubliming veſſel: The reſiduum at the bottom is a Glauber's ſalt, which, for the purpoſes of medicine, muſt ſuffer again the action of fire, in order to expel any portion of mercury that may be yet adhering to it. It is not neceſſary for this operation to purify the common ſalt of all the earthy ſalts that are combined with it, of which we have already ſpoken above, (§ 6). Hence it is only required to dry the mixture, ſo

as

as to carry off all the ſuperfluous water; the acid is carefully to be preſerved and retained.

§ IX. *The external Appearance of corroſive mercurial Sublimate.*

CORROSIVE mercurial ſublimate is collected either in the form of elaſtic ſmall needles, or a cryſtalline maſs. On being diſſolved again, and the water afterwards evaporated, it accretes into various kinds of cryſtals, according to the difference of particular circumſtances. If boiling water is ſaturated with it, and the ſolution expoſed immediately to the cold air, needle-like cryſtals are produced. If the evaporation is conducted gradually, we perceive cryſtals in the ſhape of cubes or oblique parallelepipeds *. Monet deſcribes cryſtals under yet other appearances. But ſuch is the nature of ſalts that each affects a certain form peculiar to itſelf, as an architype, unleſs its courſe is interrupted by the accidental impulſe of external things *. Corroſive mercurial ſublimate is governed by the the ſame law. In general, if ſufficient ſpace is allowed it, it aſſumes the form of quadrangular priſms, with alternate narrower ſides, and with uniform terminations of two inclined planes.

§ X.

* Mem. de l'acad. des ſciences, 1753.

* See Diſſertation on the forms of cryſtals, Eſſays, v. ii.

§ x. *Its Character in respect of Air and Water.*

Corrosive mercury does not attract moisture from the air. For the purpose of dissolving it, more or less water is requisite, according to the increase of the temperature of the water. Speilman asserts, that an ounce of water, of the temperature of 30 degrees of Fahrenheit's thermometer can dissolve thirty grains of it *; hence, half an ounce of water at 10 degrees of the Swedish thermometer, will take up a sixteenth part of its own weight. The experiments of Macquer are somewhat different from this; for, if we follow him in his conclusions, we shall believe, that half an ounce of water, at the temperature of 160, will dissolve a twentieth part; and, at the boiling point, even more than a half of its own weight.

It is, however, to be observed, that on mixing this salt with warm water, the heat of the mixture is raised beyond the 100th degree of the Swedish thermometer, but at the very time of the solution no change of temperature is observed. If sal ammoniac is added likewise, we have no inconsiderable degree of a solution; although Dossie is of a different opinion †. Macquer knew by experiment, that three ounces of water impregnated with sal ammoniac, were capable

* Inst. chem.

† Laboratory laid open, 1758.

pable of diſſolving five ounces of corroſive mercury; and that, during the ſolution, the heat was increaſed ſix or ſeven degrees. When the ſolution becomes cold, a part of the ſalt is formed into cryſtals; to prevent which the corroſive mercury ſhould be added very gradually, and as each particle diſſolves; and thus all increaſe of heat will be avoided. Theſe ſalts once combined in this manner are inſeparable by any art, and conſtitute a particular compoſition known by the name of ſal alembroth, highly extolled by the alchemiſts; if we believe Kunkel, Dippel, and others, on account of its wonderful power to diſſolve gold and other metals.

§ XI. *Corroſive Mercurial Sublimate diſſolved in Spirit of Wine.*

Among the ancient profeſſors of the chemical art, by whom the mixture of corroſive mercury and ſpirit of wine had been made, we reckon R. Lullius, Baſil Valentinus, Salomon Triſmoſinus, and many others. Pott alſo obſerved that this ſalt was altogether * deliqueſcent in that menſtruum; but a fuller illuſtration of it has been given by Macquer. Half an ounce of ſpirit of wine, of the temperature of 20 degrees, diſſolved three-eights of its weight of corroſive mercury, or when of a boiling heat it took up

* Diſſ. de ſpirtu ſalis vinoſo, in Obſ. Chem. Coll. I.

195 lb. Troy, the greateſt part of which concreted into cryſtals on the cooling of the ſolution.

Spirit of wine, ſaturated with ſal ammoniac, of 20 degrees of temperature, will diſſolve double the quantity of corroſive mercury, or three-fourths of its own weight. Being ſet on fire, it burns at firſt with a flame of the ordinary colour; but changes afterwards gradually to a yellow, throws off blue ſtarry ſparks, and at length exploding is extinguiſhed *.

§ XII. *Diſſolved in Mineral Acids.*

NEITHER are the mineral acids averſe to an union with corroſive mercury. The muriatic acid diſſolves it the moſt readily; and, if it is employed in conſiderable quantity, no cryſtals are formed, but when ſparingly uſed, needle-like cryſtals are produced.

The nitrous acid occaſions vapours ſuch as ariſe from aqua regia †. It is therefore to be concluded, that this acid has ſeized upon ſome part of the mercury. By the means of heat the whole ſalt is diſſolved; and, on the evaporation of the fluid, is formed into cryſtals, and ſuffers no alteration either in weight or character ‡.

With

* Macquer in Mem. de l'Acad. de Turin. 1766.

† Pott, de Sale communi.

‡ Macquer, l. c.

With the aſſiſtance of heat, the vitriolic acid is capable of diſſolving corroſive mercury; but cannot retain it after the ſolution is become cold. It is an obſervation of Pott, that the vitriolic acid occaſions a precipitate in the form of powder from a ſolution of corroſive mercury, which is afterwards re-diſſolved on being heated. Allowing this to be fact, it implies neither a decompoſition of the ſalt, nor a greater affinity to mercury in the vitriolic than in the muriatic acid, which P. A. Marherr apprehended to be the caſe*. When warm water was poured upon the precipitate, it was immediately diſſolved, leaving behind no turpeth mineral. There is no precipitation therefore of vitriolated mercury, but of corroſive or muriated, which had been deprived of part of its water by the vitriolic acid. But Pott himſelf found, that common ſalt occaſioned a precipitate from the vitriolic ſolution of mercury, which could not happen unleſs from a combination of the metal and the muriatic acid.

Corroſive mercury, prepared in the ordinary way with vitriol and nitre, gives a yellow colour to diſtilled vinegar. A red powder is obtained from the ſolution by evaporation, which is conceived by many to be a mercurial ſulphur. The opinion of Junker, however, that it is a martial earth ſublimed by the violence of the

 fire.

* Diſſ. de affinitate corporum Vienn. 1762.

fire, is certainly the moſt probable. For the ſame red powder clearly appears, although the corroſive mercury be repeatedly ſublimed with the ſame matter, or caput mortuum that remained after its former ſublimation, or even though the proceſs is renewed with vitriol and nitre *.

We are told by Becher, that corroſive mercurial ſublimate diſſolved in water, precipitated by an alkali, digeſted with diſtilled vinegar, then exſiccated, and afterwards macerated again and again by a long digeſtion in ſpirit of wine, is reſolved after all this labour into a milky liquor which depoſits a ſediment, and aſſumes at laſt the form of a ſweet flavoured oil. The truth of this relation, and the principles on which it reſts require the inveſtigation of repeated experiments before they can be eſtabliſhed. Pott † however aſſerts that corroſive mercury mixed with triple the quantity of ſal ammoniac, expoſed to deliqueſcence in the air, and afterwards exſiccated on bibulous paper, yielded by diſtillation a water, which being again diſtilled, contracted a ſweet ſmell, and was wonderfully calculated to diſſolve various bodies.

§ XIII. *United with alkaline Salts and cauſtic Lime.*

On the addition of fixed alkali to a ſolution of

* Conſp. Chem.

† De Sulphure Metallorum. 1716.

of corrosive mercury, a red powder is precipitated. If the acid is in considerable quantity, the colour of the precipitate will be proportionally paler, and will become perfectly white if the excess of acid is very great. The smallest particle of lixivial salt, although the acid be in a large proportion, will precipitate some of the corrosive mercury, which is however in a short time again dissolved. Peterman * is of opinion, that the red colour is owing to martial vitriol; but Teichmeyer conceives it should be attributed to the sulphureous parts of the salts. It is certain indeed that a red powder can be prepared without any vitriol.

Volatile alkali also decomposes the solution of corrosive mercury. If it is pure, it precipitates a white powder; but, if it is charged with any fatty substance, (as in the vinous spirit of sal ammoniac,) the precipitate is of an ash-colour †. From the plogiston in the volatile alkali, it sometimes happens, that a dark ash-coloured or black powder is precipitated.

According to Meyer ‡, an ounce of lime-water is capable of precipitating two grains of corrosive mercury of a yellow colour, which, on being dried, changes gradually to black. This

 is

* Chemia, 1708.

† Zimmerman in Zusatzen zu Neumans Chemischen Vorlesungen.

‡ Abhandlung vom ungelöschten Kalch.

is a mild phagedænic water, with two grains only of corrofive mercury to the ounce. The fixed alkali produces no effect on it; but the volatile feparates a very fmall portion of a white powder. The pharmacopœia of Paris and Strafburg have both this formula of the aqua phagedænica; but it may be more efficacioufly prepared, if neceffary, when it is exactly known what quantity of corrofive mercury can be either diffolved or precipitated by lime-water.

For the purpofe of determining whether an alkali is prefent in any fluid, and of what kind it is, the corrofive mercury may be conveniently employed. As foon as a fmall portion of this falt is thrown into it, it is tinged according to the nature of the alkali with a yellow or red colour, or is clouded with a white powder; if it contains no alkali, it remains unchanged.

An infufion of galls mixed in a folution of corrofive fublimate renders it thick and black. The precipitate on being dried affumes the colour of umber.

§ XIV. *With Metals.*

Most metals decompofe corrofive mercury. Stahl has obferved that it deliquefces, if powdered tin or iron are fprinkled on it, and that thefe metals are corroded with the muriatic acid *. Junker alfo informs us, that if a folution of

* Spec. Bech. 1703, 1720.

of corrofive mercury is boiled in an iron veffel, the veffel will be affected with its acrimony, and quickfilver will be collected at the bottom of it. If copper or brafs is immerfed in the folution, they are covered with a fhining pellicle of quickfilver. Zinc alfo detaches mercury from the muriatic acid, and forms with it an amalgam*.

From the combination of various metals with corrofive mercury, and fubfequent diftillation, arife the butters commonly fo called, or thick fluids, the greateft part of which is more or lefs impregnated with metallic matter. Of this kind are the butters produced by the diftillation of the ores of lead, tin, bifmuth, zinc†, or regulus of antimony, with corrofive fublimate. Silver, lead‡, and copper, effect a feparation of the mercury from the muriatic acid. The red powder, occafioned by expofing equal quantities of corrofive mercury and iron to the fire, infpiffating, and afterwards fubliming them, as feen by Cardiluccius, has been fince demonftrated from the repeated experiments of Pott; who however adds, that he was lefs fuccefsful in his attempt to afcertain what had been befides remarked by Cardiluccius in this procefs, that the refiduum being expofed to the air, and again fublimed, yielded a talcy fubftance; and that from what

* Pott de zinco, in Obff. Coll. II.
† Pott de fale, &c.
‡ Brand in Act Acad. Succ. 1753.

ſtill remained, a ſnowy-like ſalt could be extracted, by pouring upon it the diſtilled acetous acid *. I am unwilling to relate any more experiments reſpecting the various combinations of metals with corroſive ſublimate, leſt I ſhould ſeem to have forgot the juſt limits of this diſſertation.

§ XV. *The Quantity of Acid and Mercury in corroſive Sublimate, and its ſpecific Weight.*

Corrosive ſublimate was held by the ancient chemiſts in great eſtimation, chiefly becauſe they believed that in it were united all the mineral acids. Barchuſen was very properly of opinion, that it contained the acid of ſalt only: The arguments on which he founds this idea will be related as we proceed. Among the more modern chemiſts, Gellert apprehended that the nitrous, as well as the muriatic acid, entered into the compoſition of corroſive ſublimate †. But although, from the different modes of preparing this ſalt, we do not deny that it may ſometimes be corrupted with the vitriolic, or with the nitrous acid, yet theſe acids are neither always preſent or abſolutely requiſite, and corroſive ſublimate can be very well prepared without the aſſiſtance of either, (§ 3. 4.) It appears, therefore, that mercury can be altogether

* Pott de ſale communi.

† Metallurgiſche chymie, 1755.

gether united with the acid of ſalt alone, of which the metal can take only a limited quantity. From the experiments of Rouelle, it is manifeſt, that, neither by a greater proportion of common ſalt, re-iterated ſublimations with it, or repeated ſolution of corroſive mercury in the muriatic acid, it is poſſible to combine an extraordinary quantity of the acid with the metal*. As to the account given by Homberg, of the liquefaction of corroſive ſublimate, charged with a ſuperabundance of acid, and its reſemblance in conſiſtence to the butter of antimony, we conceive it is to be explained by the ſolution of the ſalt in the exceſs of acid.

The acid in corroſive mercury is ſo ſaturated as to become quite taſteleſs. Monſ. Rouelle writes, that a ſolution of corroſive mercury changes the ſyrup of violets to a green, but that it does not in the leaſt affect the tincture of turneſol. As often however as I have made the experiment, either with the ſalt that I purchaſed, or with ſome of it prepared by myſelf, waſhed even in the pureſt water, I have always ſeen it redden the tincture of the turneſol, but it produces no ſigns of an acid with the blue vegetable colours †.

It is not yet ſufficiently aſcertained what is the proportion of acid and mercury in the compoſition,

* Mem. de l'Acad. des Sc. de Paris, 1754.

† Baume aſſerts the contrary in his Manuel de Chymie.

ſition of corroſive ſublimate. Tachenius, whom I mentioned above with ſome commendation, aſſerts, that 280 pounds of mercury will produce 360 pounds of corroſive ſublimate; from which, if it is true, it follows, that the metal will be in the proportion of 3½ to 1 of the acid. On the other hand, if we are to believe Lemery, who obtained 19 ounces of corroſive ſublimate from 16 ounces of mercury, the parts of the mixture will give a ratio of 5⅓ to 1. Macquer, however, rightly obſerves, that more mercury is loſt if the proceſs is inſtituted with a ſmall than with a large quantity. Le Mort errs conſiderably in ſtating the weight of the acid to be triple that of the mercury *. The proper weight of this ſalt is yet undetermined, as it is variouſly defined by different authors. According to Coteſar, the ſpecific gravity of corroſive ſublimate is to the ſpecific gravity of rain water as 6.325 to 1000; while, on the contrary, Muſchenbroek eſtimates their weights in the proportion of 8000 to 1. Hence, then, it appears, that the bulk of the two ingredients, and eſpecially of the mercury, is greater when combined together, than when taken ſeparately.

§ XVI.

* Facies Chem. purif.——On a more accurate inveſtigation, our author afterwards found, that the proportions of acid and quickſilver in a centenary were as 24,5 : 75,5. See Diſſert. de miner. docimaſia humida, Opuſc. v. ii. p. 423.

§ XVI. *Corrosive Sublimate adulterated with Arsenic.*

I HAVE formerly mentioned the adulteration of corrosive sublimate with arsenic. Some chemists, however, have denied that these two substances can be united by sublimation*. Indeed, if we are to believe Glaser † and Sperling ‡, we shall be persuaded, that when arsenic is mixed with corrosive sublimate, and exposed to the fire, the acid of the arsenic is expelled, and a butter is formed; the mercury, at the same time freed from bondage, being restored to its metallic state. The experiments of Pott §, Gmelin ‖, and Spielman ¶, are in direct opposition to this opinion; in which the combination of mercury and true arsenic was effected. But in order to remove all doubts on this subject, I took three parts of corrosive sublimate, and two of arsenic, and triturating them both together, put the mixture into a retort, and subjected it to a violent heat. At the end of the process there was no appearance of any butter; but all the matter was

† Neuman in prælect.
† Cours de Chemie, 1663.
‡ Diff. de Arsenico.
§ De Sale comm.
‖ Diff. de specif. can. sanandi methodis, Tubing. 1757.
¶ Inst Chem.

was collected in the neck of the veſſel. After breaking the retort, a portion of arſenic and corroſive ſublimate was found, but ſo far ſeparate from each other, that they could be diſtinguiſhed by the form of their cryſtals. The reſt of the maſs was in powder, and uniform. From this experiment, therefore, unleſs I am deceived, it may be concluded, that arſenic and corroſive ſublimate, in the proportions I have directed, can be united by ſublimation, and connected in the greateſt part into a ſolid maſs.

Du Monſtier *, Doſſie, and many others affirm, that the preſence of arſenic is indicated in the black colour produced by pouring an alkaline lixivium into a ſolution of corroſive ſublimate. But Barchuſen †, and Boulduc, ſenior ‡, have long aſſerted, that this experiment is fallacious and ill-founded. Gmelin contends, that a ſolution of corroſive ſublimate adulterated with arſenic yields, on the addition of the volatile alkali, a black precipitate. To me, however, when making this trial, the event did not ſeem to anſwer my expectation. For in thoſe particles which were abſolutely under the form of arſenic and corroſive ſublimate, no change of colour was produced by the ſpirit of ſal ammoniac prepared with quicklime. The remaining ſolid

* In annotat. ad Chemiam Glaſeri & Le Fevre.
† Pyroſophia, 1698.
‡ Mem. de l' Acad. des Sc. a. 1699.

ſolid and uniform maſs aſſumed a dark and rather an aſh colour, but not in the leaſt a black. But further, I diſſolved ſophiſticated corroſive ſublimate in diſtilled water of a boiling heat; which ſolution, when I added to it the cauſtic ſpirit of ſal ammoniac, depoſited thin flakes, and in a ſhort time afterwards ſeemed here and there to become of a green colour. The change of colour was ſtill leſs when I employed the ſpirit of hartſhorn. The trial with the volatile alkali is therefore uncertain; but we can determine much more eaſily, and with greater preciſion, the preſence of arſenic, if a ſmell of garlic is emitted from corroſive ſublimate ſprinkled upon burning coals.

§ XVII. *White Mercurial Precipitate.*

The white powder depoſited in the nitrous ſolution of mercury, on the admixture of common ſalt or muriatic acid, is named white mercurial precipitate. By ſome it is called coſmetic mercury, or milk of mercury; and Potter gives it the appellation of the *calcinatum majus*. Its colour, and the method of uſing and preparing it have given riſe to various names, which were for the moſt part very indiſtinct, and have been transferred to ſubſtances of a very different nature. The preparation of it ſeems to have

been

been known for ſome centuries paſt, but we have no information reſpecting the perſon by whom it is invented.

§ XVIII. *Modes of Preparation.*

THE moſt common method is to pour a quantity of ſalt-water into a nitrous ſolution of mercury after which the mixture becomes ſtreaked and cloudy, and a white mucilaginous matter gradually ſubſides to the bottom of the veſſel. The water is added as long as any thing is precipitated; afterwards when the white maſs is collected, the clear liquor is poured off, the reſiduum is well waſhed in pure water, and being then incloſed in bibulous paper is dried either in the air *, or over the fire. The fire employed ſhould however be very moderate, leaſt by too great heat the powder acquire a yellow colour †.

In this proceſs a double ſeparation or decompoſition of the ingredients takes place. The mercury is ſeparated from the nitrous acid, and unites with the acid of the common ſalt, forming a ſalt but little ſoluble in water; and the nitrous acid quits the mercury, and with the mineral alkali of the common ſalt, produces cubic nitre.

* Barchuſen Elem. Chem. 1712.
† Maets in Collect. Chem. Leydenſ.

nitre. As the menſtruum, however, in which this mercurial ſalt is diſſolved is not in ſufficient quantity, the ſalt is tumultuouſly coagulated and precipitated in the form of a mucilage. Inſtead of common ſalt, ammoniacal or other ſalts containing the muriatic acid may be employed for this purpoſe; the acid itſelf uncombined with any ſubſtance might be uſed with advantage, if it were not too expenſive. It is, however, to be obſerved, that according to Junker, Geoffrey, and Pott, the muriatic acid in its ſtate of ſeparation, precipitates a ſalt from the nitrous ſolution of mercury, poſſeſſing more ſolubility in water *. Freſh urine added to this ſolution occaſions a mercurial precipitate of a fleſh colour; for which appearance we can readily account, if we conſider, that beſides common ſalt, it contains digeſtive and ammoniacal ſalts. The red colour is owing to the admixture of ſome extraneous matter. Lemery is of opinion that this mercurial precipitate is milder than the white †.

If on the addition of common ſalt, a ſaturated ſolution of mercury is decompoſed, it follows, that the nitrous acid ſeparated from the mercury muſt be either capable of ſaturating the alkaline ſalt, or incapable, or in exceſs. Which ever of theſe caſes occurs, may be eaſily aſcertained

* Macquer dict. de Chemie.

† Cours de Chemie, 1675.

tained by the means of reagents, unleſs nitrated mercury ſhould be rendered turbid by the acid poured upon it. As I ſuſpected that this appearance might be owing to a quantity of heterogeneous matter mixed with the ſolution, I endeavoured to ſeparate it by adding diſſolved alkali, but to little purpoſe; the cloudy ſtate of the acid was in no way to be removed, until all the mercury was firſt precipitated.

When a conſiderable quantity of muriatic acid is poured ſuddenly upon a nitrous ſolution of mercury, inſtead of a white mercurial precipitate we obtain a corroſive mercury eaſily ſoluble in water. Monnet, therefore, very prudently adviſes in the preparation of white mercurial precipitate, that both the ſolution of the mercury, and the muriatic acid to be employed, ſhould be well diluted, and the mixture of them made gradually and with caution *.

The precipitate ought to be waſhed in as much water as will be ſufficient to diſſolve all the cubic nitre combined with it. On the other hand, if too much water is poured upon the precipitate, and ſuffered to remain any length of time, it is again eaſily diſſolved †. White mercurial precipitate waſhed in warm water, is called by Mayern *manna mercurialis* ‡.

Plummer

* Acta Acad. R. Suec. a. 1770.
† Eſſay for a reformation of the London Pharm.
‡ Malouin Chymie medicinale.

Plummer has afcertained by experiments, that the weight of the white mercurial precipitate, when thoroughly exficcated, is fomewhat greater than that of the mercury employed in the procefs *.

When no more precipitate is occafioned by the addition of the folution of common falt, the liquor poured off does not altogether lofe its cauftic property; hence, therefore, it is fuppofed to poffefs the virtue of removing fpots and freckles on the face. If it is mixed with the water of rofes, lillies, and beans, &c. it becomes milky, and is reckoned among the remedies for affections of the face; and has on that account obtained the name of cofmetic mercury †. Its acrid quality arifes from the mercury diffolved in it, which may be collected in a copious fediment by pouring into it fixed or volatile alkali. This circumftance has been already obferved by Barchufen ‡; and if we are to give credit to Junker, fcarce one-fourth is precipitated, when equal weights of common falt and mercury are taken for this preparation §. The fact has been frequently remarked, and the feveral pharmacopoeias have, in confequence of it, adopted the practice of mixing the fpirit of fal ammoniac

 with

* Obfervations of the Society at Edinburgh, Vol. I.
† I. T. Cartheufer in Pharmacia.
‡ Elem. Chym.
§ Confp. Chemiæ.

with the liquor, whenever it is no longer affected by the ſolution of common ſalt. In this manner a white powder is precipitated, which according to Junker * is equal to half the quantity of the mercury employed in the ſolution. The authors of the Edinburgh pharmacopoeia direct the white mercurial precipitate to be prepared by diſſolving corroſive ſublimate in water and adding ſpirit of ſal ammoniac to the ſolution. The London pharmacopoeia, following the example of Lemery †, order corroſive mercury and nitre to be ſeparately diſſolved in four times their quantity of water ‡, the ſolution to be filtered, and fixed alkali to be afterwards added to it. By this method, a white powder is procured equal to three-fourths of the weight of the corroſive mercury §. Sal ammoniac does not render corroſive mercury milder only, but it gives a whiter colour likewiſe to the precipitate ||. If the precipitation is made with urine, and the ſpirit of ſal ammoniac is afterwards poured upon it, the black mercurial precipitate of Lemery is the produce of that mixture.

From what we have already ſaid it muſt be evident,

* L. c.

† Cours de Chemie.

‡ Which however cannot be done, unleſs ſal ammoniac is added.

§ Doſſie, Laboratory laid open.

|| Hiaerne Tent. Chym. T. II.

vident, that things of a different nature have been expreſſed under the ſame name; an error by no means unattended with danger. For it may happen, that inſtead of the white mercurial precipitate which a phyſician ſhall have ordered for his patient, mercurial calx, mercurial ſalt, or a mixture of both may be adminſtered. Theſe ſubſtances, though they agree in form and external appearance, yet in their properties and efficacy they are in no way ſimilar.—For, if we add the muriatic acid or common ſalt to a nitrous ſolution of mercury, we ſhall obtain a genuine mercurial ſalt; but, if we take the volatile alkali, a mercurial calx will be precipitated, from which all the acid can be waſhed away by water. Some writers have diſtinguiſhed this calx by particular names. Teichmeyer calls it, *turpethum album**, and in the firſt editions of the London pharmacopoeia it is deſcribed under the appellation of *mercurius precipitatus dulcis*. It is altogether milder than the white precipitate, and leſs volatile. Doſſie contends, that white mercurial precipitate ſhould be prepared by mixing fixed alkali with a ſolution of corroſive mercury. There is no doubt, that in this way a white matter is often precipitated; but Doſſie did not know that it never happened unleſs old alkali, and ſuch as had abſorbed the aerial acid, was employed.

* Inſtit. Chym.

As water diſſolves ſometimes more, ſometimes leſs, of the white precipitate, it may be yet a queſtion, whether the muriatic or the nitrous acid is united with the mercury in the compoſition of mercurium coſmeticum. Although, indeed, I do not deny that ſome portion of muriatic acid exiſts in it, as the mode of preparing it ſeems to indicate, yet I cannot help thinking, that the nitrous acid has the greater influence on its character, and is chiefly inſtrumental to its production. For if we add a few drops of nitrated mercury to a ſolution of gum arabic, the liquor becomes immediately milky, and very ſeldom recovers its tranſparency though ſtill more nitrated mercury ſhould be added. This milky colour, however, I have never ſeen when the experiment was made with corroſive mercury. Having ſhewn above, that coſmetic mercury aſſumes the appearance of milk when mixed with diſtilled water, we infer, that this change of colour is occaſioned by the nitrated mercury, ſome part of which is deſtroyed by the acceſſion of the mucilaginous matter.

We have now only further to obſerve on this part of our ſubject, that the method of preparing white mercurial precipitate, as propoſed by an anonymous writer, is yet to be noticed. He aſſerts, that from the mixture of corroſive mercury with a certain weight of crude mercury, a ſalt is obtained by the application of heat

heat in all reſpects ſimilar to white precipitate*. Whether the experiment has been made by any other perſon, I am altogether ignorant.

§ XIX. *White mercurial Precipitate diſſolved in Water.*

It is not yet ſufficiently aſcertained what weight of white mercurial precipitate can be diſſolved in a given quantity of water. The queſtion is even difficult to be determined; as from the various proportion of the acid in this ſalt, its ſolution in water is either aſſiſted or impeded. The time and manner alſo of the ſolution are principle objects of conſideration. For in that moment when the acid firſt acts upon the mercury, the ſalt ſo produced is eaſily ſoluble in water; but, if the precipitate is collected in the form of a coagulum, its affinity with that fluid is much diminiſhed. Sal ammoniac affords conſiderable aſſiſtance to the ſolution, whether it be made in water or in ſpirit of wine.

The difficulty of the ſolution prevents the white precipitate from forming into larger cryſtals, with the true form of which we are therefore yet unacquainted.

* Eſſay for a reformation of the London Pharm.

§ XX. *The Quantity of Acid contained in white Mercurial Precipitate.*

MANY circumſtances tend to prove that the white mercurial precipitate contains leſs acid than the corroſive. It is, in the firſt place, of more difficult ſolution, of a milder nature, and receives a darker colour from lime water and ſpirit of ſal ammoniac. According to their ſeveral conditions it is variouſly affected by acids and by mercury; which is by no means ſurpriſing, as all mercurial ſalts, differing from corroſive ſublimate and ſweet mercury, and holding a place between them, are commonly expreſſed under the name of white mercurial precipitate.

§ XXI. *Adulteration of white Mercurial Precipitate.*

IT is not uncommon to meet with this ſalt in a ſtate of adulteration. This is ſometimes effected by a mixture of white lead; for the diſcovery of which fraud Doſſie has inſtituted an experiment*. He directs a fourth part of a lixivial ſalt to be mixed with the mercurial precipitate, the whole to be expoſed to the fire, until the mercury riſes under the appearance of ſmoke. If lead is found in the crucible, the fraud is beyond a doubt; if not,

* Laboratory laid open.

not, the matter remaining will be a digeſtive ſalt ſoluble in water; and ſhould no part of the reſiduum admit of ſolution, the adulteration is made with white clay. White precipitate is adulterated with ſtarch alſo. The marks of this kind of ſophiſtication conſiſt in the levity of the ſubſtance remaining, and the carbonaceous maſs left after ignition.

§ XXII. *Sweet Mercury.*

Mercury preſents itſelf under another form of combination, with the muriatic acid, to which the name of *mercurius dulcis* has been generally applied. This ſalt was formerly in poſſeſſion of various appellations, as *ſublimatum dulce*, *aquila alba*, *aquila mitigata*, *manna metallorum*, *Panchymogogum minerale*, and ſeveral others. The art of preparing it was, ſo late as the beginning of the ſeventeenth century reckoned a myſtery. Oſwald Croll ſeems ſufficiently cautious when ſpeaking on this ſubject. He ſays "Sunt duo ſecretiſſimi modi tractandi mercurium pro medicina corporis.——In ſecundo mortificantur corroſivi ſpiritus vitrioli et ſalis in mercurio ſublimato, e quo miro et ſimplici artificio homogeneo fit pulvis cryſtallinus plane inſipidus *." That mercurius dulcis is meant in this paſſage I have not the leaſt difficulty to believe.

* Baſilica Chem. 1608.

believe. But it was to little purpofe to have obferved fo obftinate a filence; for in the fame year in which Croll wrote this, J. Beguin publifhed a work at Paris, entited *Tirocinium Chemicum*, where the whole compofition of this medicine (*Draco mitigatus*) is defcribed in plain terms. Soon afterwards its fame encreafed more and more, and it was called at that time by the name of *Panchymagogus Quercetanus**.—Neumann condemns the name of *mercurius fublimatus dulcis* as liable to occafion dangerous errors, and prefers the appellation of *mercurius dulcis* fimply. At London, however, the name of *mercurius dulcis fublimatus* ftill obtains.

§ XXIII. *Methods of preparing it.*

THE ancient chemifts, in all the pomp and metaphor of language in which they fo much delighted, boafted, "that they had tamed the "fierce ferpent and reduced the dragon to fuch "fubjection as to oblige him to devour his own "tail;" while they were doing that only, which we, in lefs affected terms, call foftening and abating the acrimony of corrofive mercury. All however, are agreed that this change is produced by the further mixture of crude with corrofive mercury; but different fentiments are held with refpect to the method of doing it. Some triturate as much crude mercury as the corrofive mercury

* In honour of Jof. du Chefne, a celebrated chemift.

mercury is capable to extinguiſh, and others define accurately the weight of mercury to be employed. Were the form and quantity of corroſive mercury always the ſame, and equal pains beſtowed, it would be of little conſequence which of the methods was preferred; but as this is by no means the caſe, more circumſpection becomes abſolutely neceſſary. Lemery, indeed, in other reſpects moſt attentive to determine weights and proportions, contends, that corroſive cannot enter into combination with more crude mercury than three-fourths of its weight. The authors of the London and Edinburgh Pharmacopoeias deliver the ſame opinion. I muſt own, however, that for the reaſons already adduced, I conſider it much ſafer to employ crude mercury in exceſs than in too ſmall proportion; eſpecially as the ſuperabundant mercury may be ſaved with very little additional trouble. If white mercurial precipitate is taken, a ſmall, and ſometimes no addition of crude mercury is required. According to Lemery, ſublimation alone will be ſufficient; and Neumann had ſo little doubt that white mercurial precipitate ſtood in no need of crude mercury, that he pronounces it to be already perfectly ſimilar to *mercurius dulcis*. This opinion is not without ſome appearance of truth, eſpecially as J. F. Cartheuſer * has obſerved, that white mercurial precipitate, not

* Elem. Chem.

not ſubdued by ſublimation, is the ſame in efficacy and ſolubility with the ſweet mercury prepared in the common manner.

The mixture on which we are now treating, ought neither to be made in metallic nor marble mortars, as they are corroded by the mercurial ſublimate; but mortars of glaſs are to be employed for this purpoſe. Great care is at the ſame time to be taken that the dry powder does not enter into the throat and lungs of the operator. In order to diminiſh the danger of which, the maſs ought generally to be moiſtened, and the mouth and noſtrils of the perſon engaged in the trituration covered with a cloth. When the mercury is thoroughly extinguiſhed or divided into the ſmalleſt globules, the mixture aſſumes an obſcure or aſh-like colour. This mechanical proceſs is not a little forwarded by digeſtion; but it is not altogether adequate to ſubdue the acrimony of the corroſive mercury.—An intimate combination of the two ſubſtances is required, and which is generally produced by the means of fire.

Sublimation is performed in an alembic, or (as Stahl adviſes), in a retort large enough to contain a ſufficient quantity of mercury, that none of it may be waſted. Following G. Rothius, J. F. Cartheuſer properly directs, that the alembic ſhould be covered with ſand up to the very neck, in order that the mercury, and more acrid

crid particles of the ſublimate, riſing with a leſs degree of heat, may be collected in the ſummit of the veſſel; from which circumſtance a vacant ſpace of ſome inches in length is left in the neck for the pure mercurius dulcis, when it is raiſed with an encreaſed degree of heat. If a coated veſſel is expoſed to an open fire, the upper portion of the neck muſt be left uncovered for ſeveral inches.

The fire is to be gradually augmented, until it be ſomewhat more powerful than in the preparation of corroſive ſublimate. If it is too ſtrong, Wilſon tells us, the ſweet mercury turns black, and retains this appearance with ſuch obſtinacy, that ſublimation alone repeated can ſcarce remove it, unleſs it is ſeveral times rubbed with common ſalt *.

The veſſels being broken and opened, beſides the ſweet mercury, a yellow or aſh-coloured powder is found in the receiver; a few grains of which we are told by Vogel are ſufficient to kill a dog †. This is the corroſive mercury not rendered mild by ſublimation. At the bottom of the veſſel is found a dry and inert maſs, ſometimes of a reddiſh colour, which I apprehend to be the reſiduum only of the extraneous matter adherent in the corroſive mercury; although Junker conſiders it as ſomething of a peculiar nature.

* Wilſon's courſe of chemiſtry, 1699.

† Inſtit. Chem.

ture*. The yellow or aſh-coloured powder mentioned above, if mixed wi'h a ſufficient quantity of crude mercury, and again ſublimed, can be converted into ſweet mercury; it is therefore by no means to be thrown aſide as uſeleſs, as is commonly done, on the authority of pharmaceutical writings.

The firſt proceſs being ended, many chemiſts direct the aſh-coloured powder to be ſeparated, and the ſolid ſaline maſs, either alone, or mixed with as much crude mercury as it can extinguiſh, to be again and even ſeveral times ſublimed. In this way they at laſt judge it to be properly called *mercurius dulcis*. In our laboratories, however, the ſublimation is ſeldom repeated more than twice. The French reckon frequent ſublimations of great importance; and after three are made with addition of crude mercury and three without it, they name that *calomel* or *calomelas* which is obtained by the laſt ſublimation. This appellation is however ſufficiently abſurd, and criticiſed by many †; with us it is commonly given to the mercurius dulcis, which is produced by the firſt ſublimation. La Brune has gone yet further, and added greatly to the labour of this preparation, in ſubliming ſweet mercury nine

* Conſp. Chem.

† See Lewis's notes upon Wilſon's Courſe of Chemiſtry, 1735. and the author of the book: Eſſay for a reformation of the London Pharmacopœia.

nine times, and then digefting it with fpirit of wine impregnated with aromatics.—Mercurius dulcis prepared in this manner is commonly known by the name of *panacea mercurialis* *.

§ XXIV. *In what Way the ancient Chemifts proceeded in refpect to fweet Mercury.*

Sweet mercury is prepared in the prefent age by a procefs far more ready and fimple than it was formerly. Beguin mixed corrofive mercury with crude mercury, and vitriol of Mars calcined to rednefs, and then proceeded to fublimation. The vitriol could not affift in fubduing the acrimony of the corrofive mercury, but would rather tend to adulterate the fweet mercury with martial earth and vitriolic acid. How Croll conducted this operation we know not; he probably employed a fimpler method, as he calls it *artificium homogeneum*. Compofitions of fweet mercury with various metals, which are now obfolete, were in high eftimation among the ancient chemifts. I do not chufe to difpute that fome ufeful medicines may be produced by fuch a mixture; but it is incontrovertible that the fweet mercury is more or lefs changed by it. Schroeder fays, that having fublimed fweet mercury which had been mixed and triturated with laminated filver, he found no veftige of filver in the refiduum

* Malouin Chemie medicinale.

duum; and that therefore what was fublimed might properly be called *lunar fweet mercury* *.—It is well known that volatile fubftances often lend wings, even to fuch as otherwife are very fixed, and bear a great degree of heat; therefore even this is not to be wondered at, that fweet mercury fhould raife along with it cupels of glafs, and even large ones †.

§ XXV. *Phyfical Qualities of fweet Mercury.*

THE fweet mercury commonly fold in the fhops is folid, cryftalline, and of a white colour; which however for the moft part is yellowifh inwardly and in its fractures. It is fimilar to the flowers of benzoin which are brought from China. Its proper weight is diminifhed by every fublimation. According to Mufchenbroek ‡, on its fecond fublimation, it is as 12.353; on its third, as 8.82; on its fourth, as 8.236. Hence it appears, that our falt, having often borne the force of the fire, by degrees encreafes in volume, and approaches to the weight of corrofive mercury; to which otherwife it is very diffimilar. It may be fufpected by fome, that the acid is diminifhed, and that the refiduum enters into a more intimate combination by repeated fublimations; but

* Scroeder Pharmacia. 1641.
† Baume Manuel de Chemie.
‡ Introd. in Philof. Natur.

but when, by these alone, corrosive cannot be converted into sweet mercury, it is very plain, that the addition of quick-silver is necessary; unless it is contended, that, by sublimations in a greater number than what have hitherto been attempted, corrosive may be changed into sweet mercury. There is, no doubt, a certain mutual relation in the weight of the acid and of the quick-silver, which has not hitherto been accurately defined; although Lemery by his experiments seems to evince that the ratio is as 1 to 6½.

Sweet mercury held in the sun, is, in a short time tinged with an obscure colour*. In the dark, too, as observed by Scheele, it shines if rubbed; which property, however it loses, by repeated sublimations. By this means, therefore, it may be found out how often it has been sublimed.

What is commonly said, that gold is not made pale by friction with sweet mercury, is true; but by this experiment, however, the perfection of this salt cannot be known; for even by corrosive mercury, if well prepared, the colour of gold is not changed. But since, by the addition of too much quick-silver, it contains, after the first sublimation, many metallic globules; and that gold rubbed with it may by this means be whitened, from hence this vulgar error

* Neuman. Præl. Chem.

error has taken its riſe, that corroſive mercury can change the colour of gold.

§ XXVI. *Sweet Mercury diſſolved by various Fluids.*

SWEET mercury has hardly any taſte, as it is with difficulty diſſolved by water. From the experiments of Roſſele it appears, that even with the aſſiſtance of trituration and boiling, 2 ounces of water only diſſolves a ſingle grain of ſweet mercury; that is, one part only by 1152 of water.—The ſyrup of violets is made green by this ſolution. The ſame ſolution is diſturbed by fixed alkali; but much more by the volatile alkali, which gives it the colour of an opal. There is, however, no effervеſcence produced, and after a day, there is hardly any precipitation *. Since corroſive mercury is much more ſoluble in water, it may be eaſily known, by the experiment propoſed by Cartheuſer †, whether ſweet mercury is free from the acid or not, viz. if, after pounding it groſsly, it is macerated in warm water for an hour. But it is better, however, to make uſe of the ſpirit of wine, which diſſolves the corroſive mercury eaſier than water, but the ſweet not at all.

The colour of mercurius dulcis is obſcured by lime

* Mem. de l'Acad. des Sc. de Paris, a. 1754.
† El. Chym.

lime-water, ſpirit of ſal ammoniac, or even a ſolution of lixiviated ſalt found upon it. This phenomenon is commonly thought to depend on the perfect dulcification of the mercury. But the alteration is the ſame, when white precipitate is uſed.

Some aſſert that three parts of oil of olives, and one of ſweet mercury, if boiled together, diſſolve and form a ſort of balſam.

§ XXVII. *Proceſs for preparing Corroſive Mercury from ſweet Mercury.*

Few have tried to prepare corroſive from ſweet mercury. Scheffer of the Swediſh Academy made ſome experiments with this view: and his papers, in which, among other things, I found a detail of thoſe experiments, were, after the author's death, put into my hands by the illuſtrious Patrick Alſtromer. Alſtromer was induced, by Scheffer's example, to attempt the ſolution of ſweet mercury in the marine acid; but the experiment was unſucceſsful. Sweet mercury macerated with that acid, and reduced to a powder, was indeed altered, and aſſumed a dirty colour on the ſurface, but retained its mild character unchanged. Nay, though ſublimated three times ſucceſſively, with the addition of equal quantities of common ſalt and vitriol calcined to whiteneſs, it ſtill remained the ſame. Nor was its nature altered by adding a quantity of nitrous acid ſufficient for the ſolution of the quick mercury contained in it, ſeparating that nitrous acid by diſtillation, and ſublimating the reſiduum with an equal quantity of common ſalt. But corroſive mercury was obtained by adding for every part of ſweet mercury, one of common ſalt, and two of vitriol not calcined, and ſublimating the mixture. To render the event of the experiments the more certain, a quantity of ſweet mercury was prepared, from running mercury by the ordinary proceſs, and again converted into corroſive. From theſe facts it follows, that corroſive ſublimate may be prepared without nitrous acid, and that the ſubſtances act upon each other with a greater reciprocal force in a humid mixture than in the dry way.

§ XXVIII. *How happens it that the corroſive force of ſalited Mercury is not always the ſame?*

After conſidering the various combinations of mercury with the acid of ſalt, we are led to enquire to what cauſe the diverſities in their character can be owing. The ancients imagined that the acrid power of corroſive ſublimate was derived from the influence of the vitrolic acid; as it was plain, that the mercury, conſiſting as it did,

did, of ſmall globules could have no ſuch quality. Some even aſcribed to the nitrous acid a part of the peculiar qualities of corroſive ſublimate. Barchuſen was one of the firſt who exploded theſe opinions as erroneous. The mineral acids, he obſerved, the greater their ſpecific gravity, are ſo much the leſs volatile, and the arcanum corallinum, which, in his opinion, is produced from vitriolic acid, ought to be equally white and corroſive as ſublimated mercury, were it true that this preparation owes its whiteneſs and other peculiar qualities to the vitriolic acid. Although theſe arguments be not very concluſive, yet what Barchuſen wiſhes to evince is certain,—that corroſive ſublimate is compoſed ſolely by the combination of mercury with the marine acid. It has been already proved, that in corroſive ſublimate there exiſts an exceſs, in white precipitate a moderate portion, and in ſweet mercury a ſtill ſmaller quantity of marine acid. And ſince the corroſive powers of theſe ſalts vary nearly in the ſame order, it is natural to attribute their acrid quality to that acid. But upon a more accurate examination, the cauſe appears inadequate to the effect. A drachm of acid of ſalt, if diluted in a due quantity of water, may be drunk with ſafety: but even half a drachm of corroſive ſublimate, although diluted in the ſame quantity of water, proves a mortal poiſon. Beſides in the compound ſalt, the acid is intermixed with three times its weight of mercury, and ſo qualified, that its preſence cannot be detected either by taſte, or by the influence of reagents. Inſtead of attracting moiſture with any conſiderable force, it does not diſſolve in water without difficulty. Theſe circumſtances, as they all agree to prove the intimacy of the combination between the acid and the mineral; ſo, inſtead of explaining, they rather concur to conceal more entirely the cauſe to which the mercury owes its corroſive powers, Yet, I cannot avoid praiſing the ingenuity of Macquer, who, though he does not altogether remove the difficulty, yet propoſes a plauſible and natural theory *. Nature, ſays he, has diſpoſed all bodies to a mutual union. This natural tendency is commonly called affinity or attractive force. Upon the heavenly bodies it operates even at immenſe diſtances; but on earth it acts between bodies, only when they are brought cloſe together. Beſides, the mutual attractions of terreſtrial bodies are not regulated merely by bulk and diſtance. The modes and the degrees of chemical affinity are very various. Some bodies even refuſe to combine: and this may happen, when the parts of any one of two bodies have a greater tendency to adhere together than to enter into combination with the parts of the other. Mercury and the marine acid afford an inſtance; in their natural ſtate

* Dictionary of Chemiſtry.

ſtate they refuſe to unite; but deſtroy the coheſion of their parts, and they combine without difficulty; for the acid diſſolves the mercury when either converted into vapour or precipitated from a nitrous ſolution. Mercury is given by itſelf as a medicine, with ſafety, and its efficacy then depends ſolely upon its own operation: but, again, when it is joined with the marine acid, the parts being no longer in contact with each other, the attractive force by which they were united, operates in a new direction, and carries them, with a violent impulſe, upon the bodies to which they are moſt contiguous. Hence the corroſive force of the ſublimated mercury, which in proportion to its ſuperior gravity, is more violent in its action than other poiſons. But, when mercury is combined in a larger proportion with the ſame quantity of marine acid, the particles of the metal approach nearer to each other; and their power of producing changes upon other bodies is thereby gradually diminiſhed, till they become at length almoſt incapable of operating as reagents. Sweet mercury is the reſult.

§ XXIX. *The various Uſes of Mercurial Salts.*

THE mercurial ſalts above deſcribed are uſeful, not only as medicines, but likewiſe in the arts. Kunkel beſtows laviſh praiſes on that mercury which is obtained by diſtillation from white precipitated mercury, with a mixture of iron filings, or fixed alkali. But I cannot think this to poſſeſs any higher virtues than other pure quickſilver. Gold that has contracted an unnatural hardneſs and brittleneſs, by intermixture with other metals, or by the action of their vapour, recovers its natural ductility, if it be melted, and a quantity of corroſive ſublimate caſt upon it; for the marine acid having a greater affinity with moſt of the other metals than with quickſilver or gold, forſakes the quickſilver with which it was united in the corroſive ſublimate, and attracts them from the gold. In this proceſs care muſt be taken, that the operator ſuffer no inconvenience from the vapours which ariſe from the corroſive ſublimate diſſolved by the heat of the fire, the pure mercury, and the extraneous metals ſeparated from the gold.

This mode of purifying gold is preferable to the proceſs by deflagration with nitre; for the deflagration of the nitre ſeparates not only the baſer metals, but even ſilver from gold. It is of importance to obſerve, that corroſive ſublimate may be employed to preſerve metals that are mixed and fuſed with zinc, from contracting any undue rigidity. Upon this principle, according to Neuman, workers in braſs throw ſalt on the metal in fuſion, to render it ſofter and more ductile.

Corroſive

Corroſive ſublimate and white precipitate are uſed in printing cotton, to make the cloth receive the colours, eſpecially red, and to make them ſpread equally upon the ground. It is a general, though needleſs practice, to add corroſive ſublimate, as one of the ingredients, to the preparation for dyeing black ſilk. Chemiſts, too, frequently uſe corroſive ſublimate in examining waters; in preparing butter from antimony, and other metals; as alſo in the preparation of ſal Alembroth.

PROCESS

FOR

BURNING BRICKS.

Artium magiſter uſus.

COLUMELLA.

§ 1. *Circumſtances which ſuggeſted the following Experiments, and the Deſign of communicating them.*

I HAVE long obſerved the mode of making bricks commonly practiſed, to be in many particulars injudicious, and ſuſceptible of great improvements. The Academy at Upſal, ſome years ago, impoſed on me a taſk which gave me an occaſion for a ſtricter enquiry into this matter. I was enjoined by that body to examine ſeveral different ſorts of clay uſed in making bricks in the works under their direction. The experiments which I then inſtituted, confirmed my conjectures: And I now communicate them with the greater confidence, becauſe this art, notwithſtanding

notwithſtanding its utility and importance has been hitherto neglected by chemiſts.

§ II. *The different Sorts of Bricks.*

MANY are of opinion that bricks, ſuch as are made at preſent are too porous aud ſpungy, and are much inferior to the bricks of the ancients. I myſelf have ſeen brick-walls crumble down within a few years after they were erected; yet it is not uncommon to ſee a brick-wall retain all its original firmneſs and ſolidity after having ſtood a century or two. I mean not, however, to ſpeak here of bricks for building common walls. Theſe muſt be very bad indeed, if they will not laſt for a number of years when properly cemented and plaiſtered; and this latter circumſtance I am to conſider at length elſewhere. But for chimnies and other parts of buildings of which the materials are required to be ſolid, bricks or tiles ought to be prepared by the proceſs of which I am about to give a detail. Care muſt firſt be taken, however, to have the roof formed of durable materials, as a protection from the weather and from accidents. Wooden roofs are very improper, they are very liable to catch fire, and they occaſion the woods to be cut down before reaching their full growth. Turf is no leſs unſuitable; the uſe of it cauſes the meadows to be ravaged, and beſides, other materials are ne-

ceſſary

ceſſary to fix the turfs together. Plates of any metal are both too expenſive, and require to be covered with wood, and yet are no ſecurity againſt fire. The uſe of ſlate for roofing houſes, although it may be found in Sweden, is almoſt entirely unknown to my countrymen. Tiles therefore are the only proper materials that remain for us to uſe. And it is eaſy to ſee of what conſequence it is to have them compact and ſolid.

§ III. *The ordinary Faults of Tiles.*

Softness is the greateſt fault of tiles. I have ſeen tiles burnt in the beſt brick kilns in Sweden, which on a roof of 30 degrees of inclination abſorbed water like a ſponge. The water retained in the pores of tiles is congealed in winter, and the expanſion of the ice ſplits and ſhatters the tiles, ſo as to render them in a ſhort time abſolutely uſeleſs. To keep out the water, tiles are in ſome places incruſted with a thin covering of vitreous matter; which adds conſiderably to the expence. But, if tiles were more thoroughly burnt on the ſurface, ſo as to be nearly reduced to fuſion, they might, in my opinion, be rendered ſo hard as to abſorb very little moiſture, and to be almoſt entirely proof againſt the influence of froſt. But, before ſaying more on this head, I muſt enter into a more accurate examination of the nature both of pure and common clay.

§ IV.

§ IV. *Pure Clay.*

I KNOW not that pure clay is liable to fuſion, by any intenſity of heat, unleſs perhaps by that of the burning glaſs. D'Arcet found it to undergo no change in the heat of a porcelain furnace. In the fire, however it becomes ſo hard as to give fire with ſteel. This is owing to the increaſe of its denſity, for it loſes almoſt one half of its bulk.

Pure clay is not fuſible with quicklime, in any proportion. But the addition of even the ſmalleſt quantity of ſiliceous matter brings the maſs to fuſion. And the fuſion takes place very readily if to one part of pure clay, and one of lime, two or three parts of ſiliceous earth be added; a larger proportion of ſiliceous matter is unfavourable to the fuſion of the mixture; and the addition of five parts renders it almoſt infuſible. A mixture of equal parts of clay and lime ſuffers one half leſs diminution in bulk than the ſame quantity of pure clay would ſuffer. But, if in the mixture, the clay be only in the proportion of one to five, or one to ſix, it produces ſcarce any alteration on the character of the lime. Clay is not fuſible with pure quartz; but, according to Pott, it melts without great difficulty with fluor mineral. Feldſpath, or ſcintillating ſpar, often fuſes by itſelf in the fire, and,

and even aſſiſts the fuſion of clay. The *Petuntſe* of the Chineſe, uſed in making their porcelain, is a mixture of this latter ſort; and it is by this means that they reduce their clay to fuſion.

§ v. *Common Clay.*

CLAY of various degrees of purity is found in many places on the ſurface of the earth, but ſcarce any where in perfect purity. For ſuch of the common clays as have been examined, have been found to contain a large proportion, ſometimes no leſs than ſeventy in an hundred parts of ſilicious ſand. Waſhing, indeed, detaches the ſand, but a very ſubtile ſiliceous duſt ſtill remains, and cannot be ſeparated unleſs by the ſolution of the clay. Hence it appears, why the mixture of clay and lime commonly known by the name of marl, is fuſible in the fire. It is thought to be the lime that occaſions the fuſion, whereas it is the ſiliceous earth.

The Swediſh clays are fuſible without lime; but the reaſon of this cannot be preciſely explained. Some have thought that the iron in the Swediſh clay promotes its fuſion. But Rinmann diſcovered by a ſeries of experiments, that clays contaminated with a large proportion of iron, are more refractory than thoſe in which

which there appears no indication of the prefence of this metal. Perhaps the true reafon is to be looked for in the fand intermixed, which may be often fufpected to contain many particles of fcintillating fpar. I fufpect alfo, that it fometimes participates of the nature of gypfum or fluor mineral. One thing certain, is, that vitriolic acid is almoft always intermixed with the clay: and hence the fulphureous fmell that is always felt in the neighbourhood of brick-kilns. And, if lime be intermixed with the clay, it muft unavoidably abforb the acid: for which reafon an examination with acids will always be found fallacious.

If the iron be combined with vitriolic acid, the colour appears in the burning. For as the violence of the fire increafes, it affumes firft a yellow colour, then a red, then a dark grey, and at length a deep black. The colour is darker or lighter in proportion as the quantity of iron intermixed is greater or lefs. If the burning does not expel the whole of the vitriolic acid, the acid often attracts moifture from the air, and effloref ces in the form of alum.

§ VI. *How Bricks fhould be formed and burnt.*

Bricks confift univerfally of clay and filiceous earth. The clay renders the mafs ductile, and fufceptible of induration. But as clay, by

itfelf,

itſelf, is contracted and cracked, as well as hardened by the action of fire, an intermixture of ſand is therefore requiſite, which, as it is expanded by heat, and diminiſhes the quantity of the clay, muſt render the whole brick leſs liable to contract. But we muſt beware of adding too much ſand, as that would be unfavourable to the denſity and ſolidity of the maſs.

In making bricks, therefore, as much ſand ought to be intermixed as may be neceſſary to prevent the bricks from drying and cracking; unleſs particular circumſtances may recommend a different proportion, of which hereafter. Nature, in many places, preſents clay with ſuch a mixture of ſand, that no addition whatever is requiſite. And as it is no eaſy taſk to mix clay and ſand in the due proportions, that where the mixture has been performed by the hand of nature ought always to be preferred. Art cannot imitate the perfection in which nature intermixes theſe two ſubſtances, but produces a rude unequal maſs, which is variouſly affected by the action of fire, and is liable to have its denſity greatly impaired. But when an artificial mixture is to be made, the ſand ought to be choſen fine, and conſiſting of minute particles rather than thick, and contaminated with earth, and to be painfully mixed with the clay.

The heat muſt be ſufficiently intenſe to melt the bricks on the ſurface. This renders them ſo

compact

compact as to exclude water. But if too great violence of fire be applied, there will be danger that the bricks, eſpecially in the loweſt and the middle ſtratum, be either entirely melted, or at leaſt, run together.

§ VII. *Attempts to improve Clays, by the intermixture of other Subſtances, are of no Service.*

THE makers of bricks diſapprove of mixing poor clays with a large proportion of ſand, earth, and lime: for experience has ſhewn that theſe ſubſtances are of no uſe whatever in the preparation of bricks. Yet it is often not ſo much the ſubſtance, as the method of preparation followed that is faulty. The burning is frequently conducted in ſuch a manner as to reduce the lime to quick-lime, in which ſtate it abſorbs moiſture from the atmoſphere, and cauſes the bricks to crack and form chinks for the reception of water. But a more entire burning will obviate this inconvenience, by blending the lime thoroughly with the ſand and clay, and producing a ſort of vitrification. In this caſe, the lime, inſtead of doing harm, is even of advantage, contributing, in no ſmall degree, to the fuſion of the clay. When, therefore, there happens to be marl in the neighbourhood of a brick kiln, it ought to be preferred to any other ſort of earth. But marl is liable to various imperfections which render

render it leſs ſuitable as a material for bricks. The chief of theſe, its containing too large a proportion of lime, may be remedied by the addition of clay. Another fault of marle is, when its parts have too great a tendency to vitrification; but the addition of ſiliceous earth rectifies this*. Care muſt likewiſe be taken, that the lime be ſufficiently pulverized. If it be in lumps, the proceſs is more likely to miſcarry.

VIII. *Experiments of the Author.*

I AM now to give an account of a ſeries of experiments which I made upon common clay, without any admixture of lime, and two different ſorts of marl both dug near Upſal. Of theſe earths I had bricks formed and burnt, ſome without any ſand, others with one-fourth of ſand to three-fourths of clay. Thoſe in which there was no ſand did not crack as they were dried; from which it appeared that the ſubſtance of which they were compoſed, was of itſelf, without any addition whatever, ſufficiently ſuitable as a material for bricks. Of the bricks ſome were burnt till they became red, and to others a more intenſe heat was applied, which gave them a dark brown colour and rendered them hard on the ſurface. But the hardeſt were thoſe into the compoſition

* § iv. v.

compoſition of which a fourth part of ſand had entered. Others which had been expoſed to the moſt intenſe heat, ſwelled and aſſumed the form of a black fibrous ſlag. The bricks, after being burnt and cooled, were caſt into water, which, after abſorbing copiouſly, they were removed, and expoſed for three whole years, to the open air. Thoſe which had been expoſed for the ſhorteſt time to the fire, were almoſt totally deſtroyed and crumbled down by the action of the air; ſuch as had been more thoroughly burnt, ſuffered leſs damage; and upon thoſe which were formed ſolely of clay, and had been half vitrified on the ſurface by the action of a very ſtrong fire, not the ſlighteſt alteration was produced by the influence of the air and weather.

§ IX. *Advice relative to the burning of Bricks.*

FROM theſe experiments in the ſmall way a judgement may be formed, how far any clay is proper as a material for bricks. The more clay is liable to contraction in drying, the greater addition of ſand does it require. The beſt clays are thoſe which need no ſand. For, with ſuch, the labour is abridged, and the bricks are of a ſuperior quality. The colour, after burning, ſhews whether there be any iron in the bricks. The nature and appearance of the matter varies with the degrees of the heat to which it is expoſed;

and hence we have indications by which we m distinguiſh when bricks are thoroughly burnt in the kiln. Every perſon is ready to obſerve that bricks are too ſoft, and imperfectly burnt: but few have ſkill enough to diſcern the blunders which are liable to be committed in the proceſs of preparing bricks, or how far the burning ought to be carried. For the apyrous clay of which bricks are ſometimes compoſed is not vitrifiable merely by burning: and indeed no vitrification is neceſſary when they can be rendered hard enough ſolely by the violent action of fire, If, however, a vitreous cruſt be thought neceſſary, it may be formed with great eaſe, and almoſt no expence, by diminiſhing the fire for a little, throwing in a ſmall quantity of ſalt, and ſhutting up the kiln immediately. The bricks will thus infallibly acquire a vitreous cruſt, and that in the readieſt manner poſſible. It only remains to determine the proportion of ſalt neceſſary.

§ x. *Method of aſſaying Clay for Tiles.*

To inſure ſucceſs, it will be highly proper to examine the nature of the clay before proceeding to form it into bricks. This may be moſt expeditiouſly done in the following manner: nitrous acid, poured upon unburnt clay, detects the preſence

ſence of lime by producing an effervеſcence. Calcareous clays, or marle of this character are often the fitteſt materials for bricks. Farther, take a lump of clay, of a given weight; macerate it in water, and ſhake the mixture; then, ſuffering the heavier parts to ſink to the bottom, pour the liquid into a different veſſel; mix the reſidue with a new quantity of water, and repeat this proceſs, till the whole become perfectly limpid. The clay is now all diſſolved, and what remains is nothing but ſand. Whatever matter may be found to have ſubſided in the different veſſels, may alſo be reduced by repeated waſhings to the fineſt ſand. Again, to ſeparate the lime which may be intermixed with the clay, pour upon a quantity of clay in any veſſel ſpirit of nitre to the depth of a few inches; digeſt the ſpirit of nitre upon the clay, then after the effervеſcence has ceaſed, let the clear liquor be poured on the ſand previouſly ſeparated, which is ſometimes equally contaminated with lime. An additional portion of clay muſt be from time to time added to the aquafortis, till the effervеſcence entirely ceaſe. The clay and ſand are then taken hot, and waſhed apart. It is needleſs to burn the clay in theſe experiments, as that would diſſolve a part of it. But, let ſpirit of volatile alkali be dropped into the ſolution of lime in nitrous acid, till the lime be precipitated; pour the pure liquor into a different veſſel; and wafh the refidue with hot water. At length, when the clay, the lime, and the fand are all fully dry, weigh them feparately, that their proportions in the mafs may be afcertained. The fand may be examined with the microfcope, in order to diftinguifh whether it contain any filiceous matter, fcintillating fpar, &c.

After making the affay, it will be eafy to diftinguifh the pecular nature and the compofition of the clay; whether an addition of fand be requifite to render it a fit material for bricks; what kind of fand it may be proper to add; and by what indications we are to know whether the bricks be thoroughly burnt.

Of

OF THE
ACIDULATED WATERS
OF
MEDVI.

———————— *rebus quisque relictis,*
Naturam primum studeat cognoscere rerum.

LUCRET.

§ 1. *History of the acidulated waters of Medvi.*

MEDVI is situated in the diocese of Nykyrke in Gothland. The medicinal springs are at the distance of a quarter of a Swedish mile. They owe their celebrity to Gustavus L. B. Soop, senator of the kingdom, and Lord of the Manor, who first discovered them in the year 1677. That nobleman sent a sample of the water to Ulbanus Hiærne, who was at that time royal archiater; and he, after examining its nature, and visiting the springs next year in person, pronounced it salubrious. There were then three springs, commonly known by the names of *Hogbrun*, *Dal-*

 brun,

brun, and *Rodbrun*,—the Upper, the Nether, and the Red Spring; the two firſt five and twenty paces diſtant from each other, the third an hundred paces diſtant from the firſt. The Upper ſpring, on account of the ſuperior excellence of its water, as well as its ſituation, was firſt opened, incloſed with a ſtone and lime wall, covered above, and ſolemnly conſecrated on the 25th of July, 1678.

It is remarkable, that the octangular building with which it was incloſed, ſtill ſtands entire; and the original roof is ſtill a ſufficient ſhelter from the rain, although ſurrounded with tall branchy trees, and expoſed from its ſituation to uncommon quantities of rain and continual dampneſs.

Wells have not yet been dug at the openings of the other two ſprings:—The *nether*, or *lower* ſpring, ſo called from its low ſituation; and the *red* ſpring, which owes its diſtinguiſhing epithet to the ochre with which its waters are mixed.

It is more than probable, that the virtues of thoſe waters had been long known to the neighbouring inhabitants. To the red ſpring particularly ſacrifices appear to have been offered, and religious veneration paid. Whether theſe ſprings retained their celebrity during the reign of popery, we know not. In the Collectanea Oſtrogothica of Palmſchold mention is made, that

Jos.

Jos. Constantin an Italian physician had seen in the Vatican library an old manuscript concerning the salubrious virtues of certain acidulous waters in Gothland, which I take to have been those of Medvi.

§ II. *What has been discovered by former Experiments concerning the peculiar Virtues of the Waters of Medvi.*

HIÆRNE made some experiments on the water of the upper spring, the results of which, though they did not indicate with certainty or precision what different matters it contained, or in what quantities or proportions; yet induced that author to think, that there existed in the water a certain universal acid, capable of acting upon crude iron ore, richly impregnated with sulphur, and of producing by this operation *volatile vitriol*, and a portion of ferreous sulphur. Hiærne thought farther, that a portion of this universal acid, saturated with calcareous matter, formed the *alum*, which he imagined, he discovered in the waters of Medvi.

As the waters of Medvi have been so long and so generally celebrated for medicinal virtues, superior to those of any other mineral waters in Sweden, it is surprising that no person, before me, has been induced to attempt a more accurate analysis of them. In the year

1778, indeed, the illuftrious L. B. Alftroemer, Counfellor of the Palace, and Commendator of the order of Vafa, fent me twelve pints of the water of Medvi, and half a pint of a liquor that remained after the evaporation of ten pints and an half of the fame water, with a brief detail of experiments made upon it by Dr Dubb: and at his defire I immediately fet about analyfing it. I have elfewhere related what I then obferved *. But having myfelf, in this very year, had occafion to vifit that watering place, I availed myfelf of the opportunity to make new and more accurate experiments upon the mineral waters of Medvi, of which I fhall here give an account.

§ III. *Phyfical Qualities of the Waters of Medvi.*

The water of the mineral fprings of Medvi, is indeed limpid, but not fo clear as common fpring water.

In the month of Auguft, I found the temperature to be, at the bottom of the well, 6 ¼ degrees above zero in the Swedifh thermometer, and 7 degrees of the fame thermometer at the furface. At the ufual hour of drinking the water, the temperature of the well was fome degrees above that of the open atmofphere; but this, as well as the difference between the temperature of the furface and that of the bottom of the well, might

* Opufc. Chem. v. 1. p. 255.

might probably be owing to the building which covered and inclosed the well being at that time crowded with people. When water was brought to me, in my room, I found its temperature 8 degrees. Any person wishing to have it as cold as possible, should therefore drink it at the well, and take care to have what he drinks drawn from the bottom. There is also another reason for this, which I shall mention by and bye.

It tastes somewhat of iron, though not disagreeably; but has nothing of that pungency which is peculiar to aerated waters.

In drinking it, the nostrils are offended with a hepatic smell, like that of rotten eggs. This smell, however, is not very strong, for it was not felt by any of those who were present at the spring when I first observed it, till I mentioned it to them. Hepatic air is the most powerful principle in mineral waters: to it the mineral waters of Lokarne and others in Sweden owe their virtues. And no wonder that the principle of those virtues was not earlier discovered, as vessels for receiving and collecting aeriform bodies have been but lately invented.

From what was above said respecting the water of Medvi being warmest at the surface, it is plain that the hepatic gas will be sooner disengaged there. A person whose sense of smelling is but moderately acute, will readily perceive the

the difference between water drawn from the bottom of the well, and water taken from the ſurface. And this is the other reaſon to which I above alluded, for drawing water for drinking rather from the bottom than the ſurface of the well. This may be done with a veſſel in the ſhape of an inverted cone, made of tin or pure ſilver, truncated on the under part, and cloſed with a ſolid bottom, ſo contrived that it may riſe upon a hinge, when the veſſel is immerſed, and may be again ſhut by the weight of the water when it is taken up. With this veſſel fixed to a long wooden handle, water may be taken up from any depth. A ſmall iron rod may be fixed to the brim of the veſſel, in order to clear the bottom of the well, and the water may run out from the narrow part of the cone into a different veſſel. This mode of drawing the water will be adapted, I preſume, by all who wiſh to have it as cold and as ſtrongly impregnated with hepatic air as poſſible; although I mean not to aſſert that it is of no uſe when drunk in the common way.

This mineral water appears to be lighter than common water: but not having an hydroſtatic balance at hand, I could not determine its ſpecific gravity. A pint of it weighed an hundred and ninety four drachms.

§ IV.

§ IV. *Chemical Analyſis of this Water.*

I FOUND by experiment that the water of Medvi contained two volatile principles, aerial acid, and hepatic gas. It contains alſo iron diſolved in aerial acid, or aerated; a little ſalited lime; as alſo a ſmall quantity of common ſalt, and mucilaginous extract.

The preſence of the aerial acid is detected not by the taſte, but by the infuſion of lime water, or tincture of turnſole. There are ſcarcely ever more than ſix cubic inches in a pint of water.

The ſmell again betrays the preſence of hepatic air: but ſo ſmall is the proportion in which it is contained in theſe waters, that no ſulphur is produced upon the infuſion of fuming ſpirit of nitre. Collected with the aerial acid, it fills a ſpace of 14 cubic inches; but when abſorbed by lime-water, its meaſure is only eight cubic inches.

Tincture of galls, and a lixivium of blood, indicate the preſence of iron: Or, if the water be ſuffered to remain for a few days in the open air, the iron falls to the bottom without any addition being made. From which it appears to have been maintained in ſolution by aerial acid.

It is ſome time ſince I propoſed a proceſs for diſtinguiſhing whether martial water be fit for

medical

medical uſes, or crude and contaminated with vitriol. Yet for the ſatisfaction of ſome who have lately queſtioned me on that head, I am induced to repeat here briefly what I formerly advanced.

Let the water be boiled for a quarter of an hour in a clean kettle; then let it cool, and pour it into a glaſs veſſel. Into another cup pour freſh ſpring water. Into each of theſe veſſels pour a few drops of ſpirit of wine, in which a quantity of powder of galls has been previouſly macerated in a cloſe veſſel.

If the boiled water afford not the ſame quantity of precipitated ſediment as the freſh water, it may be concluded to have contained iron diſſolved in aerial acid, and to be, of conſequence, an acidulated water. But if the ſediment be the ſame in both veſſels, or only a little ſcantier in that which contains the boiled water, the boiled water may then be concluded to contain a mineral acid, and be unfit for medical purpoſes, till its nature be farther inveſtigated.

Each pint of the water of Medvi contains three grains of iron.

This water contains no extraneous matter beſides the principles now enumerated; and all of them are of ſingular efficacy. The quantity of ſalited lime intermixed, is ſo very trifling, that the ſaccharine acid ſcarce detects its preſence at the end of four and twenty hours; and almoſt no fixed alkali can be obtained. The

nitrous

nitrous ſolution of ſilver ſhews the lime to be united with ſalt. Only half a grain of ſalited lime exiſts in each pint of water.

A few minute particles of common ſalt, ſcarcely viſible, appear in the reſiduum, after the boiling, but the whole are ſcarce equal to one fourth of a grain.

A ſolution of ponderous earth hath not the effect to render water of Medvi turbid; whence it appears, that this water contains no mixture of vitriolic acid.

Extractive mucilaginous matter precipitated with vinegar of litharge, the ſolution of ſilver being previouſly ſeparated with marine acid, is obtained in the proportion of three grains for every pint of water. There muſt therefore be a grain of pure mucilage for every pint.

Upon comparing theſe experiments with thoſe of Hiærne, it appears, that Hiærne's univerſal acid, which he regards as exiſting in a ſmaller proportion in the Medvi than in the Spa water, is the ſame principle which we denominate aerial acid;—that his ferreous ſulphur is hepatic air;—and his alum, ſalited lime.

Although there be in Sweden other acidulous waters endowed with medicinal virtues, yet we know of none, as yet, equal to thoſe of Medvi. It may therefore be proper to inſtitute a compariſon between the Medvi waters and thoſe of Pyrmont and Spa, which have been long imported

ported into Sweden, and celebrated as ſuperior to the mineral waters of our own country.

In this compariſon it appears,

1. That in the waters of Medvi there is a ſmall proportion of aerial acid, ſufficient indeed for the ſolution of iron, but not in ſo large a proportion as to give that agreeable pungent taſte which is peculiar to freſh Pyrmont water.

2. The Medvi water contains hepatic air, not a particle of which can be detected in the mineral waters of Spa and Pyrmont, in the ſtate in which they are commonly brought into Sweden.

3. The water of the Upper ſpring of Medvi affords nearly the ſame proportion of iron as the water of Spa or Pyrmont,—about one fourth of a grain to the pint.

4. The water of Medvi contains none but medicinal principles; but the foreign waters of Spa and Pyrmont have many other principles intermixed in them, which are either deſtitute of all virtue, or directly pernicious; no leſs, for inſtance, than 18 or 20 grains of lime and chalk in every pint. Nay Pyrmont water is found to contain about 38 grains of gypſeous matter, to which many who drink it in large quantities find their conſtitutions unequal.

§ V.

§ V. *Of the internal Uſe of the Water of Medvi.*

I HAVE heard many who were in uſe to drink the waters of Medvi 30 or 40 years ago complain that its ſtrength and virtue are no longer the ſame; but its taſte more inſipid, and a larger quantity neceſſary to be drunk at once, in order to produce the proper effect. But it is by no means a ſure teſt, to taſte after a long interval, what you had taſted once before, for age impairs the ſenſibility of the tongue. Again, as to this water being drunk in larger quantity now than formerly, that is no proof of its loſing its virtues. Hiærne relates, that on the firſt diſcovery of the ſpring of Medvi, a certain perſon who had loſt the uſe of his feet, drank a whole firkin of the water every day, and at night, too, called for water whenever he awaked. So far, however, was this perſon from being hurt by drinking it in ſuch enormous quantities, that he was in the ſpace of a few weeks, reſtored to perfect health. I can readily grant, indeed, that but few, and thoſe perſons of a ſtrong frame and a vigorous conſtitution, could drink ſo much water without being injured by it. But what I want to prove, and that is plain from Hiærne's relation, is that no inference can be drawn againſt the ſtrength of the water, from the circumſtance

cumſtance of its being drunk in larger quantities now than formerly.

Mineral waters may happen, however, to loſe their virtues in the courſe of time. Many ſprings have, indeed, retained their ſalutary virtues for ages : but there are others whoſe medicinal powers have generally declined. Even of Medvi the taſte and efficacy have not been uniformly the ſame. Hiærne himſelf bears witneſs, that he had found its taſte ſometimes ſweet, ſometimes bitter ; probably as the proportion of the hepatic air varied : and that ſo frequently, that it could not be referred either to the changes of the moon, or the ſeaſons. I myſelf obſerved it to undergo a ſimilar change in the end of the month of Auguſt. All who had been before at the ſpring found it to taſte ſtronger than uſual then of iron.

That the waters of Medvi are endued with remarkable healing powers, appears from numerous inſtances of perſons, who both in former times, and in the preſent age, have recovered their health by drinking of them. Many upon drinking it, immoderately have in a week or two found their ſtomach oppreſſed, their head rendered giddy, their knees infeebled, and have felt it impoſſible to reſiſt ſleep after dinner. Our water contains leſs iron than that of Pyrmont ; but this very quality renders it the fitter for ſtrengthening a weak ſtomach, which is

often

often unable to bear much iron, and is much more benefited by the daily uſe of a moderate portion. I found myſelf ſurpriſingly better for the Medvi water. And from many years experience, I can declare, that I have received leſs benefit from journies into different countries, for the ſake of health, than from exerciſe, and the uſe of this mineral water.

For the uſe of thoſe whoſe caſes may require a mineral water more ſtrongly impregnated with iron, I would adviſe the lord of the manor to open the Red ſpring, and incloſe it. The water of this ſpring contains a proportion of aerated iron, at leaſt equal to that of the water of Pyrmont:—every pint affords 4½ grains. It contains alſo no ſmall quantity of hepatic air, and of aerial acida mode rate proportion, not diſcernible by the taſte. It therefore reſembles the water of the Upper ſpring; only, has more iron in its compoſition. It may, accordingly, be of great ſervice to men of a ſtrong conſtitution; or even to thoſe who are weaker, if they uſe it only when recovering from illneſs, or drink a cup a day after drinking firſt of the water of the Upper ſpring.

§ VI. *Uſe of the Medvi Waters in Baths.*

Many of thoſe who viſit the mineral wells of Medvi, bathe in cold water from the upper ſpring, the earth uſed in the baths is found near the red ſpring. It is fine, black, and free of ſand, yet affords, in a ſlight degree, the ſame hepatic odour, as the mud of the waters of Lokarne; hence the pimples and itching of the ſkin produced in the bath of the water of Lokarne are not obſerved here. I myſelf received the the ſame beneficial effects from this bath which many had experienced before me.

OF THE

MEDICINAL SPRINGS

OF

LOKARNE.

———— *juvat integros accedere fontes.*

LUCRET.

§ I. *History of the Lokarne Springs.*

IN the pariſh of Grythytte, and the diſtrict of Oerebroeve, is a marſhy vale, lying in the midſt of high hills, with two lakes called the lakes of Lokarne, upon one ſide. In that vale are three ſprings, which from the contiguous lakes, have been denominated Loka-kalor, or the *Lokarne* ſprings. It is probable that one of theſe known by the name of Old ſpring, was in days of old, reſorted to as medicinal by the adjoining inhabitants; and that they aſſembled round it, par-

 ticularly

ticularly on John Baptiſt's eve, a cuſtom not yet entirely gone into diſuſe. But it had been long neglected, till about ſixty years ago, it was opened anew, and incloſed with a ſtone and lime-wall. The water of this ſpring is now uſed only by the lower claſs of people. Another to which people of middling circumſtances reſort, is named the new well. It is ſituated near the Inn, and was firſt opened and incloſed with a building in the year 1767. The third, called the Bath-well, is at ſome diſtance from the Inn. The water of this well is drunk at table in the Inn, and is uſed in bathing. Theſe three wells are arranged nearly in a triangle; the old well being about eight and thirty fathoms diſtant from the new, and thirty from the bath-well; the bath-well again being eight and forty fathoms from the new well.

§ II. *Phyſical qualities of the Lokarne Water.*

In June 1783, I made the following obſervations on the Lokarne water.

1. It is clear as cryſtal: and muſt therefore contain either no mucilaginous matter, or at leaſt very little.

2. It is pleaſant to drink; taſting nearly like common ſpring water. But it dries the mouth; whereas common ſpring-water rather cauſes the ſaliva to ſecrete more copiouſly.

3. This

3. This water, new out of the ſpring has no peculiar ſmell; but violent agitation makes it afford an hepatic odour. This odour is ſtronger in the water of the new than in that of the old ſpring; and again in that of the old than in that of the bath-ſpring.

4. This water feels cold. In the new well the mercury ſtood in the thermometer at ſix one-fourth degrees; while the temperature of the atmoſphere was at the ſame time no leſs than thirteen degrees, The ſame thing was obſerved of the old well. On the wall incloſing the latter, I found an inſcription bearing, that on the 25th of June 1757, the thermometer which had ſtood in the open air at twenty one-half degrees above Zero, fell in the well to eight degrees; and that at five in the morning on June 1, 1758, the temperature of the atmoſphere, being nineteen and a half degrees, that of the water in the well was only ſix. Between this laſt obſervation and my own there is only one-fourth of a degree of difference. This difference might be owing to a faulty conſtruction of the thermometer. Berge has aſſigned the ſame degrees of temperature to the mineral waters of Lokarne. As to the mercury falling in the thermometer only to the eighth degree in the old ſpring; that might happen in conſequence of the inſtrument not being ſufficiently immerſed in the water, or being too haſtily taken out. Whoſe were the obſervations

inſcribed on the wall I knew not, till the keeper of the wells informed, they were written by the celebrated Odelſtierne, director of the mines.

In the bath-well the mercury ſtood at ſeventy. It is ſcarcely a fathom deep. The water, as above mentioned, is both drunk at meals and uſed for bathing. It is alſo conveyed into that called the Engliſh bath, which is but of late date, and is 9 one-half fathoms long, three one-half broad, and two deep. The water in this bath is conſtantly freſh; it being ſo conſtructed that new water from the well runs runs it, while that which has been made uſe of is conveyed off. Hence its temperature is often eight degrees colder than that uſed in the common baths.

It is not ſo eaſy a matter as is commonly imagined to aſcertain the exact temperature of the water with the thermometer. Although the thermometer when immerſed in water indicates the temperature of the water with ſufficient accuracy; yet when taken out to be examined, it is liable to be affected by the breath, and by the temperature of the atmoſphere; and concluſions formed concerning the temperature will of conſequence be uncertain and indeciſive. To avoid theſe inconveniencies, I put the thermometer in a perpendicular poſture, into a glaſs veſſel, ſo filled with ſand, that the point of the ſcale is at the brim of the veſſel. I then wrap up the inſtrument with a thick cord; and then immerſe it ſuſpended

ded by the rope into the well; in the bottom of which it is left for half an hour. With this apparatus, I obtain what I want: I can now difcern the precife heat of the water by the thermometer, without fear of the mercury falling when it is taken out.

In the cave of the Royal Obfervatory at Paris, the mercury of the thermometer ftands through the whole year at the fame degree, correfponding to the twelfth in our Swedifh thermometer. The waters of Medvi and Lokarne, therefore, and of other perennial fprings which have come under my obfervation, exceed that temperature only by one degree. The fame temperature is found to prevail in fubterraneous cavities. Now, as the water on the furface of the earth is fupplied by lakes and fubterraneous cifterns, at leaft as diftant from the centre of the earth as thefe fprings; it follows that the fource of thofe wells muft be extremely deep, whofe temperature is only fix degrees. Befides, the openings of fuch fprings are ufually inclined to the horizon. In general, however, the heat of water on the furface of the earth is different at different feafons in the year. In natural cavites in mountains, although on the fame level with the adjacent plains, water cannot but be uncommonly cold. But I can fcarce think there are many places in which it can become fo cold in ſummer as to reduce the mercury to ſix degrees in the thermometer.

5. The water is not always in equal quality. The new ſpring gives 142½ pints in the hour; the old ſpring 465; and the bath ſpring 517, one-half.

6. I could not determine the ſpecific gravity of the water of Lokarne, for want of inſtruments.

§ III. *Chemical Analyſis.*

FROM the account above given of the phyſical qualities of the waters of Lokarne, it appears, that they contain in their compoſition, but a ſmall proportion of extraneous and mineral matter. The ſame thing appears from experiment.

1. A pint of this water afforded by evaporation only two pennyeights and twenty-eight grains apothecary's weight. Nearly a fourth part of this reſidue was fine ſiliceous powder; the reſt calcareous earth in combination with marine and aerial acid. I have never indeed met with any ſpring-water entirely free of ſalited or aerated lime. But the infuſion of a few drops of the nitrous ſolution of ſilver ſoon diſcover the preſence of the marine acid, by communicating to the water, if it contains any of that acid, an opaline colour. In a few days the ſediment

ment is found in the water, in the form of a thin purple plate. When the ſediment is more copious, the nitrous ſolution produces a violet colour in the water; and when in ſtill greater plenty, tinges it black. The calcareous earth, when in no larger proportion than in the waters of Lokarne, is ſeparated in twenty-four hours by the ſaccharine acid.

The ſalited ponderous earth intermixed in the Lokarne water diſcovers no mark of vitriolic acid; nor does tincture of galls detect the preſence of iron. In the reſidue, likewiſe, which remains after the evaporation, no iron appears; unleſs the acid employed be previouſly tinctured with iron.

I meant likewiſe, had not ill health prevented me, to have examined the water of the old and the bath ſpring by evaporation. But, by the uſe of reagents I found the water of thoſe ſprings to contain the ſame principles as that of the new ſpring, only in an inferior proportion. Berge obtained only two grains reſidue for every pint of the water of the old ſpring.

2. There is but very little volatile matter in the water of Lokarne.

The taſte gives no indication of the preſence of aerial acid: yet that every pint contains two or three cubic inches of this aeriform fluid, appears from the circumſtance of a red colour being

ing produced in this water; when tincture of turnſole is poured into it in equal quantity.

I have obſerved above, that the Lokarne water contains hepatic air. But, ſuch is its ſubtility and volatility, that it eſcapes, although the glaſs veſſel, in which the water is contained be corked and ſealed in the moſt careful manner. A bottle of Lokarne water, the temperature of which was 107, being cloſely corked and kept by me in my bed-chamber, loſt in the ſpace of four hours all its hepatic air, ſo that even when ſhaken, it exhibited no appearance of having ever contained any. And, in water newly drawn out of the ſpring, was not above a cubic inch to the pint.

From what has been ſaid it appears, that the water of Lokarne is not mere ſpring water, though but very ſlightly mineralized. Moſt mineral ſprings owe their healing virtues either to aerial acid or hepatic air. Aerial acid, unleſs contained in a pretty large proportion, in water, produces but little alteration in its nature. Such as in the proportion of eight or ten cubic inches to the pint: whence it may be inferred that the water of Lokarne is leſs indebted to the aerial acid than to the hepatic air which it contains for its virtues. Hepatic air is a much more powerful agent than aerial acid: two pints of cold water that had abſorbed only two cubic inches of hepatic air, retained the peculiar o-

dour.

dour of that gas for, at leaſt, two days. But farther obſervations are required, to determine how far the mere internal uſe of this water may be beneficial: for at preſent all who drunk the Lokarne water, bathe at the ſame time.

§ IV. *The earth of Lokarne.*

THE earth uſed in bathing by thoſe who frequent the Lokarne wells is found on the ſide of a rivulet at a ſmall diſtance from the wells. It is fine, tenacious, contains very little ſand, and is often infected with a hepatic ſmell. In the baths this earth ſerves two purpoſes—it lubricates the ſkin by friction; and keeps the body cool. Any ſort of fine earth, or ſoft muddy clay would do the ſame thing. But if the mud contain hepatic air, an irritation of the ſkin is produced, and an itch breaks out. This earth, uſed in the baths of Lokarne does not unfrequently produce this effect, after the bath has been ſeveral times uſed. The vitriol intermixed with it co-operates with the cold in contracting the veſſels of the ſkin.

Berge has proved, by various arguments, that this earth is produced by putrefaction from the *ſphagnum paluſtre.* Its ſpongineſs and lightneſs I take to be owing to nothing but the dry character of that moſs. But, in order to inveſtigate more

more accurately the nature and qualities of this earth, I tried ſeveral experiments with it. I firſt poured upon it cold diſtilled water; and after the water was ſufficiently digeſted with the earth, and a ſufficient quantity of the ſoluble parts of the latter ſuſpended in the former, poured it through a ſtrainer. The lixiviate thus prepared continued pure, and ſuffered no change of colour from the infuſion of tincture of turnſole.

Tincture of galls mixed with ſome of this lixiviate, both in its original ſtate, and boiled, aſſumed a violet colour; but not readily, nor till after a conſiderable time. The ſaccharine acid produced no precipitate, and a ſolution of ſilver ſcarce any; ſalited ponderous earth rendered the white powder by degrees turbid. Hence then it appears that there is ſome vitriol in the earth uſed in the Lokarne baths; and that it forms with water a lixivate very different from pure ſpring-water. This affords a certain proof of what was above-mentioned, that water iſſues out of ſprings even in the depths of the earth; and that this and the water on the ſurface of earth have nothing common.

§ v. *Salubrious powers of the Lokarne waters.*

To render the ſalutary effects of this water better underſtood, I ſhall preſent my readers with

with an extract from the diary of the hospital of Lokarne, exhibiting a state of the sick, and their diseases for eight years backwards, which was communicated to me by Mr Knut A. Lenæus, inspector of the wells of Lokarne.

Diseases.	Persons who left the Wells.			
	Cu-red	Conva-lescent.	Re-lieved.	Incur-able.
Rhachitis	8	5	2	2
Soreness of eyes attended with running	5	2	3	—
Soreness of eyes attended with unatural dryness	4	3	1	—
Hysteriasis	6	5	3	—
Hæmorhoids	4	3	3	1
Hæmaturia	2	3	1	—
Cancer in the nose	—	—	—	1
Ulcer in the neck	—	2	4	—
An unnatural contraction	—	3	3	—
Difficulty in speaking	—	1	1	2
Valetudinary	10	3	3	—
Epileptic	—	5	3	8
Arthritis	25	6	7	2
Cataract	—	2	1	3
Vertigo	2	1	1	—
Melancholy	6	2	2	1

Deafness

Diseases.	Persons who left the Wells. Cu-red.	Conva-lescent.	Re-lieved.	Incur-able.
Deafness	4	2	2	—
Paralytic	12	5	2	5
Head-ach	4	2	2	—
Scurvy	6	1	—	—
Worms	3	4	1	—
——— lubrici	3	2	2	—
——— tenia	—	1	1	3
Hæmoptysis	7	1	2	—
Atony	1	1	2	—
Hypochondria	3	4	3	1
Dregs of an intermittent fever	6	2	3	—
Diarrhœa	—	2	—	—
Cephalæa	3	3	2	2
Aphonia	1	1	1	1
Slow fever	1	5	—	—
Madness	—	—	4	—
Asthma	6	2	2	—
Delirium	2	1	2	—
Dullness	—	—	—	3
Atrophy	2	3	—	2
Glaucoma	—	3	2	—
Amaurosis	—	2	—	2
Angina schirrosa	—	—	—	1
Itch	5	3	2	—
Erysipelas	2	3	2	—

Ascites

Diseases.	Persons who left the Wells. Cured.	Convalescent.	Relieved.	Incurable.
Ascites	—	2	—	—
Decrepid	3	2	3	1
Imposthume in the lungs	—	2	2	3
Hip-gout	5	3	3	—
Anchylosis	2	6	3	2
Steatoma	—	3	1	—
Cardialgia	6	3	3	2
Stone in the bladder	—	3	3	—
Paraplegia after lying in	2	2	—	—
Diarrhoe	3	3	2	—
Blood-shot eyes	4	2	3	—
Irregularity of the menses	2	3	—	—
Cachexia	3	1	5	—
Bleeding at the nose	2	2	1	—
Spasm	4	3	4	1
Scrophula	—	—	2	—
Hemiplegia	—	3	1	—
Arthritis siphylitica	—	3	—	—
Arthritis nodosa	5	4	3	1
Herpes	—	4	2	—
Blindness	—	2	—	5
Hectic	1	3	5	—
Convulsions	5	3	3	2
Total	195	161	129	56

OF

OF

COBALT, NICKEL, PLATINA,

AND

MANGANESE:

WITH THE

PRECIPITATES WHICH THEY AFFORD*.

——— *conſtare neceſſe eſt*
Ex aliis ea, quæ nequeant convertier unquam.
LUCRET.

§ I. *Circumſtances which ſuggeſted theſe experiments.*

OUR anceſtors knew of eleven metals. To theſe the induſtry of the preſent age has added other four: Cobalt, Nickel, Platina, and Manganeſe. Which were all firſt examined with accuracy, and diſtinguiſhed by their peculiar characters,

* Vide N. Acta Acad. Suec. Vol. I. 1780.

racters, in Sweden *. Moſt agree, from experience, that the three firſt of the above-mentioned new metals are, in their nature, eſſentially different from all other metals. There are, however, many who think theſe not to be primary, ſimple metals, but of a compound character. But the eagerneſs with which chemiſts entered upon an inveſtigation of the relations of theſe metals, has now thrown light upon many of the difficulties which they at firſt preſented. Yet, I don't know that any body has examined them by ſolution and precipitation in different menſtrua. I have therefore been induced to ſubject them to theſe proceſſes; and ſhall proceed to relate my experiments and obſervations.

§ XI. *Examination of Platina by Precipitation.*

I HAVE elſewhere given an account of the reſults obtained by the ſolution of platina in alkaline ſalts. The only thing which I ſhall here add, is, that no alkali, whether vegetable or mineral, aerated or cauſtic, produces any precipitation of platina that is actually diſſolved. The colour of the precipitate is yellow, inclining more or leſs to red; but when evaporated to dryneſs, it becomes black. A ſolution of an hundred

 weight

* Act. Upſal. 1733. Act. Acad. Suec. 1751, 1752, 1774. N. Act. Upſal, vol. ii. p. 135, 246. Scheffer's Chem. Forelaſn, p. 390.

weight of pure platina in aqua regia, with the addition of thirty-four pounds of aerated mineral alkali, afforded upon the infuſion of a quantity of cauſtic alkali, thirty-ſix pounds of precipitate, although the utmoſt care had been taken to have the ſolution compleatly ſaturated. It follows therefore, that the other two thirds of the metal were taken up in the neutral ſalt formed at the precipitation; as the parts of the platina that were diſſolved, could not but be of the ſame bulk and ſuperficies as thoſe which were precipitated.

To aſcertain the cauſe of this phenomenon more fully, I reſolved to try the ſame experiment on platina with other metals, inſtead of the alkali which I had uſed. I accordingly diſſolved an hundred weight of pure platina in aqua regia; and then poured into the ſolution, after diluting it in diſtilled water, as much zinc in ſmall thin plates, as it would diſſolve. No leſs than 416 pounds of the zinc, were diſſolved, with a conſtant effervеſcence, although the menſtruum had been previouſly ſaturated with platina to ſuch a degree that it would not diſſolve another grain of that metal.

Meanwhile, as the zinc was diſſolving, the black flaky matter ſubſided to the bottom of the veſſel. This reſidue, when waſhed and dried, was found to weigh 77 pounds. And when expoſed to the blow-pipe, firſt exhaled an aſh-coloured

loured ſmoke, and thus loſing its black colour, aſſumed ſoon after a grey and nearly metallic appearance. The ſmoke was not unlike the vapour which mercury emits.

A little of this black precipitate, mixed with microcoſmic ſalt, and expoſed to the heat of the blow-pipe, emits a ſmoke at the very firſt. The precipitate then runs into union with the ſalt; yet does not form a globule, unleſs when a very ſmall grain of it is expoſed to fire with a particle of the ſalt. When the proportion of the precipitate employed is too large, the maſs aſſumes a variety of colours; but if a ſecond time melted by a ſtrong blaſt of the fire, becomes generally pellucid. The ſame thing nearly takes place, if borax be uſed inſtead of microſmic ſalt; only the changeable colours do not then make their appearance ſo ſoon.

The pure liquor remaining after the precipitation of the platina and the ſolution of the zinc, was tinged with yellow, and ſeemed ſtill to retain a little platina; for when evaporated to dryneſs, with the addition of a little vegetable alkali, it afforded a few yellow grains of reſidue.

The black precipitate is not ſubject to the attraction of the magnet, either when newly precipitated, or no being expoſed to heat.

All the metals precipitate platina from aqua regia, juſt as readily as zinc.

§ 111. *Precipitates of Nickel.*

A faturated folution of nickel in nitrous acid is well known to be green. All alkalis whatever, diffolve the combination between nickel and nitrous acid. An hundred weight of nickel precipitated by aerated alkali, is of a very light green colour, which it retains when dry. The powder weighs, when dried, 135 pounds. Cauftic alkali produces a fimilar precipitate from the fame folution: but 100 pounds of nickel arife only to an hundred and twenty eight, when precipitated from a folution in nitrous acid with cauftic alkali. Plogifticated alkali produces a powder of the fame colour nearly, but rather yellower, and liable to affume, as it is dried, a greenifh yellow, of a darker hue. The precipitate obtained with phlogifticated alkali, after being wafhed and dried, weighs 250 pounds.

From acid of nitre in which I had diffolved an hundred weight of common regulus of nickel, which had previoufly undergone only a fingle procefs of reduction, upon the addition of a quantity of zinc, there fubfided feventeen pounds of arfenic, in the form of a black metallic powder. Meantime, the mercury ftood in the thermometer at fifteen degrees. By the application of a ftrong heat the powder was calcined to whitenefs. Yet fuch is the mutual attraction between nickel and arfenic, that a confiderable propor-

tion

tion of nickel is unavoidably precipitated with the arſenic. This appears from the melting of the precipitate with borax. For when the arſenic is diſſipated by the action of the fire, the glaſs that remains, diſplays the colour peculiar to glaſs of nickel. But when the ball of glaſs cools, the colour then diſappears, when it is evident that even in the precipitate there remains zinc. Another and ſtill more convincing proof of what has been above aſſerted, is, that the acid ſolution, when in a large quantity, and well warmed, affords together with the black powder, alſo a conſiderable portion, nearly an hundred pounds of a white powder. When this takes place, the green colour of the ſolution is very little altered; although it could not fail to become paler, if calx of nickel conſtituted the largeſt part of the precipitate. The powder precipitated from acid of nitre is eaſily ſoluble with the help of heat. The ſolution is grey, and on the infuſion of phlogiſticated alkali, affords a powder of an orange colour: a pretty ſtrong indication of the preſence of a conſiderable quantity of zinc. But that the ſame powder contains alſo zinc, appears from the colour of the ſolution, from the fuſion of which it is ſuſceptible with borax or microcoſmic ſalt, and from its reduction by which ſeveral pounds of regulus of nickel are obtained ſeparate.

From the green ſolution that remains after

 precipitation,

precipitation, all but a few pounds of the nickel originally employed, may be ſeparated.

From theſe facts it plainly appears, that zinc does not precipitate the nickel itſelf from the ſolution. For, whatever weight of zinc be put into the ſaturated ſolution of nickel, the green colour ſtill remains unchanged. If, then, there be any portion of nickel in the precipitated powder, its precipitation ſeems to me to be owing merely to the mutual attraction of the metallic calces; ſince it appears in the precipitate diveſted of its metallic form, which could not be the caſe, if nickel were, like other metals, precipitated by a double affinity. But there are various inſtances of metallic calces being connected by mutual attraction: gold combines with tin, copper with zinc, in the form of calces.

§ IV. *Precipitates of Cobalt.*

If a hundred pounds of regulus of cobalt be diſſolved in common nitrous acid, and a quantity of aerated mineral alkali be added to the ſolution thus prepared; a yellowiſh dark green precipitate, 160 pounds in weight, will inſtantly be produced. On the other hand, if cauſtic mineral alkali be poured into the ſame ſolution, the precipitate will weigh only 140 pounds, and will be indeed of the ſame appearance as the former precipitate, only darker in colour. Phlogiſticat-
ed

ed alkali precipitates from the ſame ſolution a powder of the ſame colour, but of a different character in other reſpects, and in weight 142 pounds. The production of the firſt precipitate is accompanied with effervescence; the ſecond ſubſides without any emotion in the liquor, the third is abſolutely inſoluble in acids. The ſame thing is true of the precipitates of nickel, prepared with the ſame alkali.

Nitrous acid ſaturated with an hundred weight of regulus of cobalt, upon the addition of an equal quantity of zinc, precipitated only a ſmall portion of ſlimy matter. I rendered the ſolution thicker by boiling, but in vain; for except the ſlimy matter, a part of which covered the plates of zinc, no other precipitate was produced. The zinc itſelf, as I found, upon waſhing and drying it again, had ſuffered no loſs of weight. Water poured upon the reſidue was very ſoon tinged with a red colour; and, on the admixture of aerated fixed alkali, afforded 135 pounds of a precipitate, unuſually red. The ſlimy matter when ſeparated, waſhed and dried, had a green colour, which the action of fire rendered blackiſh, and was ſubject to the attraction of the magnet; whence it appears to have been calx of iron ſeparated in the boiling, in the ſame manner as ochre is commonly ſeparated from a ſolution of iron. This feruginous matter is for the moſt part, void of arſenic; a ſmall portion of cobalt adheres to it, and is the cauſe of its acquiring a green colour from borax and microcoſmic ſalt. It communicates a yellow colour to the acids in which it is diſſolved; and without the portion of it employed be conſiderable, no redneſs appears in the ſolution.

§ v. *Precipitate of Manganeſe.*

The exiſtence of manganeſe was but very lately diſcovered. Of this I have elſewhere given a particular account. From a ſolution of an hundred pounds of this metal, aerated mineral alkali precipitates 185 pounds, cauſtic alkali 168, and phlogiſticated alkali 250. The firſt of theſe precipitates is whitiſh, with yellowiſh brown particles intermixed. The ſecond is of a dark colour. The third is at firſt green, but changes to yellow towards the end of the precipitation; in conſequence of which the dried powder, being a mixture of green and yellow, has a greeniſh appearance. But it is always to be obſerved, that while regulus of manganeſe is diſſolving, a brown powder is ſeparated,; which I obtained in the proportion of ſeven pounds to the hundred weight of manganeſe diſſolved in vitriolic acid. This powder is micaceous; it produces a violent detonation with hot fuſed nitre; the ſmall portion of iron which it contains, enables it to communicate an orange colour to acids; but it is in-

ſoluble.

ſoluble. From theſe circumſtances it may be ſuſpected to contain plumbago.

Into a ſolution of an hundred pounds, or rather of the ſoluble part of an hundred pounds, of manganeſe in vitriolic acid, I put a quantity of zinc, which I obſerved to precipitate only ſeven pounds of a brown ponderous metallic powder. This powder gives a green tinge to microcoſmic ſalt, but renders borax red, and like copper, deprives it of its tranſparency. But only a very ſmall part of the precipitate can be of a cupreous nature; for in its nitrous ſolution, unleſs the ſolution be very compleatly ſaturated, the infuſion of ſal-ammoniac ſcarce produces any green tinge. If, however, the volatile alkali be added in a larger proportion than what is requiſite to ſaturate the ſolution, a fine white powder immediately falls, communicating as it falls a ſlight tinge of green to the ſupernatant liquor. This white powder, when collected, waſhed and diſſolved in nitrous acid, aſſumes, upon the infuſion of phlogiſticated alkali, in part a green, and partly a yellowiſh colour, and ſubſides to the bottom of the veſſel: whence it appears plainly to be a mixture of calces of iron and zinc.

Zinc then does not precipitate the manganeſe itſelf, but the extraneous matters accidentally adhering to it. That the manganeſe remains in ſolution together with the zinc, appears plainly from what takes place on the infuſion of alkali.

For

For the alkali precipitates a powder that becomes black in the fire, tinges borax and microcosmic ſalt with the colour peculiar to manganeſe; which colour, however, ſoon fades on account of the zinc intermixed; zinc being well known to efface the colours of glaſſes.

From a ſaturated nitrous ſolution of manganeſe, there is a precipitate of copper obtained by the intervention of zinc; which has in part the red colour peculiar to that metal, and partly that pale green appearance which a precipitate, even a ſolution of fine copper uſually exhibits.

§ VI. *Corollaries..*

1. Were platina only a mixture of iron and gold, theſe two metals would, of neceſſity, be ſeparated, upon the addition of zinc to a ſolution of the mixture. Gold is precipitated from its ſolutions by all the other metals, and eſpecially by zinc. But zinc can never precipitate iron, even though diſſolved in vitriolic acid, which in other caſes combines but very ſlightly with the metals. Wherefore, ſince platina is precipitated by zinc, without the loſs of any of its qualities, I infer that iron, though often accidentally intermixed in it, forms no eſſential part of its ſubſtance. That which I uſed in my experiments had only a fourth part of iron, but the proportion varies; and in common platina there is

ſometimes

ſometimes more, ſometimes leſs iron. In the powder precipitated no mark of the preſence of iron appeared, although I fuſed it repeatedly by the action of the blow-pipe, with microcoſmic ſalt.

2. From ſolutions of nickel, cobalt, and manganeſe, zinc precipitates only heterogenous ſubſtances, accidentally intermixed with theſe metals. Now, as zinc precipitates all metals, except iron, it follows, that nickel, cobalt, and manganeſe are either particular modifications or ſpecies of iron, or entirely diſtinct from it. Some may, perhaps, ſay, that two or three metals may be ſo combined by nature, that zinc cannot ſeparate them in a ſolution in which they exiſt in natural combination, although capable of precipitating each of them from a ſolution in which it exiſts by itſelf. To this, if proved by experiments, I ſhall not refuſe to agree; but till it be eſtabliſhed by experiments, it would be fooliſh to receive it upon mere fancy and conjecture.

That nickel, cobalt and manganeſe are, as has been thought by ſome, modifications or ſpecies of iron, may be maintained by other arguments, beſides thoſe above-mentioned. Iron has much greater verſatility of nature, and is ſuſceptible of a much greater diverſity of forms than any other metal. Fuſed iron, cold iron, hot iron, brittle iron, ſteel, &c. have all diſtinct characters: and each

of

of them is by inſenſible degrees changed, till it be transformed into ſome other. A variety of colours too, red, yellow, green, azure, brown, and others are produced in iron by different modes of treatment, although not preciſely the ſame as are obſerved in the above three metals. It is, however, exceedingly difficult to ſeparate iron from nickel, cobalt, and mangaueſe; as I have elſewhere ſhewn particularly, in the inſtance of nickel. Of regulus of nickel I have obſerved, that the more painfully it is purified, the more does it come to reſemble iron in attractability by the magnet, and even the very fragments of the reguli then attract one another. I know that ſome reguli of nickel are not ſuſceptible of magnetic attraction. But ſuch need only to be purified in order to acquire this quality, eſpecially nickel precipitated with liver of ſulphur, muſt be freed of all extraneous mixture before it can become ſubject to the power of the magnet.

There has not, as yet, been ſo much pains taken to purify cobalt and mangaueſe as to purify nickel. But the experiments which have been made ſhew clearly that iron adheres to theſe metals with great obſtinacy, and is often attracted by them from among other matters.

There is alſo another argument which ſhews how great the affinity of nickel and cobalt with iron is. The pure reguli of theſe metals, though evaporated to dryneſs with acids, yield no ochre; which,

which, however, always appears when either iron by itſelf, or iron mixed with any other metal is diſſolved in an acid.

From theſe particulars it appears, that there exiſts a remarkable and ſingular ſimillitude between cobalt, nickel, mangaueſe, and iron; yet that ſimilarity is by no means ſo great as to induce us to think all theſe only are one and the ſame metal. For this can be demonſtrated no other way, but by producing pure iron out of cobalt, nickel, or manganeſe. But experiments ſeem rather to evince the contrary. For pure iron is eaſily calcinable by fire, and becomes brittle by fuſion with fluxes. Whereas nickel not only acquires new ductility in the fire, but reſiſts calcination with obſtinacy, and acquires ſuch additional weight, that it is now to water in the proportion of 9.605 to 1. Iron impregnated with cobalt, becomes ſofter and more ductile. Cobalt, when free of arſenic, bears the impreſſion of fire, unaltered. Wherefore, in making ſmalt of pure cobalt, an addition of arſenic is requiſite, which they need not to uſe, who employ an impure calx, impregnated with arſenic. It appears, that ſince nickel, cobalt, and manganeſe are much more difficult of calcination than iron, they muſt contain ſome other metal. It ſeems to be ductile, more ponderous than iron, as difficult of fuſion as wrought iron, not ſuſceptible of calcination, and not precipitable by zinc.

2. From

3. From a comparifon of nickel, cobalt, and manganefe, it appears, that when pure of arfenic, thefe metals will fcarce melt in the fire; when combined with arfenic, with which they enter very eagerly into combination, they are no longer fubject to the attraction of the magnet: it likewife appears, that they can fcarce be entirely free of iron if attractability by the magnet be the teft of the prefence of iron; when carefully purified, they become ductile, and precipitate faturated folutions of filver, thus differing from iron. Thefe qualities, juft mentioned are, therefore, common to thefe three metals; but in other particulars they plainly differ. For manganefe differs fo far from the reft in its fpecific gravity which is 6,850, and in other qualities peculiar to itfelf, that any perfon who makes experiments upon it, can have no doubt of its being a peculiar fubftance. As to what has been lately afferted by a celebrated chemift, that nickel and cobalt are one metal, only in different forms, that has indeed fome fhew of probability, if what I have above related concerning thofe metals be taken into confideration. Yet proofs of their diverfity are not wanting. Nickel, when impregnated with cobalt, cannot, without great difficulty, be feparated from it, and *vice verfa*; this circumftance alone might be fufficient to produce the miftake. But nickel, when feparated from cobalt, cannot, with any addition of arfenic,

ſenic, be converted into a green glaſs; neither is it a fit ingredient for ſympathetic ink, nor does it afford red ſolution with acids, or a green calx ſimilar to that of cobalt. Beſides, pure nickel will melt and run into a maſs with ſilver, but not cobalt; and to precipitate an hundred weight of ſilver, twice as much of nickel as of cobalt is required. Lead and biſmuth are much liker to each other, yet no body doubts their diverſity.

Although Brandt ſhewed by experiments, fifty years ſince, that cobalt is a peculiar metal; yet ſome perſons, chiefly in Saxony, have ſince denied that part of cobalt which ſtains glaſs to be metallic. They have referred, too, to a certain ore of cobalt (*cobalt-mulm,*) which communicates a green tinge to glaſs, and yet affords no regulus of cobalt. But, although I have not, as yet, either ſeen or examined this ore of cobalt, I ſuſpect its purity to be the cauſe of its affording no regulus. For, from what I have ſaid above it appears, that pure cobalt, without any intermixture of arſenic is extremely difficult to melt. In aſſaying many glaſſes tinged with cobalt, with an addition of black flux, I always obtained a regulus of that metal, although but a very ſmall quantity is neceſſary to ſtain a large piece of glaſs. The precipitate too, produced in ſolutions of cobalt by the admixture of phlogiſticated alkali afforded, upon reduction, a regulus fit for ſtaining glaſs, and was

in

in all other reſpects very like pure cobalt. Now, ſince experiments have ſhewn, that none but metallic matters are precipitable from ſolutions by phlogiſticated alkali, when the ſaturation is complete; it follows neceſſarily, that the part of cobalt with which glaſſes are ſtained, muſt be metallic.

SOME

SOME OBSERVATIONS

ON

URINARY CALCULI.

Cujus rei natura in portionibus ejus minimis optime cernitur.
ARISTOTELIS.

ABOUT the time when the celebrated Scheele was making his experiments on urinary calculi, I, not knowing that he was ſo engaged, had entered upon the ſame taſk. In the proceſs of my experiments I not only diſcovered with Scheele, that thoſe calculi contain a peculiar acid in a concrete ſolid ſtate, but made ſome other obſervations not correſponding to his; but the difference might poſſibly be occaſioned by a diverſity of nature in the matter on which our experiments were made.

I was unſucceſsful in all my attempts to diſſolve calculi entirely in diſtilled water, or nitrous acid. Indeed, the more minutely the matter is pulveriſed, the ſcantier is the reſidue. But,

 ſome

ſome part ſtill remains undiſſolved: as any perſon may ſee, if he attempt the ſolution of a pretty conſiderable quantity of the matter of the calculi in a ſmall veſſel. In that caſe, what remains undiſſolved, gathers into one place, while the liquor cools. But a ſtill better teſt is to put ſmall bits of calculus to the weight of a few grains, into a copious proportion of menſtruum, and expoſe it to a heat nearly equal to that of boiling water; the greater part will then be diſſolved; but there will remain a very ſmall portion of a fine white matter, almoſt inſoluble in water, ſpirit of wine, acids or cauſtic alkali. Increaſe the heat to a boiling temperature; and the ſubſtance which has hitherto reſiſted the action of the ſolvents, will be reduced into flakes, and will almoſt diſappear, but will not even yet be abſolutely diſſolved. I have not been able to procure a ſufficient quantity of this matter for a more accurate ſeries of experiments. But I know that a coal which is ſcarce combuſtible and not ſoluble in nitrous acid, remains.

Saccharine acid produces no precipitate in a nitrous ſolution of calculi. Hence it is plain to any perſon, that thoſe calculi contain no calcareous earth; otherwiſe it would be inſtantaneouſly detected by the Saccharine acid. But, having obſerved, in the proſecution of my experiments on elective attractions, that on the addition of a third body to two already in combination,

bination, the third body, inſtead of effecting the ſeparation of the two previouſly combined, often added itſelf as a new ingredient in the compoſition; I was induced to ſuſpect that in the preſent inſtance a ſimilar event took place, and with the greater confidence, as I was certain ſome, although but a very ſmall, portion of unctuous matter was always joined with ſugar. The fact confirmed my conjecture. For by the thorough combuſtion of urinary calculi, I obtained a white aſh, evidently calcareous, which effer-veſced with acids, and acquired on the infuſion of vitriolic acid, a gypſeous character; was eaſily precipitable by ſaccharine acid, and was to a certain degree, ſoluble in water, &c. There ſtill remains, however, nearly an hundredth part which is inſoluble in nitrous acid. But the reſidue above-mentioned, forms in conjunction with the concrete acid, the ſubſtance of the calculus. The matter of the calculus may be obtained by evaporation from a nitrous ſolution of it; and if burnt to whiteneſs, will afford a calcareous powder.

Pure vitriolic acid not being contaminated with any unctuous matter, I hoped to ſucceed in examining the calx with it: and it proved ſo. For on pouring into a nitrous ſolution of calculi a few drops of ſtrong and limpid vitriolic acid, I perceived a few cryſtals detached, which upon a particular examination, and chiefly by precipitation with faccharine acid proved to be gypfeous. In a diluted folution of a calculous matter, no change was at firft obferved; but after a confiderable part of the moifture was evaporated, cryftals began to appear. From thefe circumftances it appears, that there is actually quick-lime in urinary calculi; but in a very fmall proportion, as one hundred weight fcarce ever affords more than half a pound.

Strong vitriolic acid diffolves calculous matter, with the help of heat, and with effervefcence. The folution is of a black colour; and if a little water be poured into it, feems in fome degree to coagulate; but on the addition of a larger quantity of water, recovers its limpidity, and affumes a brown colour.

Muriatic acid feems to be incapable of diffolving calculous matter; yet, I know not but it may feparate a part of the lime.

The rednefs which fometimes arifes in the nitrous folution of calculous matter is remarkable. When the folution is faturated, it gives no indication of the prefence of the nitrous acid by its fmell; and when evaporated in a large open veffel, it is changed into a darkened liquor, in which tincture of turnfole can fcarce detect any remains of nitrous acid. Any acid deftroys the rednefs; and neither the infufion of alkali, nor any other addition can reftore it. If the moifture be more fpeedily evaporated, the folution fwells ſwells with innumerable aerial bubbles, and forms a froth which is at firſt ruddy, and when more entirely evaporated, becomes black. This black matter tinges a great deal more water than the weak ſolution, and is ſoluble even by thoſe acids which act not upon the calculus, and always the ſtronger the acid infuſed, the ſooner does the colour diſappear. Even alum, in which there is but a ſmall proportion of acid, deſtroys the colour of this froth.

Nitrous acid acts in a ſingular manner on inflammable matters; and as inflammable matter is the principle of colour, hence it is eaſily underſtood why none but the nitrous acid extracts the colour from the calculus. A due proportion of the acid is, however, requiſite to render the colour permanent. Diluted nitrous acid ſhould therefore be employed to avoid the inconvenience of an exceſs; for an exceſs does not produce too ſtrong a red, but deſtroys the colour by the abſorption of all the phlogiſton. Strong nitrous acid, mixed with calculous matter, is, after a ſhort interval, converted, without the application of heat, into froth.

The acid of the urinary calculi is eaſily ſeparated from the nitrous acid by evaporation; the nitrous acid being rendered more volatile by combination with phlogiſton. Alkaline ſalts do not ſeparate theſe acids; for it almoſt always happens in the caſe of two acids being mixed, that no disunion is produced, but the alkali attracted into the composition. The red matter which is obtained by inspissation, is evidently different from the concentrated acid which exists in calculi; its saturated colour, the force with which it attracts moisture from the atmosphere, the rose colour which it communicates to water, its solubility in the muriatic and other acids, which sooner or later deprive it of all heat, these particulars mark sufficiently the peculiarity of the red matter. That remarkable change is produced, as I have observed, not so much by the residue of the nitrous acid, as by its efficacy in dissipating phlogiston. A solution of this matter produces rosy spots on the skin, as also on bones, glass, paper, &c. but on these latter, the redness does not appear so soon unless heat be applied.

I forbear an account of my other experiments on calculi; as their results were the same with those which Scheele has laid before the world. I shall only add, that the chemical analysis of the stone in the bladder may be of great benefit to medicine. For we can scarce hope to find any remedy which may afford a certain relief to the evils of this dreadful case; unless we first discover the nature of the stone. Experience has shewn that lime-water and lixiviated caustic alkali are a medicine for this complaint; which might

might indeed be diſcovered, had it not been previouſly known by conſidering the compoſition of the calculus. But, whether all calculi be of the ſame nature, I cannot preſume to determine. New experiments are neceſſary to decide this queſtion.

INDEX.

Biſmuth

Double

——— ſanctioned

FINIS.