
COLL. REG. MED. LOND.
MDXVIII
Ο ΒΙΟϹ
ΤΕΧΝΗ
ΒΡΑΧΥϹ Η
ΔΕ
ΜΑΚΡΗ

ELEMENTS
OF
NATURAL HISTORY
AND
CHEMISTRY.

By M. *FOURCROY*;

DOCTOR OF THE FACULTY OF MEDICINE AT PARIS, OF THE ROYAL ACADEMY OF SCIENCES, &c.

Tranſlated from the laſt Paris Edition, 1789, *being the third, in* 5 vols 8vo.

WITH

An Alphabetical Comparative View of the Ancient and Modern Names of CHEMICAL SUBSTANCES, with all the TABLES, and a Complete INDEX.

To which is prefixed by the TRANSLATOR,

A PREFACE, containing Strictures on the Hiſtory and preſent State of CHEMISTRY; with Obſervations on the Poſitions, Facts, and Arguments, urged for and againſt the ANTIPHLOGISTIC THEORY, and the NEW NOMENCLATURE, by Meſſrs LAVOISIER, PRIESTLEY, KIRWAN, KEIR, SAGE, &c.

IN THREE VOLUMES.

VOL. I.

LONDON:
Printed for C. ELLIOT and T. KAY, at Dr Cullen's Head, No 332. Strand; and C. ELLIOT, Edinburgh.

M,DCC,XC.

TO

DR BLACK.

THIS TRANSLATION
OF THE
LAST EDITION OF A BOOK
WHICH HE HAS RECOMMENDED TO
STUDENTS OF CHEMISTRY,
IS RESPECTFULLY DEDICATED
BY THE
TRANSLATOR.

PREFACE

BY THE

TRANSLATOR.

WERE the controverſy, which was ſo keenly agitated about the beginning of the preſent century, concerning the comparative literary merits of the Ancients and the Moderns, to be renewed, the Moderns would now, in all probability, find abler advocates than a Perrault or a Wotton; and even the wit and ingenuity of a Boileau or a Temple would be inſufficient to maintain the ſuperiority of the Ancients.

AMONG almoſt all the nations of Europe, polite literature and philoſophy, in all their different branches, have made the moſt rapid progreſs ſince the cloſe of the ſeventeenth century. Even the ſcience of mathematics, in which perhaps the ancients excelled more than in any other, and which had been ſucceſsfully cultivated between the æra of the revival of literature and that period, has been ſince carried to higher perfection, and applied to a greater variety of purpoſes. How very lately was natural hiſtory, in which the order of ſyſtem has been ſo happily eſtabliſhed, nothing but a confuſed heap of inaccurate and uncertain facts?

The ſcience of chemiſtry, till it engaged the attention of Boyle, Boerhaave, and Stahl, appears to have been only in the firſt ſtage of a ſickly infancy.

The principles on which men proceeded in the purſuits of ſcience, and the ſpirit with which they proſecuted them, were long unfavourable to its advancement. Content with the imperfect knowledge of a few general facts, the philoſophers of antiquity ſeldom took pains to eſtabliſh the certainty or increaſe the number of thoſe facts; but ſought to diſtinguiſh themſelves as men of genius, and to aſſert their title to the character of philoſophers, by forcing them into unnatural combinations, and diſtorting them to ſupport fanciful hypotheſes. No qualities are more neceſſary to him who would contribute to the advancement of ſcience than humility and patience: but theſe qualities ſcarce appear united in the character of any of the moſt celebrated ancient philoſophers; nay, whether ancient or modern, thoſe whom we honour as men of genius and philoſophers, have been too generally diſtinguiſhed by the oppoſite qualities of pride and impatience, to deduce general inferences, without entering into a full examination of particulars. Syntheſis, which was long the eſtabliſhed mode of proſecuting ſcientific reſearches, deſerves no higher character than that of an ingenious way of impoſing on one's ſelf and others by falſe poſitions and unfair concluſions. It is indeed nothing but a partial, a falſe analyſis. You have ſome general inaccurate knowledge of the nature and relations of ſome being; and you conclude, that you know every thing concerning it; that you are intimately acquainted with its nature; that all its relations muſt be conſiſtent with your ideas of it; and that it can

can ſuffer no changes but thoſe to which you perceive it to be liable. Such is ſyntheſis *.

But, till of late, ſcarce any of the other ſciences was in ſo unfavourable circumſtances as chemiſtry. The Egyptians, Greeks, and Romans, *might be* ſkilful chemiſts: but we do not know that they *were.* The Arabians involved this ſcience in myſtery. Their ignorance of the phænomena of nature, and the abſurd notions which they entertained concerning ſuperior beings, and *their* influence on the affairs of this world, naturally led them to involve every thing with which they were acquainted in circumſtances of myſtery and wonder. The Saracens were the firſt who practiſed chemiſtry in modern Europe. Their neighbours, to whom they communicated their chemical knowledge, were ſtill more ignorant than themſelves. They who had received ſo many religious myſteries with ſuch profound reverence, ſuch fond credulity, were *excellently* prepared for adopting chemical myſteries in all their abſurdity. Gold, too, was ſcarce as it was precious; and longevity, amidſt all its miſeries, is ſtill eagerly coveted. Hence came the alchemical doctrines of the Arabians to be ſo eagerly embraced in Europe, and improved into abſurdities ſtill wilder by Lully, Paracelſus, and the Roſicrucian brethren. Fancy eſtabliſhed her dominion in a place where we ſhould not naturally expect to find *her* either ſeeking or obtaining admittance. Taking up her abode in the laboratory, amid furnaces, cupels, cucurbites, and aludels, ſhe amuſed herſelf in ſuperintending proceſſes of digeſtion, diſtillation, rectification, and ſuch others. Uſeful diſcoveries, when made, were owing

---

* Chemical ſyntheſis is not here meant.

ſolely to accident; abſurd hypotheſes and ridiculous theory were the only things here produced by the exertions of human ingenuity. By degrees, however, alchemy fell into diſcredit, and myſtery was almoſt entirely rejected as inconſiſtent with ſcience. The facts have been by degrees connected into a ſyſtem. Capricious and unmeaning proceſſes have gone into diſuſe. Chemiſts have learned, that ſome degree at leaſt of plauſibility is no leſs neceſſary to their theories, in order to prevent them from being abſolutely ridiculous, than to thoſe of the natural or the moral philoſopher. Their operations are now conducted upon ſcientific principles; they no longer proceed blindly like the mechanic, or a pupil in arithmetic, who follows his rules without inquiring how it comes that the operations which they direct bring out the anſwer required.

We are all ſenſible what an important rank heat and light hold among the phænomena of nature. We have conſtant occaſion to take notice of them: And in ſome of thoſe ſciences which depend on the obſervation of the appearances diſplayed in the material world, to mark their modes of exiſtence and their influence, muſt ſurely be a capital part. Heat, not the ſenſation to which we give this name, but the cauſe of the ſenſation, naturally engages the attention of the chemiſt in a very high degree. Accordingly, as ſoon as chemiſtry began to aſſume the character of a ſcience, chemiſts ſet themſelves eagerly to aſcertain the various phænomena of heat; to trace it as it ariſes and again diſappears.

The theory of *phlogiſton,* which has ſo long made an an eminent figure in all chemical reaſonings, and has been ſo intimately incorporated with the whole body of facts on which the ſcience is eſtabliſhed, originated from ſome of the earlieſt attempts of philoſophical chemiſts to eſtabliſh general principles with reſpect to the phænomena of heat. We behold flame, we ſee bodies conſumed, we feel a pleaſing, and at length a painful ſenſation, when we approach within the ſphere of theſe phænomena. We call, in popular language, the cauſe of theſe phænomena *fire;* that which acts immediately on our organs, and on the bodies conſumed, we call *heat;* and to the ſenſation thus communicated to us we give likewiſe the name of *heat.* Now, is this fire, or flame, or heat, as much a material body as a piece of wood, or glaſs, or ſtone, or any other groſſer ſubſtance? If it be, whence does it ariſe? and what becomes of it? We neither ſaw nor felt it before the fire was kindled; and when the fuel is conſumed, it no longer appears.

In anſwer to theſe inquiries, the ingenious Stahl and his followers tell us, that fire or heat is actually a material body; and, like other material bodies, liable to be modified by the influence of circumſtances. In bodies liable to be burnt, it exiſts in a latent ſtate: place them in the circumſtances in which combuſtion is produced,—you then behold it appear, perceive it operate, and feel its influence. In thoſe bodies, though it exhibit no flame, nor produce the other effects which it accompliſhes on ſurrounding bodies when developed by combuſtion, yet it is far from being abſolutely dormant. Whatever qualities combuſtible bodies loſe by combuſtion, thoſe they owe to phlogiſton or the latent principle of fire. Bodies which loſe none of their principles by combuſtion muſt be incombuſtible, and

can

can contain no phlogiſton. An incombuſtible body may be volatile, and therefore reducible to vapour by the action of fire; but its principles cannot be divided; it cannot be decompoſed by burning. The latent principle of fire does indeed elude our inveſtigation; we cannot obtain it, like the other principles of bodies, in a ſeparate ſtate; whenever it eſcapes or is expelled out of one combination, it enters into another; it operates unſeen; but ſtill it operates. When it makes its way out of a burning body, it mingles in the ſurrounding atmoſphere; and no fact is better known, than that air is altered in its nature, and acquires new qualities, in conſequence of being expoſed to the contact of a burning body.

SUCH are the general ideas on which the theory of phlogiſton is founded. It is natural and plauſible, and juſtified by many facts. That this ſubſtance has never appeared in a ſeparate ſtate, cannot well be conſidered as a proof of its nonexiſtence: It is not the only material ſubſtance of which the eſſence is too ſubtile for our obſervation. When a number of facts, all referable to this general principle, were diſcovered, it was very natural for thoſe who obſerved the analogy among the facts, to extend the influence of the principle farther than their obſervations warranted. Such is the character of the human mind. In the ſame manner have other general principles been on many occaſions carried beyond their juſt limits, till men have been tempted to call their truth or propriety in queſtion, even in inſtances in which it was abſurd to deny it.

SINCE its propagation by Stahl, the doctrine of phlogiſton has undergone many modifications. Chemiſts, rather unwilling to believe in the exiſtence of an imperceptible material ſubſtance, have been anxious to obtain it in a ſeparate ſtate. The diſcovery of a number of gazeous or aerial bodies, which till within theſe laſt twenty years were entirely unknown, naturally excited new hopes of accompliſhing ſo important a purpoſe. Some of the moſt reſpectable Britiſh chemiſts have at length perſuaded themſelves, that it muſt be *inflammable gas* which performs that great part which has been aſſigned to phlogiſton. Mr Kirwan, the great patron of this opinion, would have us to believe, that bodies owe to this gas, exiſting in them in a concrete ſtate, all the properties which they have been ſaid to derive from phlogiſton; and that when they are decompoſed by combuſtion, this concrete gas is diſengaged from them, and from a concrete reduced into a gaſeous or elaſtic fluid ſtate. To make out his ſyſtem, he adds to this, that *fixed air*, or carbonic acid, is the principle of acidity. And theſe, with ſome other additions, compoſe a body of theory which he finds means to apply, ſometimes naturally, and now and then with a little violence, to all the phænomena which it is the province of chemiſtry to explain.

But the French chemiſts have treated the ſyſtem of Stahl with ſtill leſs reſpect. Their diſcoveries have led them to give a very different account of the principle of heat. They are not willing to allow of its exiſtence in a quiet ſtate in combuſtible bodies; nor do they aſcribe to its influence the properties which thoſe bodies loſe by combuſtion. M. Lavoiſier and his followers are the French chemiſts to whom we here allude. He has diſcovered, that, inſtead of loſing a part of their weight by that proceſs which is thought

to

to deprive them of a principle, bodies actually become heavier, by burning, than they were before. It is the ſurrounding atmoſphere, not the burning body, that ſuffers a diminution. Whatever the levity of phlogiſton or inflammable air, or any other principle of terreſtrial bodies, it cannot ſurely be *abſolute*. Some bodies, we know, have a tendency to occupy a ſituation nearer to the centre of the globe; while others recede to a greater diſtance from it, and give place to thoſe of which the ſpecific gravity is greater. But we do not know, we cannot think, that any bodies or principles of bodies are actually repelled from the centre of the globe, while others are attracted to it. Were the exiſtence of any ſuch to be diſcovered, it would contradict all our preſent notions of the laws by which the material world is regulated. But if Stahl's and the other ideas of the exiſtence of phlogiſton be juſt, and M. Lavoiſier's experiments at the ſame time accurate, and the reſults faithfully related, phlogiſton muſt be ſuch a body; for, by loſing it, the body to which it is ſaid to have belonged gains an addition of weight;—and by taking it in, the ſurrounding atmoſphere is diminiſhed both in weight and bulk.

THIS is indeed a perplexing fact for the advocates of phlogiſton. But if it cannot be denied or explained away, recourſe may be had to others, which will ſtrike with no ſmall force againſt any theory that can be founded on it. In many inſtances of combuſtion a new elaſtic fluid, which did not before exiſt in the atmoſphere, appears to be formed. That elaſtic fluid is inflammable air, the phlogiſton of Mr Kirwan. Now, if not diſengaged from the burning body, whence can it proceed?—A ſubſequent diſcovery, however, has ſolved this difficulty. In proſecuting his experiments, M. Lavoiſier diſcovered, that water, which had been always conſidered as a ſimple body, was actually a compound conſiſting of two diſtinct principles; one of which was the ſubſtance which is in certain circumſtances rarefied into inflammable gas. And it has been farther diſcovered, or is at leaſt aſſerted, that in all thoſe caſes of combuſtion in which inflammable gas is produced, it is ſupplied by the decompoſition of water, or oils, or ſome other ſubſtance in which it exiſts in combination.

The experiments to which this laſt diſcovery was owing were extremely nice; ſuch, that the utmoſt accuracy of obſervation was neceſſary to diſtinguiſh the reſults. In ſuch caſes miſtakes are eaſily made; nay, it is ſcarce poſſible to avoid them. Dr Prieſtley and ſome other Engliſh philoſophers were at firſt diſpoſed to acquieſce in the reſults of thoſe experiments. Facts may be tortured to ſupport a theory, or explained away: But when they are eſtabliſhed, when they force themſelves on our obſervation, the philoſopher cannot, without forfeiting his character, ſhut his eyes againſt them. But, by repeating the experiments above alluded to in different circumſtances, Dr Prieſtley, whoſe ſkill in making experiments and obſerving the reſults cannot be doubted, has been ſince induced to think, that they do not juſtify the inference that water is a compound body; and that the appearances from which this inference has been deduced, may be more naturally accounted for, by allowing water to be a ſimple ſubſtance, and ſtill admitting the exiſtence of phlogiſton in combuſtible bodies, and its diſengagement by combuſtion. Mr Kirwan, and Mr Keir too, who in theſe

matters

matters may be conſidered as the diſciples and followers of Dr Prieſtley, eagerly contend in late publications for thoſe modifications of the phlogiſtic theory which they have adopted. They trace the antiphlogiſtic principles in their application to all the different facts which chemiſtry has collected; they find, that the French chemiſts, notwithſtanding all their ſpecious pretences, repreſenting the antiphlogiſtic theory as being not a theory, but merely a plain ſtatement of facts, often reaſon by analogy, ſometimes venture to indulge conjecture, and even find it neceſſary, at times, to make a bold aſſertion, and require us to take what they advance upon their credit. The champions of phlogiſton think they may very fairly put on the ſame arms, and practiſe the ſame arts: And they have certainly done both with ſo much addreſs as to keep the conteſt ſtill undecided.

M. Lavoisier, whoſe name, whatever be the iſſue of the preſent controverſy, muſt ſurely be long reſpectable in the annals of philoſophy, has lately publiſhed a ſmall treatiſe, in which the elements of chemiſtry are explained on his own principles.

The method which he follows is different from that which has hitherto been uſually adopted by writers on the elements of this ſcience. He begins not with explaining the nature and aſſerting the dignity of chemiſtry; nor does he inquire into the number of the elements of nature, or explain the laws of affinity in the introductory part of his book. He is of opinion, that thoſe who are only beginning the ſtudy cannot well underſtand theſe things, if they attempt to ſtudy them in the order in which they are uſually laid down.

His

His principles, too, render it neceſſary to follow a new order in explaining the elements of the ſcience.

His work is divided into three parts. In the firſt, he explains the formation and the decompoſition of aeriform fluids, the combuſtion of ſimple bodies, and the formation of acids. In the ſecond, he treats of the combinations of acids with ſalifiable baſes, and of the formation of neutral ſalts. The third part is occupied with an account of the apparatus and inſtruments of chemiſtry, and of the manner of conducting chemical proceſſes.

The reader who is at all acquainted with the principles of this ſcience, will perceive, on taking the trouble merely to compare the contents of this comprehenſive work with that of M. Lavoiſier's, that ſcarce any of thoſe things which are explained by M. Lavoiſier have eſcaped the notice of M. Fourcroy. The formation of gazeous fluids, the compoſition of the atmoſphere, the origin of acids, the component principles of water, the various phenomena of heat, the compoſition of animal and vegetable matters, are explained with no leſs ingenuity and perſpicuity by the latter of theſe writers than by the former. They have been at equal pains in tracing the radical principles of the acids through all their various combinations ; and they are equally careful to render their works intelligible, by exhibiting a comparative view of the new nomenclature which *they* have adopted, with the names of chemical ſubſtances which have hitherto been in general uſe.

But their objects were different. M. Lavoiſier confines himſelf to explain the principles of his own theory, to relate the experiments, and point out the analogies on which it is founded; and to illuſtrate it by exhibiting a view of ſuch of the doctrines of chemiſtry as are moſt happily calculated for that purpoſe. M. Fourcroy examines all the kingdoms of nature, and gives a complete body of chemical knowledge. The two works differ alſo in point of arrangement; but each has in this reſpect its peculiar advantages and diſadvantages: And it would not be eaſy to decide, which of the two plans is moſt likely to facilitate the ſtudy of the ſcience. Perhaps M. Lavoiſier's is beſt calculated to impreſs the mind of the reader with a favourable opinion of the antiphlogiſtic theory. But he is almoſt too artful and too intereſted an advocate for the beginner to liſten to; who wiſhes, not to enliſt under the banner of a party, but to acquire juſt ideas of the elements of the ſcience, and to diſtinguiſh between thoſe truths which are incontrovertibly eſtabliſhed, and poſitions which have, as yet, only probability or plauſibility on their ſide.

The tranſlator of this work was ſo much pleaſed with Lavoiſier's book when it came firſt into his hands, and impreſſed with ſuch veneration for a name ſo illuſtrious in the annals of chemiſtry, that he formed the idea of enriching his tranſlation of M. Fourcroy's work with a pretty large analyſis of M. Lavoiſier's. After proceeding ſo far in the execution of this deſign as to make out his analyſis, with conſiderable trouble; he found, upon a reviſal of it, and a compariſon of its ſubſtance with parallel paſſages in this work, that it only repeated in a different form what M. Fourcroy had explained with the greateſt perſpicuity, and even ſtated in a more im-

impartial manner. Nay, M. Fourcroy, in his ſupplementary *Diſcourſe on the Principles of Modern Chemiſtry*, in the third of theſe volumes, has actually given a ſhort ſketch of the very plan which M. Lavoiſier follows. To introduce this work, therefore, with a tedious account of M. Lavoiſier's book, would have been merely to ſwell the ſize of this firſt volume, without adding to its intrinſic value. And with whatever complacency he might regard that of which the compoſition had coſt him a good deal of pains; he now ſaw that it would be impertinent to preſent that analyſis to the public in the honourable place for which he had deſigned it. He contents himſelf therefore with mentioning in this general manner the plan of that treatiſe, and in what reſpects it differs from, and agrees with, the preſent work.

If in any Part of his book M. Lavoiſier has turned his attention to what has been more ſlightly noticed by M. Fourcroy, it is in the Third, in which he deſcribes the inſtruments and the apparatus of chemiſtry, and explains the methods of conducting chemical proceſſes. But the neceſſity of plates for the illuſtration of this part of the work, together with ſome other circumſtances, rendered it equally inconvenient and unſuitable to introduce here any thing from this part, as to give a particular account of the two preceding parts.

The new nomenclature which M. Fourcroy has now adopted in this work, and which the antiphlogiſtians wiſh to eſtabliſh, will perhaps be regarded rather with an unfavourable eye by the Engliſh reader, to whom, even tho' not a novice in the ſcience, it may probably be a ſtrange language. Objections have been propoſed and urged againſt it; ſome of them frivolous and captious, others not without force. Thoſe objections have been made, too, by ſome of the moſt ſkilful and ingenious chemiſts, who cannot be thought ready to object without reaſon; and whoſe voice, in matters reſpecting the ſcience which they have cultivated, muſt have authority. Among the moſt eminent of theſe are M. Sage and Mr Keir. One of the moſt plauſible of the objections is, that this nomenclature, like others, muſt be fluctuating: if the principles of the antiphlogiſtic theory be not in the end eſtabliſhed, the nomenclature muſt be rejected together with the theory: nay, if even any part of its principles ſhall prove falſe—and even its authors do not pretend to have demonſtrated the truth of every part of it by unequivocal experiments; then muſt this nomenclature undergo a reformation. Mr Keir ſeems to be of opinion, it is not eaſy to ſee upon what grounds, that it is abſurd to propoſe a chemical nomenclature formed upon principles of analogy, and deſigned to convey in the names, juſt ideas of the nature and the compoſition of the ſubſtances. To form ſuch a nomenclature muſt certainly be an arduous taſk; perhaps it has not been fully accompliſhed by the French chemiſts: but could it be accompliſhed, it would ſurely contribute much to facilitate the ſtudy of the ſcience. In different departments, the utility of ſuch ſyſtems of names has been generally experienced. Muſt the ſtudent of chemiſtry be denied thoſe helps which have proved ſo beneficial in other inſtances? The French chemiſts have perhaps been in too great haſte; it would perhaps be ad-

advantageous, if they and all the other chemiſts in Europe would agree to uſe the ſame Latin names. But their deſin is at leaſt laudable; and let us not invidiouſly deny due praiſe to their labours.

Of the reaſons for a tranſlation of this third edition of M. Fourcroy's work, it is ſcarce neceſſary to give an account. They are very obvious. He now appears a convert to the antiphlogiſtic ſyſtem; it is only in this edition he uſes the new nomenclature: the additions are ſo ſcattered through the whole work, that it would be a very unpleaſing taſk for the reader to have recourſe to a ſeparate volume whenever they occur to be taken in. Theſe, it is hoped, will be conſidered as reaſons ſufficient to juſtify the preſent tranſlator in his undertaking, even after the reſpectable Engliſh tranſlations of the two former editions of this work with which the public have been favoured.

The tranſlator is afraid, that whatever favour the public may be diſpoſed to ſhow to M. Fourcroy's work, they may find reaſon to conſider the preſent tranſlation as very inferior in its merits to either of the two former, and very unworthy of the original. Yet, whatever labour could do, he has painfully done; he has ſtudied the original with careful attention; and has endeavoured to adhere in his tranſlation to a reſpectful uſe of the phraſeology appropriated to the ſcience. The road to ſcience, like that to perfection in virtue, is ſcarce ever found a flowery path; the ſtrict language which muſt be uſed in laying down the principles of ſcience, and various other cauſes which it would perhaps appear petulent to mention, often occaſion a degree of heavineſs and perplexity in the ſtyle of books of ſcience which are very uninviting. It is not indeed to be expected or wiſhed that the elements of ſcience ſhould be explained in the ſame airy, lively language in which an agreeable tale is told: but force, and energy, and ſome degree of vivacity, can have no bad effects. The tranſlator, therefore, while he was ſtudious to expreſs faithfully the ſenſe of his author, wiſhed alſo to preſerve, nay, would have been glad to improve, the energy and livelineſs of his ſtyle. He is ſorry that he cannot pleaſe himſelf with the thought of having fully accompliſhed what he wiſhed.

It would be very ungrateful were he to neglect mentioning his obligations to the former tranſlations of this work: he read them carefully over; and he hopes he has profited by them.

He has added here and there a few notes, the ſubſtance of one or two of which he has taken from the notes to the tranſlation of the ſecond edition; but his notes are ſo very few, that he will himſelf confeſs they do not add greatly to the value of the work. He was indeed deterred from adding many notes, by obſerving that a conſiderable part of thoſe with which the tranſlator of the ſecond edition had adorned his pages, contained nothing that was not communicated in different parts of the text. He is afraid that ſome inaccuracy has ſlipped into two or three of the numbers in the hiſtory of heat; and therefore begs the reader to be on his guard againſt it, and correct it.

Perhaps this ſhort view of a few general facts concerning the hiſtory and the preſent ſtate of chemiſtry, may, as the language in which it is written is looſe and popular, not ſtrictly ſcientific, be read and underſtood without much difficulty, and have ſome ſmall influence in inducing the reader to proceed to a more eager and attentive peruſal of the valuable work to which it is prefixed. If it have any ſuch effect, the writer's wiſh will be fully gratified. The account here given of the circumſtances of this tranſlation, and the reaſons upon which it was undertaken, the public had a right to expect.

The Tranſlator of this work, ſince he has not ventured to bring M. Lavoiſier and M. Fourcroy together in theſe volumes, is very happy to find that ſuch as are diſpoſed to peruſe M. Lavoiſier's work—and it is certainly well worthy of peruſal—may, if they do not chooſe to ſtudy chemiſtry in French, gratify their curioſity, by having recourſe to a very faithful and elegant tranſlation of that work publiſhed by an ingenious medical gentleman of this city.

PREFACE TO THE THIRD EDITION,

BY THE

AUTHOR.

NO ſcience was ever more generally or more eagerly cultivated than chemiſtry has been during theſe laſt twelve years: No ſcience ever made ſuch rapid progreſs in ſo ſhort a time. Theſe circumſtances render a third edition of this work neceſſary. The ſecond being almoſt entirely ſold off in the ſpace of eighteen months, I have conſequently had leſs time for improving it in a third edition, than I had for improving the firſt in it. In this edition, therefore, the work is enlarged only with one additional volume: but in the ſecond two were added. Every elementary work, as it paſſes through ſucceſſive editions, muſt at length reach a period at which the judgment of the learned and the diſcerning will declare farther additions unneceſſary; and after which, review and careful corrections will be the only proper means of improving it. I am of opinion, that in this third edition my work has reached that period. An account of the new diſcoveries ſince the year 1786 would not have added greatly to the bulk of the volumes: But by the advice of ſome judicious perſons, and in conſequence of underſtanding that beginners found ſome difficulties in the peruſal of this work, I have been induced to altar and enlarge ſome chapters in the hiſtory of ſaline matters, of ſome of the metals, and of ſeveral of the immediate principles of vegetable and animal bodies. Theſe new articles, with the new diſcoveries, of which an account is now introduced in theſe volumes, are extracted and publiſhed as a ſupplement to the ſecond edition by M. Adet, a young phyſician, who has been ſo good as to undertake this taſk, for which I had not leiſure myſelf. As that ſupplement comprehends, in a ſmall volume, every thing now added to the ſecond edition, I ſhall ſay nothing farther concerning the additions, but confine myſelf to a few reflections on the progreſs which the work has made, on the theory which it exhibits uniformly through all its parts, and on the new nomenclature now adopted in it.

When I compoſed, in the years 1780 and 1781; a ſhort account of the fundamental facts of this ſcience, to ſerve as a Syllabus to my Lectures; I followed the ſame plan which I had before adopted in my lectures, and of which ſome years' experience had taught me the advantages. The unexpected ſucceſs of that work induced me to follow the ſame plan in the ſecond edition, publiſhed about four years ſince. The encouragement which the ſecond edition has again received from the proficients in chemiſtry and the friends of ſcience, and the preference which the rapid ſale and the various tranſlations authorize me to ſay, has been given to it as an elementary book on chemiſtry through all Europe, induce me ſtill to adhere to the ſame plan which was laid down in the firſt edition. To alter my arrangement would have been in ſome meaſure to form a new work.

work: yet I don't know but it *might* be altered without any impropriety. Perhaps, the more accurate knowledge which has been gained ſince the publication of my firſt edition, the more concluſive reaſonings, and the more exact and numerous experiments with which chemiſtry has, ſince that time, been enriched, would render it advantageous to arrange the elements of the ſcience in an order ſomewhat different: To place, for inſtance, the hiſtory of all combuſtible bodies, ſulphur, coal, metals, &c. before that of acids; moſt of which ſalts are either burnt bodies, or compounds of combuſtible bodies. This would be to proceed from ſimple to compound: the acids of one kingdom would not then be ſeparated from thoſe of the other two kingdoms: only, the differences between the principles of organic bodies and thoſe of minerals would be treated of in diſtinct chapters. I have marked out a ſketch of this method in my Treatiſe on the Elements of Chemiſtry, intended for the uſe of the ladies, and the pupils of the Royal Veterinarian School *.

But although, in the preſent ſtate of chemiſtry, this laſt mentioned arrangement of its elements may be preferable; yet that which I at firſt adopted and ſtill adhere to, is not without its advantages. It requires a little more attention from the ſtudent: but even in this inſtance it is peculiarly favourable to his improvement. It exhibits the ſame facts in two different lights; it recals the mind a ſecond time to facts, which have been already expoſed to its view; and thus impreſſes more diſtinct ideas of the phænomena.

With

---

* School of Medicine of Animals at Alfort, near Paris.

WITH reſpect to the theory laid down in theſe elements, this third edition differs eſſentially from the two former editions. In them, I appeared only as the hiſtorian of the different opinions which has prevailed among chemiſts. But, in this edition, though I ſtill maintain the ſame impartiality, and give an account of the principal theories which have been propoſed; yet I have taken a ſide, and declared myſelf an entire convert to that doctrine which has received from ſome philoſophers the name of *pneumatic* or *antiphlogiſtic*. I flatter myſelf, that every unprejudiced perſon who ſhall carefully peruſe theſe elements, will find that this theory differs eſſentially from all others that have been hitherto propoſed; as it takes nothing upon ſuppoſition, admits no hypothetic principle, and conſiſts only in a fair detail of facts. I may even venture to ſay, that thoſe philoſophers who have not yet adopted this doctrine, particularly thoſe who have combated it in ſome inſtances with rather too much warmth, have not entered fully into our ideas. They do not ſee that the ground of our opinions, the foundation on which our principles ſtand, is totally different from thoſe of other theories which occur in the ſtudy of phyſics. We only deduce plain inferences from a great variety of facts: we admit nothing not demonſtrated by experiments: and as we reject every hypotheſis, we cannot poſſibly commit ſuch blunders as thoſe into which the authors of all former ſyſtems of phyſics have fallen. Either I, and thoſe other modern chemiſts who have produced ſo many ingenious diſcoveries, are groſsly miſtaken; or the riſing generation of ſtudents, who are taught to reaſon in a very different manner from their predeceſſors, will renounce, as we have preſumed to do, the hypotheſes which have been

ſo

ſo much agitated in the ſchools, and will confine themſelves to the reſults of fair experiments. A number of celebrated profeſſors have already adopted the doctrine laid down in this work. Meſſrs de Morveau, Van-Marum, and Chaptal, have been convinced of its truth and ſimplicity. In order to make himſelf fully acquainted with this doctrine through all its different parts, and to have an opportunity of comparing it with that which is ſtill maintained by ſeveral philoſophers, I would adviſe the ſtudent of chemiſtry to read carefully over the celebrated Mr Kirwan's work upon phlogiſton, with the notes and obſervations which we have added to it. They will find in Mr Kirwan's explanation of the ſimple facts, a train of hypotheſes, truly ingenious indeed, but always in a greater or a leſs degree forced and inconſiſtent with the facts which they are adduced to explain; in our application of the ſame facts, hypotheſis is no where introduced.

In this third edition, I uſe the new nomenclature which was propoſed in the year 1787, by Meſſrs de Morveau, Lavoiſier, Berthollet, and myſelf. I ſhall not here repeat the reaſons which induced us to make this innovation; the late diſcoveries and the ſyſtematic order introduced into this ſcience in conſequence of theſe rendered it indeed unavoidably neceſſary. Neither ſhall I make any reply to thoſe objections, in general exceedingly weak, which have been urged againſt it; and ſtill leſs can I think of anſwering the abuſive language and witticiſms which have been thrown out by men who had no reaſons to offer. I ſhall only ſay, that in five courſes of lectures which I have delivered ſince the formation of this nomenclature, I have conſtantly made uſe of it, and have found the uſe of it attended

attended with all the advantages which it was expected to produce. Thoſe who heard theſe lectures, eaſily underſtood this ſyſtem of names, and entered into the analogies on which it is eſtabliſhed. They actually acquired more knowledge from one courſe, than it was formerly poſſible for a ſtudent to gain by attending three or four, however eager and unremitting his application.

THERE is one among the objections, urged againſt this nomenclature, to which it may not be improper to call the reader's attention. The words *oxygene* and *hydrogene* are ſaid to be too limited in their ſignifications to anſwer properly the purpoſes to which we have applied them; the principle to which we have appropriated the firſt of theſe denominations, not always forming acids in its combinations; and the ſecond not being allowed by all philoſophers for one of the component principles of water. But, in our treatiſe on the nomenclature, we have obſerved, that we do not preſume to offer it as a word expreſſive of the more general qualities of vital air; it would perhaps have been impoſſible to find a word more generally expreſſive of its nature, and at the ſame time ſuitable to our purpoſe: ſuch an attempt would have rendered the denomination too vague; and it could not, in that caſe, have been ſo diſtinctly comprehended by the ſtudents, as that which we have propoſed, and which is taken from one of the moſt ſtriking characteriſtic properties of this principle; though a property which it does not exhibit in all its combinations. On the word *hydrogene* we have obſerved, that it is formed to be preciſely expreſſive of a fact, the reſult of certain unequivocal experiments; that the body to which we give this name is one of the eſſential principles of water; and that its

neceſſity

neceſſity to the compoſition of its water is one of the moſt ſtriking of its properties. It is ſurpriſing, that it never occurs to the people who repeat ſuch objections againſt us, one after another, that theſe, with many others, muſt have ariſen to ourſelves, when we were no leſs than nine months diligently employed on the reformation of the nomenclature. It is ſurpriſing that it never occurs to them, that we can can find nothing new in the reaſonings which they urge againſt us, after having already often diſcuſſed them; and that they have not learned, that all their objections, all their arguments, having been an hundred times propoſed, and diſcuſſed, and viewed in every light, in our converſations on the ſubject, at which a number of our learned brethren of the academy obligingly aſſiſted, appeared ſo trivial in compariſon with the advantages likely to be obtained by the uſe of the new denominations, that we thought we might with good reaſon overlook them. Thoſe people are to be farther informed, that it was not till after having in vain ſought through all the varieties of etymology, for words which might be expreſſive of the more general properties of theſe principles, that we gave up the hopes of accompliſhing this object. Had we obſtinately adhered to our firſt purpoſe, we ſhould have introduced into our language a ſet of harſh and barbarous terms, which it would have been difficult for the underſtanding to comprehend, or for the memory to retain.

The only thing that ſeems to need correction in our nomenclature is the expreſſion *azotic gas*, which might with great propriety be changed into the expreſſion *gas azote*; as has been obſerved by M. Arejula, a Spaniſh chemiſt, who I am proud to number among my pupils,

pupils, and who has publiſhed ſome very judicious obſervations on our nomenclature. It was certainly an overſight in us to give to the name of this gas a termination different from that of its baſe, and the ſame with that in which the names of a whole claſs of acids terminate; and I, for my part, thank the author for his remarks. In this work, therefore, the reader may, if he think proper, read *gas azote*, inſtead of *azotic gas*, wherever the latter of theſe expreſſions occurs *.

These are moſt of the particulars which I wiſhed to mention to the reader in this place. The great object of this work is to afford as complete a collection as poſſible of chemical facts in the narroweſt compaſs within which they could be reduced. The ſcience of chemiſtry is ſo generally uſeful to the purpoſes of human life, that there is reaſon to expect, that the number of the ſtudents of this ſcience will ſtill increaſe. It is with a view to promote their improvement that I have added in this edition every thing that appeared to me likely to facilitate the ſtudy. It is my earneſt wiſh to be uſeful to them.

---

* The tranſlator has not ventured to make this alteration; for of innovations there will be no end, if we are thus ready to indulge in them.

CONTENTS

OF THE

THREE VOLUMES.

CONTENTS OF VOLUME FIRST.

PART I.

Chap.

PART II.

SECTION I.

SECTION II.

Fluoric

CONTENTS OF VOLUME SECOND.

SECTION III.

MINERALOGY.

PART III.

CON-

CONTENTS OF VOLUME THIRD.

PART III. CONTINUED.

PART IV.

Continuation of the Animal Kingdom.

5. *Nu-*

Supplement to the Mineral Kingdom.

A TABLE, EXHIBITING THE CHEMICAL NOMENCLATURE

Propoſed by Meſſieurs De MORVEAU, LAVOISIER, BERTHOLLET, and De FOURCROY, in May 1787.

		I. SUBSTANCES THAT HAVE NOT BEEN YET DECOMPOSED.		II. THE SAME SUBSTANCES REDUCED INTO THE STATE OF GAS BY THE ADDITION OF CALORIC.		III. THE SAME SUBSTANCES COMBINED WITH OXIGENE.		IV. THE SAME SUBSTANCES IN AN OXIGENATED GAZEOUS STATE.		V. THESE OXIGENATED SUBSTANCES NEUTRALIZED BY THE ADDITION OF BASES.		VI. THE SAME PRIMARY SUBSTANCES COMBINED WITH OTHER SUBSTANCES, BUT NOT ACIDIFIED.		
		NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	NAMES NEWLY INVENTED OR ADOPTED.	ANCIENT NAMES.	
1		Light.	—	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	1
2		Caloric.	*Latent heat, or matter of heat*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	2
3		Oxigene.	*The baſe of vital air.*	Oxigenous gas. *N B* It appears that light contributes to the reduction of oxigene into a gazeous ſtate.	*Dephlogiſticated* or *vital air.*	— —	— —	— —	— —	— —	— —	— —	— — —	3
4		Hydrogene.	*The baſe of inflammable gas.*	Hydrogenous gas.	*Inflammable gas.*	Water.	*Water.*	— —	— —	— —	— —	— —	— — —	4
5	ACIDIFIABLE BASES.	Azote, *or* the radical principle of the nitric acid.	*The baſe of phlogiſticated air, or of atmoſpheric mephitis.*	Azotic gas.	*Phlogiſticated air, or atmoſpheric mephitis.*	The baſe of nitrous gas. Nitric acid *With an exceſs of azote,* Nitrous acid	*The baſe of nitrous gas.* *White nitrous acid.* *Fuming nitrous acid.*	Nitrous gas. Nitrous acid gas.	— —	Nitrate of potaſh. of ſoda, &c. Nitrite of potaſh.	*Common nitre.* *Cubic nitre.*	— —	— — —	5
6		Carbone, *or* the radical principle of the carbonic acid.	*Pure coal.*	— —	— —	Carbonic acid.	*Fixed air, or cretaceous acid.*	Carbonic acid gas.	*Fixed air, mephitic air.*	Carbonate of lime. of potaſh, &c. of iron, &c.	*Chalk.* *Effervescent alkalies.* *Ruſt of iron, &c.*	Carbure of iron.	*Plumbago.*	6
7		Sulphur, *or* the radical principle of the ſulphuric acid.	—	— —	— —	Sulphuric acid. *With leſs oxigene,* Sulphureous acid.	*Vitriolic acid.* *Sulphureous acid.*	Sulphureous acid gas.	*Sulphureous acid gas.*	Sulphate of potaſh. of ſoda. of lime. of aluminous earth. of barytes. of iron, &c. Sulphite of potaſh, &c.	*Vitriolated tartar.* *Glauber ſalt.* *Selenite.* *Alum.* *Ponderous ſpar.* *Vitriol of iron, &c.* *Stahl's ſulphureous ſalt.*	Sulphure of iron. of antimony. of lead. Sulph. hydrogenous gas Sulphure of potaſh. Sulphure of ſoda. Alkaline ſulphures with metals ſuſpended in them. Alkaline ſulphure with carbonaceous matters ſuſpended in it.	*Factitious iron pyrites.* *Antimony.* *Galena* *Hepatic gas.* *Alkaline livers of ſulphur.* *Metallic livers of ſulphur.* *Liver of ſulphur with carbonaceous matters ſuſpended in it.*	7
8		Phoſphorus, *or* the radical principle of the phoſphoric acid.	—	— —	— —	Phoſphoric acid. *With a ſmaller proportion of oxigene,* Phoſphorous acid.	*Phoſphoric acid.* *Fuming* or *volatile phoſphoric acid.*	— —	— —	Phoſphate of ſoda. Calcareous phoſphate. Superſaturated phoſphate of ſoda. Phoſphite of potaſh &c.	*Phoſphoric ſalt with a baſe of natrum.* *Earth of bones.* *Haupt's ſal perlatum.*	Phoſphorized hydrogenous gas. Phoſphure of iron.	*Phoſphoric gas.* *Syderite.*	8
9		Radical principle of the muriatic acid.	—	— —	— —	Muriatic acid. *With an exceſs of oxigene,* Oxigenated muriatic acid.	*Marine acid.* *Dephlogiſticated marine acid.*	Muriatic acid gas. Oxigenated muriatic acid gas.	*Marine acid gas.* *Dephlogiſticated marine acid gas.*	Muriate of potaſh Muriate of ſoda. Calcareous muriate &c. Ammoniacal muriate. Oxigenated muriate of ſoda, &c.	*Febrifuge ſalt of Sylvius.* *Marine ſalt* *Calcareous marine ſalt.* *Sal ammoniac.*	— —	— — —	9
10		Radical principle of the boracic acid.	—	— —	— —	Boracic acid.	*Sedative ſalt.*	— —	— —	Borate ſuperſaturated with ſoda, *or* borax. Borate of ſoda, &c. *ſoda ſaturated with the acid.*	*Common borax.*	— —	— — —	10
11		Radical principle of the fluoric acid.	—	— —	— —	Fluoric acid.	*Acid of ſpar.*	Fluoric acid gas.	*Spathoſe gas.*	Fluate of lime, &c.	*Fluor ſpar.*	— —	— — —	11
12		Radical principle of the ſuccinic acid.	—	— —	— —	Succinic acid.	*Volatile ſalt of amber.*	— —	— —	Succinate of ſoda, &c.	— —	— —	— — —	12
13		Radical principle of the acetic acid.	—	— —	— —	Acetous acid. *With more oxigene,* Acetic acid.	*Diſtilled vinegar.* *Radical vinegar.*	— —	— —	Acetite of potaſh of ſoda. of lime. of ammoniac. of lead. of copper. Acetate of ſoda, &c.	*Terra foliata tartari.* *Mineral terra foliata.* *Calcareous acetous ſalt.* *Spirit of Mendererus.* *Saccharum ſaturni.* *Verdigris.*	— —	— — —	13
14		Radical principle of the tartareous acid.	—	— —	— —	Tartareous acid.	—	— —	— —	Acidulous tartarite of potaſh. Tartarite of potaſh Tartarite of ſoda, &c.	*Cream of tartar.* *Vegetable ſalt.* *Salt of Seignette.*	— —	— — —	14
15		Radical principle of the pyro-tartareous acid.	—	— —	— —	Pyro-tartareous acid.	*Empyreumatic tartareous acid, or ſpirit of tartar.*	— —	— —	Pyro-tartarite of lime. Pyro tartarite of iron, &c.	— —	— —	— — —	15
16		Radical principle of the oxalic acid.	—	— —	— —	Oxalic acid.	*Saccharine acid.*	— —	— —	Acidulous oxalate of potaſh. Oxalate of lime. of ſoda, &c.	*Salt of Sorrel.*	— —	— — —	16
17		Radical principle of the gallic acid.	—	— —	— —	Gallic acid.	*Aſtringent principle.*	— —	— —	Gallate of ſoda. of magneſia. of iron, &c.	— —	— —	— — —	17
18		Radical principle of the citric acid.	—	— —	— —	Citric acid.	*Lemon juice.*	— —	— —	Citrate of potaſh. of lead, &c.	*Terra foliata with lemon juice.*	— —	— — —	18
19		Radical principle of the malic acid.	—	— —	— —	Malic acid.	*Acid of apples.*	— —	— —	Malate of lime, &c.	— —	— —	— — —	19
20		Radical principle of the benzoic acid.	—	— —	— —	Benzoic acid.	*Flowers of benzoin.*	— —	— —	Aluminous benzoate. Benzoate of iron, &c.	— —	— —	— — —	20
21		Radical principle of the pyro-ligneous acid.	—	— —	— —	Pyro-ligneous acid.	*Spirit of wood.*	— —	— —	Pyro-lignite of lime. Pyro-lignite of zinc, &c.	— —	— —	— — —	21
22		Radical principle of the pyro-mucous acid.	—	— —	— —	Pyro-mucous acid.	*Spirit of honey, ſugar, &c.*	— —	— —	Pyro mucite of magneſia. Ammoniacal, &c. pyro-mucite	—	— —	— — —	22
23		Radical principle of the camphoric acid.	—	— —	— —	Camphoric acid.	—	— —	— —	Camphorate of ſoda, &c.	— —	— —	— — —	23
24		Radical principle of the lactic acid.	—	— —	— —	Lactic acid.	*Acid of milk.*	— —	— —	Lactate of lime, &c.	— —	— —	— — —	24
25		Radical principle of the ſaccho-lactic acid.	—	— —	— —	Saccho-lactic acid.	*Acid of ſugar of milk.*	— —	— —	Saccho-lactate of iron, &c.	— —	— —	— — —	25
26		Radical principle of the formic acid.	—	— —	— —	Formic acid.	*Acid of ants.*	— —	— —	Ammoniacal, &c. formiate	*Spirit of magnanimity.*	— —	— — —	26
27		Radical principle of the Pruſſic acid.	—	— —	— —	Pruſſic acid.	*Colouring matter of Pruſſian blue.*	— —	— —	Pruſſiate of potaſh, &c. Pruſſiate of iron, &c.	*Phlogiſticated alkali,* or *Pruſſian alkali.* *Pruſſian blue.*	— —	— — —	27
28		Radical principle of the ſebacic acid.	—	— —	— —	Sebacic acid.	*Acid of greaſe.*	— —	— —	Sebate of lime, &c.	— —	— —	— — —	28
29		Radical principle of the lithic acid.	—	— —	— —	Lithic acid.	*Stone in the bladder.*	— —	— —	Lithiate of ſoda, &c.	— —	— —	— — —	29
30		Radical principle of the bombic acid.	—	— —	— —	Bombic acid.	*Acid of the ſilk-worm.*	— —	— —	Bombiate of iron, &c.	— —	— —	— — —	30
								OXIDES WITH VARIOUS BASES *.						
31	METALLIC SUBSTANCES.	Arſenic.	*Regulus of arſenic.*	— —	— —	Oxide of arſenic.	*White arſenic,* or *calx of arſenic.*	Yellow / Red ſulphurated oxide of arſenic Arſenical oxide of potaſh.	*Orpiment.* *Realgar.* *Liver of arſenic.*	Arſeniate of potaſh, &c. Arſeniate of copper.	*Macquer's arſenical neutral ſalt.*	Alloy of arſenic and tin.	*Arſenicated tin.*	31
32		Molybdena.	—	— —	— —	Oxide of molybdena. Molybdic acid.	*Calx of molybdena.*	Sulphure of molybdena.	*Molybdena.*	Molybdate.	— —	Alloy, &c.	— — —	32
33		Tungſten.	—	— —	— —	Oxide of tungſten. Tunſtic acid	*Yellow calx of tungſten.*	— —	— —	Calcareous tunſtate.	*Swediſh tungſten.*	Alloy, &c.	— — —	33
34		Manganeſe.	*Regulus of manganeſe.*	— —	— —	White / Black / Vitreous oxide of manganeſe.	*Manganeſe.*	— —	— —	— —	— —	Alloy of manganeſe and iron.	— — —	34
35		Nickel.	—	— —	— —	Oxide of nickel	*Calx of nickel.*	— —	— —	— —	— —	Alloy of nickle, &c.	— — —	35
36		Cobalt.	*Regulus of cobalt.*	— —	— —	Grey / Vitreous oxide of cobalt.	*Calx of cobalt.*	Alkaline cobaltic oxides.	*Precipitates of cobalt again diſſolved by alkalies.*	— —	— —	Alloy, &c.	— — —	36
37		Biſmuth.	—	— —	— —	White / Yellow / Vitreous oxide of biſmuth.	*Magiſtery of biſmuth,* or *white paint.* *Yellow calx of biſmuth.* *Glaſs of biſmuth*	Sulphurated oxide of biſmuth.	*Biſmuth precipitated by liver of ſulphur.*	— —	— —	Alloy, &c.	— — —	37
38		Antimony.	*Regulus of antimony.*	— —	— —	Oxide of antimony by the nitrous acid, by the muriatic acid ſublimated. vitreous.	*Diaphoretic antimony.* *Powder of Algarotti.* *Flowers* or *ſnow of antimony.* *Glaſs of regulus of antimony.*	Grey / Red / Orange / Vitreous ſulphurated oxide of antimony. Alkaline oxide of antimony.	*Grey calx of antimony.* *Kermes mineral.* *Golden ſulphur.* *Glaſs and liver of antimony* *Rotrou's ſolvent.*	— —	— —	Alloy, &c.	— — —	38
39		Zinc.	—	— —	— —	Oxide of zinc. Sublimated oxide of zinc	*Calx of zinc.* *Flowers of zinc, pompholix, &c.*	Sulphurated oxide of zinc.	*Precipitate of zinc by liver of ſulphur* or *factitious blende.*	— —	— —	Alloy, &c.	— — —	39
40		Iron.	—	— —	— —	Black / Red oxide of iron	*Martial æthiops* *Aſtringent ſaffron of Mars.*	Sulphurated oxide of iron.	—	— —	— —	Alloy, &c.	— — —	40
41		Tin.	—	— —	— —	White oxide of tin.	*Calx or putty of tin.*	Yellow ſulphurated oxide of tin	*Aurum muſſivum.*	— —	— —	Alloy, &c.	— — —	41
42		Lead.	—	— —	— —	White / Yellow / Red / Vitreous oxide of lead.	*Ceruſe,* or *white lead.* *Maſſicot* *Minium* *Litharge.*	Sulphurated oxide of lead.	—	— —	— —	Alloy, &c.	— — —	42
43		Copper.	—	— —	— —	Red / Green / Blue oxide of copper.	*Brown calx of copper.* *Green calx of copper,* or *verdigris.* *Mountain blue*	Ammoniacal oxide of copper	—	— —	— —	Alloy, &c.	— — —	43
44		Mercury.	—	— —	— —	Blackiſh / Yellow / Red mercurial oxide.	*Æthiops per ſe.* *Turbith mineral.* *Precipitate per ſe.*	Black / Red ſulphurated oxide of mercury.	*Æthiops mineral.* *Cinnabar.*	— —	— —	Alloy *or* amalgam of, &c.	— — —	44
45		Silver.	—	— —	— —	Oxide of ſilver	*Calx of ſilver.*	Sulphurated oxide of ſilver.	—	— —	— —	Alloy, &c.	— — —	45
46		Platina.	—	— —	— —	Oxide of platina.	*Calx of platina.*	— —	— —	— —	— —	Alloy of platina & gold.	— — —	46
47		Gold.	—	— —	— —	Oxide of gold.	*Calx of gold.*	— —	— —	— —	— —	Alloy, &c.	— — —	47
48	EARTHS.	Siliceous earth.	*Vitrifiable earth, quartz, &c*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	48
49		Aluminous earth.	*Clay, or earth of alum.*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	49
50		Barytes	*Terra ponderoſa.*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	50
51		Lime	*Calcareous earth.*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	51
52		Magneſia.	—	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	52
53	ALKALIES.	Potaſh.	*Vegetable fixed alkali of tartar, &c.*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	53
54		Soda.	*Mineral alkali, marine alkali, natrum.*	— —	— —	— —	— —	— —	— —	— —	— —	— —	— — —	54
55		Ammoniac.	*Fluor, or cauſtic volatile alkali.*	Ammoniacal gas.	*Alkaline gas.*	— —	— —	— —	— —	— —	— —	— —	— — —	55

* the ſubſtances in the lower part of this column cannot be reduced into a gazeous ſtate, and not only they, but ſeveral of thoſe in the upper part: we have therefore changed at this place the title of the column and ſubſtituted another, which expreſſes the peculiar combinations of the metals.

DENOMINATIONS newly appropriated to ſeveral Subſtances, which are more compound in their Nature, yet enter into new Combinations without being decompoſed.

	1	2	3	4	5.	6	7	8	9	10	11	12	13	14	15	16	17
New Names.	Mucous matter.	Glutinous matter, or gluten.	Sugar.	Starch.	Fixed oil.	Volatile oil.	The aroma, or aromatic principle.	Reſin.	Extractive matter.	Extracto-reſinous matter in which the extractive matter predominates.	Reſinous-extractive matter in which the reſin predominates.	Feculum.	Alcohol or ſpirit of wine.	Alcohol of potaſh, of guaiacum, of ſcammoneum, of myrrh, &c	Nitrous / Gallic / Muriatic alcohol	Sulphuric / Muriatic / Acetic, &c. ether	Alkaline / Earthy / Acid / Metallic ſoaps. Saponula of turpentine, &c.
Ancient names.	*Mucilage.*	*Glutinous matter.*	*Saccharine matter.*	*Amylaceous matter.*	*Fat oil.*	*Eſſential oil.*	*Spiritus rector.*	*Reſin.*	*Extractive matter.*			*Feculum*	*Spirit of wine*	*Alkaline tinctures.* *Tincture of guaiacum* *———— ſcammonium.* *———— myrrh, &c.*	*Dulcified ſpirit of nitre.* *Tincture of nutgalls.* *Dulcified marine acid*	*Ether of Frobenius.* *Vitriolic ether* *Acetous ether, &c.*	*Alkaline, earthy, &c. ſoaps.* *Combination of volatile oils with baſes.*

ELEMENTS OF NATURAL HISTORY AND CHEMISTRY.

PART I.

General Facts, *and* Introduction *to the* Work.

CHAP. I.

Definition of Chemiſtry; Chemical Proceſſes; and the advantages of the Science, &c.

CHEMISTS are not generally agreed concerning the moſt proper definition of chemiſtry. Boerhaave, in his Elements, has ranked it among the arts, or, to ſpeak more accurately, has defined only the practical part of it. Chemiſtry, according to Macquer, is a ſcience, the object of which is to diſcover the nature and properties of all bodies by means of analyſis and ſyntheſis. This definition is indiſputably the beſt that has yet been given. But as analyſis and ſyntheſis cannot be employed with equal ſucceſs in inveſtigating the properties of all natural bodies, it would perhaps be better not to mention them at all when we attempt to define this ſcience. The chemiſt cannot attain the knowledge of the properties of bodies without bringing them into contact; and as all that he can poſſibly diſcover is only the mutual operations of bodies, perhaps the following definition may deſerve to be adopted, even in preference to Macquer's: Chemiſtry is that ſcience which explains the intimate mutual action of all natural bodies*. The facts which we are to relate will illuſtrate this definition. In order to diſplay the extent of this ſcience in a regular perſpicuous manner, we ſhall conſider the ſubjects upon which it is engaged; the means which it employs; the purpoſes it purſues; and the advantages which it affords.

§ I. *Concerning the Object, the Methods, and the Intentions, of Chemiſtry.*

THE ſubjects on which the labours of the chemiſt are engaged, are all the ſubſtances that compoſe the globe which we inhabit, whether buried in its interior parts or found at its ſurface: chemiſtry is therefore of equal extent with natural hiſtory, and the ſame limits are common to both.

---

* The addition of the word *intimate* ſeems to obviate the objection offered againſt this definition by the Engliſh tranſlator of the former edition. It diſtinguiſhes chemical from mechanical action.

Analyſis or decompoſition, and ſyntheſis or combination, are the two proceſſes which chemiſtry employs to accompliſh its purpoſes. The firſt is nothing but the ſeparation of the conſtituent parts of a compound ſubſtance: Cinnabar, for inſtance, is a compoſition of mercury and ſulphur; the chemical art analyſes it by ſeparating theſe two bodies from one another. Till of late it was generally thought, and many are ſtill of opinion, that this method is more advantageous in chemical reſearches than the other. This opinion had even gained ſuch ground among the learned as to induce ſeveral of them to define chemiſtry, The ſcience of analyſis. But nothing can be more inconſiſtent with the juſt idea of decompoſition. In order to ſet this important truth in a proper light, we muſt divide analyſis into two kinds; the true or ſimple, and the falſe or complicated. The true analyſis is that by which the component principles of the body decompoſed are obtained, without ſuffering any alteration. The only criterion by which we can diſtinguiſh whether this analyſis has taken place, is when, by reuniting the ſimple ſubſtances to which the compound body has been reduced, we can form a new compound preciſely ſimilar to the former. Cinnabar will again furniſh an inſtance. When the two ſubſtances of which this compoſition is formed, namely mercury and ſulphur, are ſeparated by a chemical proceſs, they are found to be in a ſtate of purity ſimilar to that which they poſſeſſed before their ſeparation; for by uniting them we can form a new body, differing in no reſpect from the original cinnabar. But unfortunately for the ſcience, this kind of analyſis can ſeldom be effected. Chemiſts are not ſo happy as to be able to apply it to many of the bodies on which they make experiments. The neutral ſalts, and a few other mineral ſubſtances, are the only bodies in nature ſuſceptible of this ſpecies of decompoſition.

The falſe or complicated analyſis is that by means of which a body is reſolved into principles different from thoſe which appeared to exiſt in the compoſition, and incapable of forming, by their reunion, a body ſimilar to that from which they were obtained.

This kind of decompoſition takes place in moſt of the bodies that are ſubject to a chemical analyſis; no other condition being requiſite, but that more than two principles enter into the combination to be examined, and that they be united by a certain degree of mutual affinity. Many minerals, and all vegetable and animal ſubſtances without exception, admit of no other ſpecies of analyſis. Thus ſugar, diſtilled in a retort, affords an acid, an oil, and a coaly reſidue; but all attempts to recombine theſe into the ſame ſubſtance from which they were obtained, are uniformly fruitleſs. This kind of analyſis cannot enable us to diſcover in what ſtate ſubſtances exiſted together in any combination before being ſeparated; and it therefore affords but little uſeful information, and is not to be truſted without the greateſt caution. By truſting too haſtily to reſults of this kind, chemiſts have afforded room for all that cenſure to which their art has been expoſed. On this account has chemiſtry been accuſed of abſolutely deſtroying bodies in its attempts to ſeparate their component parts; and we cannot but acknowledge that the cenſure was for a long time juſt: but becoming more circumſpect in proportion to her progreſs, chemiſtry now rejects that deceitful

ceitful analyſis to which ſhe formerly had recourſe, and poſſeſſes the means of examining the properties and diſtinguiſhing the component principles of bodies, without deſtroying their nature. She even proceeds farther, and, as we ſhall have occaſion to mention more particularly when we come to treat of vegetable ſubſtances, eſtimates the mutual action of principles, and determines by what cauſes they are thus modified and changed.

Syntheſis or compoſition, the ſecond method of proſecuting chemical inquiries, is the formation of a compound by the artificial reunion of ſeveral principles. Its utility, its extent, and the dependance that may be placed on the reſults which it affords, render it much more valuable than the other: nay, not even a ſingle operation in chemiſtry can be conducted without producing ſome new combination. Chemiſts appear not to have been ſufficiently ſenſible of its importance. In fact, as ſyntheſis is both more frequently employed and more highly uſeful than analyſis, chemiſtry might be, with a good deal of propriety, repreſented as the ſcience of combination, not of analyſis.

Theſe two methods are ſometimes employed ſeparately, but oftener together It frequently happens that a true analyſis cannot be effected without the help of ſome combination. Falſe analyſes are always accompanied with new combinations by ſyntheſis; nay, compoſition itſelf often produces a kind of analyſis. The laſt of theſe facts, however, has been but lately diſcovered. The diſcovery of a great nnmber of aeriform fluids, the exiſtence of which was not formerly ſo much as ſuſpected, has ſhown that in many operations which were conſidered as ſimple combinations, an inviſible elaſtic fluid is diſengaged with efferveſcence, and either eſcapes into the atmoſphere, or is received in veſſels which have been ingeniouſly contrived to confine it. Moſt of the combinations of two principles which were before thought to be ſimple ſubſtances, exhibit this kind of analyſis. We ſhall have occaſion to give frequent inſtances of it when we come to treat of neutral ſalts.

From this ſhort account of the analyſis and ſyntheſis of the chemiſts, it appears that the whole art of chemiſtry conſiſts in promoting the intimate mutual action of bodies, and in obſerving carefully the phenomena with which it is attended. It is to be remembered, that Nature herſelf conſtantly employs theſe two methods, and that from her the chemiſt firſt learned to uſe them. As they depend on the mutual affinities of bodies, all that the artiſt can do is to diſpoſe theſe in ſuch a manner that they may act upon each other. The young chemiſt ought carefully to acquaint himſelf with theſe important truths: for theſe, with the reſt to be explained in the following chapters of this firſt part, form the baſis of the ſcience.

Hence it is very eaſy to comprehend the final intention of chemiſtry. That cannot be merely to diſcover the firſt principles of bodies; for there are many ſubſtances which cannot be reſolved into others more ſimple, and whoſe component principles are therefore unknown: yet theſe ſubſtances, though not ſuſceptible of analyſis, admit of combination, and act upon other bodies; and therefore it appears evident, that the chief deſign of chemiſtry is to diſcover the mutual actions of natural bodies, to diſtinguiſh the order of their combinations, and to eſtimate the ſtrength of that mutual

attraction

attraction which gives them a tendency to unite and to remain in union.

§ II. *Concerning the uſeful Purpoſes to which Chemiſtry may be applied.*

A PARTICULAR treatiſe would be neceſſary to give a full view of all the advantages which mankind derive from this ſcience. As the deſign of this work does not admit of our entering minutely into that ſubject, we will content ourſelves with exhibiting its outlines; inſiſting, however, more particularly on ſuch of them as appear not to have been hitherto conſidered with all the attention which they deſerve.

Chemiſtry is beneficial to ſo many of the arts, that we may arrange them all under two diviſions: the firſt, comprehending all the mechanical arts which depend on geometrical principles; the ſecond, including all thoſe which depend upon chemiſtry, and therefore merit the name of chemical arts. Theſe laſt are much more numerous than the other. As they are all founded on chemical phenomena, it is eaſy to ſee that the practice of them ought to be regulated by the rules of chemiſtry; which, by new diſcoveries, ſimplifies the proceſſes, renders their ſucceſs more certain, and even extends the limits of all the arts dependant upon it. Theſe are, 1*ſt*, The arts of making bricks, tiles, china, porcelain, and the other ſpecies of earthen ware; all of which are preparations of different kinds of clay, baked into different forms, and expoſed to the action of heat till each acquire its proper degree of hardneſs.

2dly, The art of making glaſs; which, by combining a vitrifiable earth with a ſaline ſubſtance, produces a new body, hard, tranſparent, and almoſt impregnable by the action of the air: A wonderful art, from which mankind have derived many important advantages! *3dly*, The arts of extracting metals from their ores, of caſting, of purifying, and of allaying them by mixture, owe alſo their origin and progreſs to chemiſtry, which is daily throwing new light upon them. *4thly*, The vegetable kingdom affords materials to a great number of arts, which, as well as thoſe above mentioned, belong to the province of chemiſtry. The arts of converting ſaccharine juices, or farinaceous ſubſtances, into vinous liquors; of extracting from thoſe liquors the ardent ſpirit which they contain; of ſeparating that ſpirit from the water with which it is at firſt combined; of uniting this ardent ſpirit with the aromatic parts of plants; of extracting the colouring matter of plants, and applying it ſo as to tinge ſtuffs; and, laſtly, the arts of converting wine into vinegar, and combining vinegar with various ſubſtances; of ſeparating from grain and other parts of vegetables that precious ſubſtance of which we form bread; and of converting ſo dry and inſipid a body as meal into a light, digeſtible, and pleaſant ſubſtance; all theſe arts, and many more, which our preſent limits allow us not to take particular notice of, belong to the province of chemiſtry, and are indebted to that ſcience for their preſent perfection, and in many inſtances for their firſt invention.

It has equal claims to all thoſe arts which are employed on animal ſubſtances. Such is the uſeful and too little valued art of cookery; the true end of which is not to flatter the palate, or to vary the forms and flavours of meats, for the gratification of capricious taſte; but to render aliments eaſy of digeſtion, by means of boiling, or by applying to them mild and natural ſeaſoning. Hat-making, and the dreſſing, tanning, and currying of leather, belong to the ſame claſs of arts. But one of the moſt valuable of all the arts, which indeed occupies a middle rank between the arts properly ſo called and the ſciences, and to which chemiſtry is ſingularly uſeful, is pharmacy. Every perſon concerned in pharmacy needs a very extenſive knowledge of chemiſtry, that he may not be ignorant of thoſe alterations to which the bodies he makes uſe of are ſubject; may know how to prevent or correct ſuch alterations; may be called to diſcover the changes which compound medicines undergo; and, in a word, may foreſee readily the combinations or analyſes that may be produced by the mixture of any ſimple drugs. Every impartial perſon muſt agree, that to acquire a competent ſkill in pharmacy, the ſtudent ought, after acquainting himſelf with the natural hiſtory of materia medica, to turn his attention to chemiſtry, and ſtudy it with the moſt earneſt aſſiduity. By theſe means only can pharmacy be practiſed on certain principles, ſo as to render mankind thoſe important ſervices which intitle it to the high rank it holds among the arts.

A very curſory view of the ſciences will be ſufficient to convince us what important benefits they may derive from chemiſtry. To natural hiſtory it is peculiarly beneficial. The earlier naturaliſts employed the phyſical properties of colour, form, and conſiſtency, &c. as the diſtinguiſhing characteriſtics of minerals: but thoſe properties being very liable to variation, the bodies of which ancient philoſophers have ſpoken

ſpoken are no longer known, and their diſcoveries are almoſt totally loſt. The moderns have become ſenſible, that, in order to obviate this inconvenience ſo fatal to the progreſs of natural hiſtory, ſome new method muſt be adopted. Chemical analyſis has been thought the happieſt that can be employed; and by this method ſuch progreſs has already been made, that minerals are now ranked into claſſes according to the nature and quantity of the principles of which they are compoſed. The progreſs made in this branch of natural hiſtory is owing to the labours of Meſſrs Bergman, Bayen, Monnet, &c. Wallerius, Cronſtedt, and ſome other naturaliſts, firſt began the arrangement of mineral bodies according to their chemical properties. M. Bucquet, in his latter courſes of lectures, had improved on the ideas of thoſe two celebrated naturaliſts; and his mode of arrangement was entirely chemical. M. Sage, who has analyſed a great number of minerals, has alſo employed a chemical mode of arrangement: and tho' no chemiſt has adopted the whole of his theory, yet mineralogy owes him the higheſt obligations; and few in France have purſued the ſtudy with more induſtry and ſucceſs. M. Daubenton has availed himſelf of the labours of all his cotemporaries and predeceſſors; examining them, however, with a degree of caution worthy of the true philoſopher, whoſe proper object is to diſcover truth amid that maze of error and uncertainty, in which, unfortunately for mankind, it is too often concealed. Nothing, then, can be more certain than the utility of chemiſtry to natural hiſtory; it affords the only means of removing that obſcurity and uncertainty which muſt ever attend ſimple deſcriptions of natural objects. One obſervation of M. Daubenton merits the particular attention of all chemical philoſophers:

phers:

phers: He adviſes them to deſcribe carefully the ſpecimens on which they make their experiments, in order that they may be generally underſtood by naturaliſts, and may avoid that confuſion which, according to this celebrated profeſſor, prevails through the works of many modern chemiſts. The only means which I have found proper for avoiding that confuſion, is, to connect the two ſciences in my lectures, by uniting phyſical deſcriptions of bodies with an account of their chemical properties.

But the world are not ſo generally convinced of the uſefulneſs of chemiſtry in medicine. The errors of the chemical phyſicians of the laſt century, and the indifference of a number of medical practitioners for this ſcience, have impreſſed many with an unfavourable opinion of it, which time alone can remove. Yet, it would ſurely be better not to lend an ear to the voice of prejudice, but to inquire candidly into the cauſes of thoſe miſtakes which chemiſts have committed, and to conſider by what means they may be for the future avoided, and the ſcience reſtored to its juſt honours. Though the firſt phyſicians who cultivated chemiſtry were miſled by a blind enthuſiaſm; yet from that no inferences can be drawn applicable to the chemiſtry of the preſent time. The preciſion which the moderns have introduced into every part of experimental philoſophy, cannot but remove all the apprehenſions which might be entertained, if chemiſtry were ſtill involved in the ſame degree of myſtery and obſcurity in which it was a century ago. If employed with caution, and with a due regard to the extent of its powers, it cannot but be highly beneficial to medicine. After thus acknowledging the whims and blunders of chemiſts, let us proceed to juſtify the ſcience, by examining how far it is uſeful to every branch of medicine. Let us firſt diſtinguiſh between the two great departments of this extenſive ſcience, namely, the theory and the practice; which, however, ought not to be entirely ſeparated from each other, as they have been by ſome authors. The ſtudy of medicine ought always to begin with the anatomy of man and the other animals. But the ſolids are the only part of the animal frame ſubject to the examination of anatomy; while it is well known to phyſiologiſts, that the greateſt part of animal bodies conſiſts of fluids, by the motion of which life is maintained. Were we then to confine our obſervation to the ſtructure of the veſſels, without examining the nature and properties of the fluids which they contain, we ſhould be acquainted with only one part of the animal ſyſtem. It is the buſineſs of chemiſtry to explain to us the qualities of theſe fluids: chemiſtry affords the only means by which we can acquire a knowledge of the principles of which they are compoſed, and of the changes which they undergo in performing thoſe functions by which they contribute to the ſupport of life. Without the aid of this ſcience, it would be impoſſible for us to diſcover the mechaniſm of the animal functions; to diſtinguiſh between the various fluids ſeparated by the different viſcera; to obſerve what alterations theſe ſuffer when collected in their ſeveral reſervoirs; or to underſtand how they are affected by heat, cold, or mixture with other fluids, &c. When we are thus far acquainted with the compoſition of animal fluids, it will next be proper to examine what variations they are liable to, from differences of ſex, age, conſtitution, climate, and ſeaſon; and

and to trace them through the various ſpecies of animals: thus ſhall we eſtabliſh certain points of compariſon, by means of which the limits of ſcience may be extended. It is not enough, however, to examine the chemical properties of the animal fluids when the syſtem is in a ſound ſtate: they ſhould be obſerved with no leſs attention when the body languiſhes under diſeaſe, in order that it may be certainly diſcovered what alterations they ſuffer in the various diſtempers to which the human frame is liable; what part of the humours predominates in putrid, inflammatory, ſcorbutic, or ſcrophulous diſorders; what ſaline combinations are formed during the progreſs of the diſtemper; what matter extruded from its proper veſſels. Such reſearches cannot fail to make phyſicians better acquainted with the hiſtory of pathology. We think it equally neceſſary to examine the ſolids by chemical methods, in the ſound as well as in the diſeaſed ſtate of the body; that by conſidering their properties, we may diſcover from what fluid they are produced; and, this known, may conjecture upon good grounds, what ſolid or fluid has ſuffered alteration in any diſtemper. This poſition, which is here but ſlightly mentioned, will be more particularly explained in the chapters on Animal Matters.

But chemiſtry is no leſs uſeful to the practice than to the theory of medicine; nor can it indeed be uſeful to the one without promoting the other at the ſame time. It will, therefore, be no difficult taſk to ſhow the dependance of the practice upon this ſcience. To begin with the art of preſerving health; an accurate chemical knowledge of the various articles of food, and of the atmoſpheric fluid, is neceſſary to enable us to make a proper choice of air and aliments. By chemiſtry

miſtry we learn what quantity of nutritive matter is contained in every different article of food; in what particular ſtate that matter exiſts in each of the bodies in which it is found; the nature of the ſeveral ſubſtances with which it may be combined; and the means of extracting, purifying, and preparing it in a manner ſuitable to the ſtrength or weakneſs of different ſtomachs. It is the ſame ſcience that explains to us the nature of thoſe fluids which we uſe for drink; what properties render water wholeſome or noxious, and how to ſeparate from it whatever may render it injurious to the animal œconomy; what are the principles of fermented liquors, and in what proportion thoſe are mingled together in the ſeveral kinds of wine; as alſo by what proceſſes we may diſtinguiſh whether wine is genuine or adulterated: Laſtly, by the ſame means we learn, what properties render air fit for reſpiration; to what changes that fluid is liable; and what other ſubſtances are capable of altering its purity, by entering into combination with it. Chemiſtry likewiſe ſupplies us with the happy means of correcting the qualities of air when noxious, ſo as to reſtore it to that ſtate in which it is proper for reſpiration: for the diſcovery of which means we are indebted to the induſtry of the moderns, as ſhall be ſhown in the Hiſtory of Air.

The phyſician ought not to make uſe of medicines unleſs he knows their nature; and that knowledge he muſt learn from chemiſtry. This has been ſo long generally acknowledged, that the writers of the materia medica arrange medicines by their chemical properties. The uniform experience of all ages has eſtabliſhed it as a certain truth, that there is a cloſe and natural relation between the taſte of bodies and the manner

in

in which they act on the animal œconomy; ſo that by taſting any ſubſtance we may judge of its medicinal qualities: Bitters are ſtomachic; inſipid ſubſtances, mild and relaxing; bodies of an agreeable ſweet taſte, nutritious; acid ſubſtances, active, penetrating, and inciſive. But as taſte is undeniably a chemical property, depending on the tendency of ſubſtances to combination, as ſhall be elſewhere ſhown, we muſt confeſs ourſelves indebted to chemiſtry for whatever knowledge of the properties of bodies we can gain by examining their taſte: Yet it would be abſurd to ſuppoſe, with the chemical phyſicians of the laſt century, that the ſtomach is a veſſel in which chemical proceſſes are carried on, as in a laboratory. The inteſtines poſſeſs indeed ſenſibility and a peculiar motion, which modify the nature and operation of ſuch medicines as are adminiſtered; but it becomes the phyſician to repreſs thoſe wild ſallies of imagination which lead to ridiculous hypotheſes, and to admit only ſuch facts as are eſtabliſhed by accurate obſervation. It cannot be denied, that, in ſome caſes, medicines act in the firſt paſſages by means of their chemical properties: then, indeed, the phyſician may apply his chemical knowledge. Long experience has ſhown, that in the diſeaſes peculiar to children, the ſtomach and inteſtines are coated with a tenacious viſcous matter, which is manifeſtly of an acid nature. The abſorbent earths, and alkalis adminiſtered on ſuch occaſions, deſtroy this acid by entering into combination with it, and form a neutral purgative ſalt, which by ſtimulating the inteſtines, cauſes them to evacuate the noxious matter. All diſeaſes that occaſion an accumulation of obſtructive matter in the primary paſſages, require the phyſician to poſſeſs ſome chemical knowledge; as it is certain that ſome ſubſtances will act with more force than others on that obſtructive matter. Thus, for inſtance, acids may be adminiſtered to remove one kind of obſtruction, and ſolutions of ſalts for another.

But the greateſt advantage which the practitioner of medicine can derive from chemiſtry, is on thoſe alarming occaſions when, by accident or deſign, ſome of thoſe corroſive ſubſtances have been ſwallowed, which prove fatal to life by attacking the viſcera, and deſtroying their organization. On ſuch occaſions chemiſtry lends the readieſt and moſt effectual aid to medicine, by ſupplying ſubſtances which have power to decompoſe the poiſon, and by that means obviate its direful effects. Navier, a celebrated medical chemiſt of Chalons, has publiſhed a work, in which he points out effectual remedies to prevent the deſtructive effects of the poiſons of arſenic, corroſive ſublimate, verdegris, the preparations of lead. Notwithſtanding the angry declamations of ſome phyſicians, who ſeem deſirous of excluding the ſciences from the practice of medicine, his work well deſerves the gratitude of poſterity. Not only does chemiſtry at preſent enable us to counteract effectually the operation of mineral poiſons; but there is even reaſon to hope, that careful inquiries into the nature of animal and vegetable poiſons, may enable us to diſcover ſome ſubſtances capable of diveſting them alſo of their pernicious powers. Opium, and all narcotic vegetables, the acid and cauſtic juices, ſuch as thoſe of ſpurge and euphorbium, the noxious plants, particularly muſhrooms, are all well worthy of the particular attention of the chemiſt; as by his reſearches ſome means may poſſibly be diſcovered which may render them no longer equally dan-

dangerous. It is of no leſs importance to examine the nature of animal poiſons. From the experiments of Margraaf and Fontana we are already acquainted with the acid of ants: Thouvenel has diſcovered ſeveral acrid ſubſtances in cantharides: Mead has examined the venom of the viper: Fontana has purſued a train of obſervations on the ſame poiſon; and has diſcovered, that the *lapis cauſticus*, introduced immediately into the wound made by this reptile, decompoſes the poiſon, and prevents its effects.

Though chemiſtry were not to contribute ſo much in theſe inſtances to the benefit of medicine; yet ſtill by ſupplying ſuch a number of valuable drugs, ſhe muſt be confeſſed to render ſervices of the higheſt importance to this uſeful ſcience. Stibiated tartar, together with the various mercurial, antimonial, and martial preparations, which are ſo often and ſo ſucceſsfully preſcribed, when conſidered as the gifts of chemiſtry, muſt ſurely induce phyſicians to eſteem the ſcience, and to encourage thoſe who proſecute chemical reſearches from a deſire to contribute to the advancement of medicine. As for myſelf, the natural bent of my genius, no leſs than my particular ſituation, leads me to cultivate both ſciences with the moſt earneſt wiſhes to promote their improvement. The declamations of thoſe, who from their ignorance of chemiſtry, are induced to repreſent it as of no utility in medicine, ſhall never detach me from this ſcience. I have engaged with ardour in the ſtudy of animal chemiſtry, and am determined to follow the ſteps of thoſe who have already proſecuted it with ſo much ſucceſs.

To conclude our obſervations on the utility of chemiſtry to medicine; we ſhall only add, that a certain degree of chemical knowledge is abſolutely neceſſary

to

to enable the phyſician to make out a preſcription of any compound medicine, to be prepared by the apothecary. Perſons unſkilled in chemiſtry are liable to commit the groſſeſt blunders daily in making out preſcriptions; to order, for inſtance, the compoſition of ſubſtances incapable of ſubſiſting in union, or which have a mutual tendency to decompoſe one another. In the caſe of decompoſition, the medicine adminiſtered cannot poſſibly produce the deſired effects. Chemiſtry furniſhes the only means to prevent ſuch blunders; which are often attended with the moſt unhappy conſequences. If poſſeſſed of chemical knowledge, we will never attempt to compound together ſubſtances incapable of mutual combination; the laws of chemiſtry muſt always direct us in the preparation of compound medicines. Without a knowledge of chemiſtry, the phyſician muſt ever be liable to commit numerous blunders; which, though they ſhould be followed by no other bad conſequences, cannot but expoſe him to the contempt of the apothecary; as the practice of the apothecary naturally makes *him* acquainted with many chemical facts.

The uſefulneſs of chemiſtry in the arts, and the reſemblance of its proceſſes to the manipulations of artiſts, have cauſed it to be confounded ſometimes with alchemy, ſometimes with pharmacy; though *they* muſt be very ignorant indeed, who can thus confound objects ſo widely different from one another, and can regard the chemiſt as a fanciful projector, unweariedly employed in a vain ſearch for the philoſopher's ſtone. Even a very ſlight attention to the nature and purſuits of chemiſtry, may be ſufficient to convince any perſon that there is a vaſt difference between thoſe purpoſes which

which the chemiſt purſues in a train of regular connected reſearches, and the tranſmutations which the alchemiſt pretends to effect by a ſet of abſurd and deſultory proceſſes. That miſtake which leads many people to regard chemiſtry as the art of preparing drugs is more excuſable; it confounds not the chemiſt with the ignorant and inſignificant operators of the Great Work; who, as is humorouſly obſerved by Macquer, are the artiſans of an art which has no exiſtence; but aſſociates him with a claſs of uſeful and reſpectable artiſts, whoſe labours are of high importance to ſociety. Yet as pharmacy is but one branch of chemiſtry, to confine chemiſtry to the making up of medicines, is to entertain a very unjuſt idea of the extent of the ſcience. Pharmacy, as well as all the other arts dependant on chemiſtry, is guided and aſſiſted in its operations by this ſcience. But chemiſtry, in its nature and objects, is more ſublime and extenſive; it extends its inquiries and inductions to the reciprocal action of all the bodies in nature; and thus contributes at the ſame time to the advancement of both philoſophy and the arts.

CHAP. II.

The Hiſtory of Chemiſtry.

THE ſtudent of any ſcience ſhould make himſelf acquainted at leaſt with the outlines of its hiſtory. A knowledge of the leading facts, and of the dates of different diſcoveries, will be of uſe to enable him to avoid the errors of thoſe who have preceded him in the ſame purſuits, and to direct him to the path which leads to improvement. But as a very minute detail of the hiſtory of chemiſtry might poſſibly be conſidered as an unneceſſary digreſſion from the main object of this treatiſe, we ſhall confine ourſelves to a view of leading facts, without entering into particulars. Whoever is deſirous of fuller information concerning the riſe and progreſs of chemiſtry, may conſult a variety of well-written works which have been publiſhed on the ſubject; particularly, the Treatiſe of Olaus Borrichius, *de ortu et progreſſu Chemiæ;* the article *Chimie* in the *Dictionnaire Encyclopedique;* the Introduction to Senac's Treatiſe on Chemiſtry; Abbé Lenglet du Freſnoy's Hiſtory of the Hermetic Philoſophy; the firſt chapter of Boerhaave's Chemiſtry; and the Diſcourſe prefixed to Macquer's Chemical Dictionary, &c.

To

To give the reader a brief and methodical account of the progreſs of the human mind in the ſtudy of chemiſtry, and of the ſucceſſive diſcoveries which have been made in this ſcience; we ſhall divide our hiſtory into ſix periods.

I.

The Origin of Chemiſtry among the Egyptians, and its progreſs among the Greeks.

The origin of chemiſtry is hid in the ſame obſcurity which conceals that of the other arts and ſciences. The patriarch Tubal-Cain, who lived before the flood, is conſidered as the inventor of chemiſtry; but the only part of it known to him was the art of working metals: he ſeems to have been the ſame with the Vulcan of fabulous hiſtory.

We may with more confidence aſcribe the invention of this ſcience to the ancient Egyptians. According to Abbé Lenglet du Freſnoy, Thoth or Athotis, ſurnamed Hermes or Mercury, is the firſt of this nation of whom mention is made as being a chemiſt. He was the ſon of Mezraim or Oſiris, and the grandſon of Cham. He became king of Thebes.

Siphoas was the next Egyptian monarch, who was alſo diſtinguiſhed as a philoſopher. He lived 800 years after Athotis, and 1900 before Jeſus Chriſt. He is named Hermes, or Mercury Triſmegiſtus, by the Greeks; and is therefore the ſecond Mercury: he is conſidered as the inventor of natural philoſophy; he wrote two and forty books on the ſubject of philoſophy, the titles of which have been handed down to us by various hiſtorians.

ſtorians. None of them ſeems to have treated directly of chemiſtry; though from him has the ſcience been intitled the Hermetic Philoſophy.

We know but little concerning thoſe who cultivated chemiſtry among the Egyptians; but the ſcience appears to have made conſiderable progreſs among them, for they practiſed many of the arts dependant on chemiſtry; particularly the arts of forming imitations of the precious ſtones, of caſting and working metals, of painting upon glaſs, &c.: but the chemiſtry of this ancient people has been loſt, as well as their other arts and ſciences. The prieſts involved them in myſtery, and concealed them under the veil of hieroglyphics. Alchemiſts have perſuaded themſelves, that ſome veſtiges of their pretended art may be traced among the remains of the Egyptian hieroglyphics; and that the temple which the Egyptians dedicated to Vulcan was erected in honour of alchemy.

The Iſraelites acquired a knowledge of chemiſtry from the Egyptians. Moſes is conſidered as a chemiſt, on account of his diſſolving the golden idol which the people had ſet up. It has been thought, and Stahl has even written a diſſertation to prove, that he rendered the gold ſoluble in water by means of liver of ſulphur. Such a proceſs ſuppoſes a pretty extenſive knowledge of chemiſtry.

Democritus of Abdera, who lived about 500 years before Jeſus Chriſt, travelled into Egypt, Chaldea, and Perſia, &c. and is ſaid to have gained ſome ſkill in chemiſtry in the firſt of thoſe countries. Though the ſon of a man whoſe opulence had enabled him to entertain Xerxes and all his attendants, he returned very poor to his native country, where he was kindly received, however, by his brother Damaſſus. Retiring to a garden near the city-walls of Abdera, he employed himſelf in the ſtudy of plants and precious ſtones. Cicero aſſerts, that Democritus, in order that he might not be diverted from his ſpeculations by external objects, deprived himſelf of ſight by gazing on the rays of the ſun reflected from a veſſel of poliſhed copper: But Plutarch denies this fact. Pliny was ſo amazed at the knowledge of Democritus, that he conſidered it as quite miraculous.

Several authors reckon Cleopatra a chemiſt, becauſe ſhe knew how to diſſolve pearls. It is even affirmed, that the art of chemiſtry being known to all the Egyptian prieſts, continued to be practiſed among that nation till the time when, according to Suidas, Diocleſian thought to reduce them more eaſily under ſubjection, by burning their books on chemiſtry.

II.

The Chemiſtry of the Arabians.

After a long ſeries of ages, through which it is impoſſible to trace the progreſs of chemiſtry amid the revolutions of empire; this ſcience again appears among the Arabians, and cultivated ſo ſucceſsfully as to merit our attention.

Under the dynaſty of the Achemides, or Abaſſides, the ſciences, which had long been neglected, regained their former vigour. Almanzor, the ſecond Caliph of that family, eagerly cultivated aſtronomy. Harum Raſchid, the fifth caliph, who was cotemporary with Charlemagne, cauſed ſeveral books on chemiſtry to be tranſlated from the Greek into the Arabic.

In the ninth century, Gebber of Thus, in Chorazan, a province of Perſia, wrote three different treatiſes on chemiſtry; which contain a number of tolerably good things. His maſterpiece is intitled, *Summa perfectionis magiſterii.* He has written with conſiderable perſpicuity on diſtillation, calcination, the reduction and the ſolution of metals.

In the tenth century, Rhazes, phyſician to the hoſpital of Bagdad, firſt applied chemiſtry to medicine. Some of his pharmaceutic preſcriptions are ſtill in eſteem.

In the eleventh century, Avicenna, a phyſician, in imitation of Rhazes, applied chemiſtry to medicine. His merit raiſed him to the office of Grand-Vizir; but his debaucheries occaſioned his degradation from that office.

III.

Chemiſtry paſſes from the Eaſt to the Weſt, in the time of the Cruſades.

The art of making gold continued long in repute, according to the authors who have written upon it. But the madneſs that gave riſe to it roſe to its greateſt height between the eleventh and the ſixteenth century. The chemical facts which had been diſcovered by the Egyptians, collected by the Greeks, and applied to medicine by the Arabians, became known to the four nations who viſited the eaſt in the Cruſades; and England, France, Germany, and Italy, ſoon ſwarmed with a ſet of men eager in ſearch of the philoſopher's ſtone. As their labours contributed to the advancement of

chemiſtry,

chemiſtry, it is but reaſonable to take notice of ſome of the moſt diſtinguiſhed among thoſe ſingular geniuſes.

In the thirteenth century, Albert the Great, a Dominican of Cologne, and afterwards of Ratiſbon, was reputed a magician; and compoſed a work, which contains deſcriptions of many alchemical proceſſes.

Roger Bacon, born in the year 1214, near Ilcheſter in the county of Somerſet, ſtudied at Oxford, and came afterwards to Paris to proſecute his ſtudies in mathematics and medicine. He is celebrated as the author of ſeveral inventions; any one of which might well intitle him to immortality. Among theſe are the camera obſcura, the teleſcope, and gunpowder. He is ſaid to have made a ſelf-moving chariot, a flying machine, a ſpeaking head, &c. He was a cordelier, and was ſirnamed the *Admirable Doctor*. Being accuſed of magic, his fellows were obliged to impriſon him. He afterwards reſided in an houſe in Oxford, where he is ſaid to have worked in alchemy. Borrichius ſaw the houſe, which was ſtill known by his name *.

Arnold of Villeneuve, born in Languedoc in 1245, died in 1310, having ſtudied medicine at Paris for 30 years. He wrote a commentary on the Schola Salernitana. The alchemiſts reſpect him as one of their greateſt maſters. Borrichius, in the year 1664, ſaw one of his deſcendants, an alchemiſt, in Languedoc.

Fourteenth century. Raymond Lully, born in Majorca in 1235, came to Paris in 1281; where he became acquainted

---

* Concerning this houſe, if I miſtake not, a tradition has been long known at Oxford; that when a greater man than Roger Bacon paſſes beneath it, it will tumble down upon his head. It ſtands on a bridge.

"And Bacon's manſion trembles o'er his head." JOHNSON.

acquainted with Arnold of Villeneuve, and ſtudied under him. Robert Conſtantine relates his having ſeen in the Tower of London a Roſe Noble ſtruck out of gold, made by Lully, under the reign of Edward V. in the years 1312 and 1313. He has left ſeveral books on alchemy, which contain ſome facts relative to the preparation of acids, or ſtrong waters, and the properties of metals.

Fifteenth century. Baſilius Valentinus, a Benedictine of Erfort in Germany, was ſkilled in medicine and natural hiſtory. He has left a work on antimony, under the pompous title of *Currus triumphalis Antimonii*, on which a commentary has been written by Kerkringius. That book deſcribes a conſiderable number of antimonial preparations, which have been ſince offered to the world as new diſcoveries, under different names, and have been preſcribed with great ſucceſs for ſeveral diſorders.

The two Iſaacs of Holland, father and ſon, though but little known, have left ſome treatiſes which are praiſed by Boerhaave, and from which they appear to have been acquainted with aquafortis and aqua regia.

All theſe authors have written on chemiſtry in a very obſcure, confuſed manner. Though acquainted with ſome proceſſes of ſolution, extraction, and purification, &c. their pretenſions roſe much higher than their knowledge; and ſcarce any advantage can be derived from a peruſal of their works.

IV.

The univerſal Medicine; Pharmaceutic Chemiſtry; Alchemy oppoſed, from the ſixteenth to the middle of the ſeventeenth Century.

THOUGH the vain projects of the alchemiſts had been invariably unſucceſsful, and had been almoſt always attended with the loſs of fortune and reputation; yet, in the ſixteenth century, a prodigious number appeared, at the head of whom was Paracelſus a Swiſs phyſician, born at Zurich in 1493, whoſe reveries were eagerly embraced by the reſt. That fanciful man aſſerted, that there was an univerſal medicine, and ſubſtituted chemical preparations in the place of the Galenical pharmacy then in uſe. He cured many diſeaſes in which the ordinary remedies had been ineffectually applied, and particularly venereal complaints with mercurial preparations. He performed ſome very ſurpriſing cures; but became ſo extravagantly fluſhed with his ſucceſs, as to burn in public the writings of the Greek phyſicians. He died amid his imaginary triumphs in an inn in Saltzburgh, at the age of 48, after having promiſed himſelf immortality from the uſe of his ſecrets.

Notwithſtanding the extravagance and abſurdity of his idea of an univerſal medicine, it attracted the attention of alchemiſts, and revived the ſpirit of alchemy. Several imagining that they had diſcovered the univerſal medicine, aſſumed the new title of *Adepts*. Among thoſe were, at the beginning of the ſeventeenth century,

1. The Roſicrucians, a fraternity that aroſe in Germany, were never known but by name in France, and whoſe individual members never made any public acknowledgment of their principles. They pretended to be in poſſeſſion of the art of tranſmutation, the univerſal ſcience, the univerſal medicine, and the ſcience of occult things, &c.

2. A wandering fellow, named Alexander Sethon or Sidon, who is ſaid to have performed the work of tranſmutation in Holland, in the preſence of a perſon of the name of Hauſſen. Hauſſen related the fact to Vander Linden, grandfather to the phyſician of that name, who collected a medical library.

3. Another named Thomas Vaughan, born in England in 1612. He went to America, where Starkey ſaw and received gold from him. Boyle correſponded with him. This is the ſame adept who, in France, gave his powder of projection to Hevelius. The latter, in conſequence of this pretended miracle, which was nothing but a trick, wrote a diſſertation *De Vitulo aureo*, &c.

Yet the ſucceſs with which Paracelſus had preſcribed his chemical medicines, induced a number of phyſicians to cultivate that new art; and in a ſhort time ſeveral valuable works appeared on the preparation of chemical medicines. Such are the works of Crollius, Schroder, Zwelfer, Glaſer, Tackenius, Lemery, &c.; as well as the pharmacopœiæ publiſhed by the principal faculties of medicine in Europe. About this time Glauber, a German chemiſt, rendered an important ſervice to his art, by examining the reſidues of operations, which had hitherto been always thrown aſide as uſeleſs, and diſtinguiſhed by the name of *caput mortuum*, or *terra damnata*. He diſcovered by this means the

the neutral ſalt which bears his name, and the ammoniac vitriolic ſalt, and explained the chemical proceſſes neceſſary in preparing mineral acids, &c.

Several of thoſe who have contributed to the advancement of chemiſtry ſince the days of Paracelſus, were not fully convinced of the abſurdity of his wild notions. Among thoſe were Caſſius, known for his precipitate of gold; Sir Kenelm Digby, who believed in the ſympathetic action of medicines; Libavius, who has communicated his name to a preparation of tin; Van Helmont, famous for his ſingular notions both in chemiſtry and medicine; and, laſtly, Borrichius, a Daniſh phyſician and chemiſt, who firſt diſcovered and made known to the world the poſſibility and the manner of inflaming oils with the nitrous acid, and who deſerves the gratitude and reſpect of the world for having bequeathed his library and chemical laboratory for the uſe of indigent ſtudents of medicine.

Alchemy was now oppoſed by two celebrated geniuſes, who were ſucceſsful in their attacks. The one, the celebrated Father Kircher the Jeſuit, to whom we are indebted for a noble work, intitled *Mundus Subterraneus;* the other, the learned Conringius.

V.

Riſe and Progreſs of philoſophical Chemiſtry, from the middle of the ſeventeenth to the middle of the eighteenth Century.

HITHERTO chemiſtry had never been treated in a philoſophical manner. The chemical arts had indeed been deſcribed, medical formulæ had been given, and the

the nature of metals painfully examined, from the hope of making gold, or diſcovering an univerſal medicine: A chimera ſtill fondly believed by the ignorant and enthuſiaſtic! But nothing more had been done. A great number of chemical facts were known; but none had attempted to form them into a ſyſtem: And, as the celebrated Macquer has ingeniouſly obſerved, though many branches of chemiſtry were known and practiſed, the ſcience itſelf was not yet in exiſtence.

Towards the middle of the ſeventeenth century, James Barnet, phyſician to the King of Poland, arranged the principal facts then known in a methodical manner, accompanying them with obſervations, in his Philoſophy of Chemiſtry. The work of that learned author is the more valuable, on account of his being the firſt who attempted to form a complete ſyſtem of chemical knowledge, and ranked chemiſtry among the ſciences.

Bohnius, profeſſor at Leipſic, wrote alſo a book on ſcientific chemiſtry, which was very favourably received by the world, and was long the only elementary book on the ſubject.

Joachim Beccher of Spires, a man of very conſiderable genius, phyſician to the Electors of Mayence and Bavaria, diſtinguiſhed himſelf ſo highly in this ſcience as to cauſe the names of the two laſt mentioned writers to be almoſt entirely forgotten. In his noble work, intitled *Phyſica ſubterranea*, he has collected all the chemical phenomena at that time known, and has deſcribed them with amazing accuracy. He has even foretold many of the diſcoveries which have been ſucceſſively made ſince he wrote; ſuch as the exiſtence of aeriform or gazeous ſubſtances; the poſſibility of reducing animal bones into a tranſparent glaſs, &c.

A celebrated phyſician, whoſe name marks the commencement of a new and more illuſtrious æra in the annals of chemiſtry, has done him the honour of writing a commentary on his work. J. Erneſt Stahl, who was born with a natural fondneſs for chemiſtry, undertook to illuſtrate the doctrine of Beccher by a commentary. His favourite object, to which he more particularly directed his attention, was to demonſtrate the exiſtence of that inflammable earth which he denominated Phlogiſton. Not inferior to Beccher in genius, he excelled him in accuracy and method. His treatiſes on ſulphur and ſalts, together with that which is intitled *Trecenta Experimenta*, have acquired him immortal honour, and have ranked him among the firſt characters of the age in which he appeared.

Boerhaave, amid his various engagements, found leiſure to cultivate chemiſtry, and compoſed a very profound work on this ſcience, which has long been highly celebrated. The treatiſes on the four elements, particularly that on fire, which form a part of that work, are each of them maſterpieces, containing all that was at that time known on their particular ſubjects. He was alſo the firſt who attempted to analyſe vegetables; and to him we owe the ſpiritus rector, &c.

Stahl's theory has been generally adopted by ſucceeding chemiſts, and has acquired greater ſtability from the labours of the two illuſtrious brothers Meſſrs Rouelle, to whom we are chiefly indebted for the progreſs which chemiſtry has made in France, and whoſe loſs is ſeverely felt by the chemical world.

The illuſtrious Macquer, of whom death has now deprived the philoſophical world, contributed in a very ſignal manner to the advancement of the ſcience; and

and his valuable works are ſtill juſtly eſteemed, over all Europe, as the beſt guides to chemical knowledge. Beſides the important ſervices which he performed to the world, by publiſhing his Dictionary and Elements of Chemiſtry, his inquiries and diſcoveries concerning the nature of arſenic, Pruſſian blue, the dying of ſilks, clays for pottery, &c. might well immortalize his name, and intitle him to the gratitude of poſterity.

VI.

Pneumatic Chemiſtry: the preſent Time.

STAHL, being totally engaged in demonſtrating the exiſtence of phlogiſton, and tracing it through all its combinations with other bodies, ſeems to have overlooked the influence of air in moſt of thoſe phenomena in which he aſcribes ſo much to the energy of the inflammable principle. Boyle and Hales had already ſhown the neceſſity of referring many chemical phenomena to the operation of that fluid. Boyle had taken notice of the different appearances which the ſame chemical events exhibit in the open air and *in vacuo*. Hales had obtained from a variety of bodies a fluid which he took for air, but in which he obſerved a number of peculiar properties; ſuch as ſmell, inflammability, &c. according to the nature of the ſubſtances from which it was obtained. He was led to conſider air as the principle on which the conſiſtency and ſolidity of bodies depended.

Dr Prieſtley, by repeating a great part of Hales's experiments, diſcovered a number of fluids, which, though they have the appearance of air, yet differ from it it in all their eſſential properties: and, in particular, from metallic calces he extracted a ſpecies much purer than atmoſpheric air.

M. Bayen, a chemiſt deſervedly celebrated for the accuracy of his reſearches, examined the calces of mercury, and found that they are reducible without phlogiſton, and that during the proceſs they emit an aeriform fluid in great abundance.

M. Lavoiſier, ſoon after this, diſcovered, and proved by a number of fine experiments, that in the proceſs of burning or calcination, a portion of the air always enters into combination with the body which is calcined or burnt. In conſequence of this diſcovery, he formed a ſect of chemiſts who agreed with him in doubting the exiſtence of phlogiſton, and aſcribed to the fixation or the diſengagement of air all thoſe phenomena which Stahl had referred to the ſeparation or the combination of phlogiſton. It muſt be granted, that this doctrine has been more fully demonſtrated than Stahl's; and that it agrees better with that accuracy and method which have of late been introduced into the ſtudy of natural philoſophy. In this light did it appear to the late M. Bucquet, who in his two or three laſt courſes of lectures ſeemed to give it the preference. The moſt prudent part on this occaſion certainly was, to wait till it could be determined by a greater number of facts, whether all the phenomena of chemiſtry might be explained by the theory of gaſes, without our having recourſe to phlogiſton. M. Macquer, ſenſible that a conſiderable revolution muſt neceſſarily take place in the ſyſtem of chemiſtry in conſequence of theſe diſcoveries, but thinking it impoſſible to account for all the phenomena without admitting the preſence of an inflammable principle, ſubſtituted light in the room of phlogiſton; as the exiſtence of the latter had never been ſtrictly demonſtrated, while the influence of light on many chemical phenomena is a well known and undeniable fact.

Since the death of that celebrated chemiſt, the ſcience has been enriched with a variety of diſcoveries, all tending to confirm the new theory. The multitude of facts which I have been collecting during a period of twelve years, and the number of the experiments of other chemiſts, which, on a repetition of them, I have found attended with the ſame reſults, have finally convinced me of the juſtneſs of that theory, and have led me to conſider thoſe naturaliſts who ſtill continue to maintain, with more or leſs keenneſs, the exiſtence of phlogiſton, as either unſkilled in the ſcience, or incapable of accuracy in their experiments.

C H A P. III.

Concerning the Chemical Affinities.

IN the firſt chapter it was obſerved, that the means uſed in performing chemical operations, which have been arranged under the two general heads of Analyſis and Syntheſis, are imitated from Nature, who employs them in her operations. To illuſtrate that truth, we ſhall here explain what is underſtood by the chemical affinities.

A perſon cannot even enter upon the ſtudy of nature, without taking notice of that wonderful mutual force by which all natural bodies are attracted towards each other. On this great and univerſal law, all thoſe phenomena depend which the philoſopher contemplates with curioſity, and which even the moſt ignorant of men cannot behold without admiration.

This force, by which indeed the order of the univerſe is maintained, actuates the moſt minute bodies as well as the moſt enormous maſſes of matter. But it acts by laws, either eſſentially different, or at leaſt differently modified, according to the maſs, conſiſtency, and diſtances, of the bodies ſubject to its influence. Without examining its effects on the planetary bodies, whoſe diſtances and motions it regulates *, let us conſider in what manner it affects the different parts of the globe which we inhabit, that we may by this means diſcover its laws.

Natural philoſophy teaches, that when two ſolid bodies of the ſame kind come into contact, they adhere together with a degree of force proportioned to the extent and ſmoothneſs of the ſurfaces in contact. Thus, two planes of glaſs, or two ſections of a metal ſphere, if preſſed together, unite with a degree of tenacity which renders a conſiderable effort neceſſary to ſeparate them. This force produces all the phenomena obſerved in chemiſtry. It becomes, therefore, an object of the higheſt importance to ſtudy all its laws, and inquire what variations it undergoes from diverſity of circumſtances.

The greater part of chemiſts have denominated this force *affinity* or *relation;* becauſe it has been thought to depend on an analogy or conformity of principles in the bodies between which it ſubſiſts. Bergman has given it the name of *chemical attraction:* and though its phenomena are different from thoſe of the planetary attraction firſt obſerved by Newton, yet, as both depend upon the ſame principle, we ſhall follow Bergman in the uſe of the name. Chemical attraction may take place between bodies of the ſame nature, or between bodies of different natures. Let us conſider it under theſe two points of view.

§ I.

---

* Neither experiments nor analogy, as far as we know, authoriſe chemiſts to confound their affinities with the general laws of gravitation. This notion makes us recall to mind the univerſal medicine, &c.

§ I. *Concerning the Attraction or Affinity that takes place between Bodies of the ſame Kind, or the Affinity of Aggregation.*

WHEN two bodies of the ſame nature, for inſtance two globules of mercury, placed at a certain diſtance from each other, tend, by virtue of this force, to unite, and do actually enter into union, they form a ſphere greater in bulk, but preciſely the ſame in nature. In that event, therefore, this force affects only the phyſical, or obviouſly apparent qualities of bodies; it joins ſeparate portions of ſimilar matter; by confounding together ſeveral diſtinct maſſes, it forms a body of greater bulk, and unites a number of ſeparate parts into one *whole*. It is denominated the *attraction or affinity of aggregation*, in order to diſtinguiſh it from that which takes place between bodies of different natures. It produces an aggregate in which the phyſical qualities of the bodies united undergo a new modification, without any ſenſible change being produced on their chemical qualities. The *aggregate* is nothing more than a coherent body, the parts of which are retained in union by the force of aggregation. It muſt be diſtinguiſhed from the maſs called an *heap;* for though an heap conſiſts of parts all of a ſimilar nature, yet thoſe parts are diſpoſed looſely, and without coherence. It is likewiſe to be diſtinguiſhed from a *mixture;* which conſiſts of a quantity of diſſimilar particles blended together without adherence. This may be farther explained by a familiar example: Flowers of ſulphur, or ſulphur in powder, whoſe parts have no adheſion, and may be ſeparated by the ſlighteſt effort, compoſe an heap, the parts of which are not affected by the affinity of aggregation. This mixed with another heap, with one for inſtance conſiſting of nitre in powder, gives what is called *a mixture by confuſion.* But if, by the help of fuſion and cooling, you ſubject this heap to the power of aggregation, the molecules or integrant parts of the ſulphur will then be drawn towards each other during its liquefaction, and will mix and unite in ſuch a manner as to form, when cooled, an uniform maſs or ſolid, which will be a true aggregate.

The force or affinity of aggregation exiſts in various degrees, which are meaſureable by the effort neceſſary to ſeparate the integrant parts of any aggregate body. We ſhall diſtinguiſh aggregates into four kinds, under which all the bodies in nature may be arranged.

1. The firſt is the hard or ſolid aggregate, in which the integrant parts are united by a very conſiderable force, and cannot be ſeparated without great exertion. This genus comprehends many ſpecies or degrees, from the hardneſs of the precious ſtones and of rock-cryſtal, to the yielding contexture of the ſofteſt wood. Its peculiar characteriſtic is to form a maſs, the conſtituent parts of which cannot ſuffer any diſcernible motion without being divided.

2. Bodies whoſe conſtituent parts may be eaſily moved backwards and forwards, ſo as to change their relative ſituation, without being ſeparated, belong to the ſoft aggregate. Leſs force is requiſite to maintain the coheſion of a ſoft body than to preſerve the conſiſtency of a ſolid aggregate; and leſs reaction to deſtroy it.

3. The fluid aggregate. Its integrant parts are ſo ſlightly united, that the gentleſt effort is ſufficient not

only to change their relative ſituation, but even to divide them into diſtinct globules.

4. Laſtly, the aeriform aggregate, the tenuity of whoſe integrant particles renders them imperceptible, and in which the affinity of aggregation is the leaſt poſſible. The air of the atmoſphere affords an example of this.

Theſe four kinds of aggregate are, properly ſpeaking, but different degrees of the ſame force: but it is abſolutely neceſſary to diſtinguiſh accurately between them; becauſe they have an important influence on the operations and phenomena of chemiſtry, which is diverſified according to their differences: yet it may be proved in the moſt ſatisfactory manner, that they are only ſo many different degrees of the ſame force; for many bodies are capable of aſſuming each of theſe four ſtates ſucceſſively. Water, in the form of ice, is a ſolid aggregate; its hardneſs is greater in proportion as its temperature is lower; when expoſed to the temperature of 32° Fahrenheit, it aſſumes a kind of ſoftneſs * before paſſing into a fluid ſtate. Its exiſtence in this laſt ſtate is univerſally known: and philoſophers have calculated what degree of expanſive force is neceſſary to reduce it to vapour; in which ſtate it becomes an aeriform aggregate. Metals, greaſe, concrete oils, wax, &c. may be in the ſame manner cauſed to paſs through theſe ſeveral ſtates of aggregation.

The more particularly any perſon is acquainted with the laws of chemical attraction, ſo much the more will he be convinced of the importance of diſtinguiſhing

---

* A doubt expreſſed by the tranſlator of the ſecond edition, cauſed me to repeat this experiment; and I found that M. Fourcroy had by no means miſrepreſented the fact.

between theſe ſeveral kinds of aggregation, and eſtimating each of them aright. Accurate ideas concerning each of them are eſſentially neceſſary to enable us to compare this with the ſecond ſpecies of chemical attraction, which will come next to be examined.

As theſe two kinds of affinity, though they appear to depend on the ſame cauſe or principle, yet in all the phenomena of chemiſtry ſeem to act in direct oppoſition to each other (for it may even be inferred from facts which ſhall be related, that they are in the inverſe ratio of each other), it is abſolutely neceſſary for the chemiſt to weaken or deſtroy the one, when he wiſhes to effect any operation by means of the other. Now, the attractive force of which we have been ſpeaking, is almoſt always that which he has occaſion to diminiſh; and it likewiſe admits of various modifications by the power of art.

All that is neceſſary to deſtroy or weaken the affinity of aggregation, is, to oppoſe to the coheſion of the aggregate an external force more than ſufficient to counterbalance that which preſerves the union of its component parts; and the external force applied muſt therefore be proportioned to the adheſion of the parts. This is the great law to be always obſerved in the preparatory operations; the ſole purpoſe of which is to deſtroy the affinity of aggregation. Pulverization, grinding, raſping, filing, and cutting, are ſo many means for counteracting the coheſion of bodies and dividing their conſtituent parts. Heat and evaporation produce the ſame effects on fluids, and on thoſe ſolids which are ſuſceptible of dilatation or fuſion. But theſe laſt mentioned operations being effected by heat, come properly under the ſecond ſpecies of chemical attraction; as does alſo the ſolution of bodies by water.

As art can apply a great variety of means to counteract, and even deſtroy the force of aggregation; ſo it likewiſe affords others to reſtore it, and cauſe it to act with all its former energy. All the manipulations which it employs for this purpoſe, conſiſt in placing the bodies, whoſe force of aggregation is to be reſtored, in ſuch a ſtate of diviſion and fluidity, that their particles may be at liberty to obey the power of attraction, by applying to each other thoſe of their ſurfaces which are beſt adapted to unite; and they thus form a new aggregate, which, in regularity of figure and coheſive force, is generally equal, and ſometimes ſuperior, to natural aggregates of the ſame kind. We may take this opportunity to obſerve, that all aggregate bodies may be divided by their figure into two claſſes, Regular and Irregular. Every body in nature appears under the one or the other of theſe two forms; and art, which always emulates, and ſometimes even rivals, nature, can produce at pleaſure a regular or an irregular aggregate. All ſubſtances capable of paſſing through the ſeveral ſtates of aggregation above enumerated, but more eſpecially ſalts and metals, may be ſo managed during the proceſs by which they are reduced from a fluid to a ſolid ſtate, as to aſſume the form either of an irregular maſs, or of a body with regular lines, angles, and ſurfaces, which is called a cryſtal. The firſt form is obtained by keeping the particles of the fluid body, whether its fluidity may have been occaſioned by fire or water, very near each other; and cauſing the liquefaction to ceaſe ſuddenly, ſo that they may come into contact all at once, and the affinity of aggregation may cauſe them to unite into one irregular maſs. But, on the contrary, to produce cryſtallization, it is neceſſary to keep the parts of the body which you wiſh to bring into that ſtate, at as great a diſtance as poſſible from one another, that they may remain for ſome time in a kind of equilibrium, before coming into union, and may preſent to each other ſuch of their ſurfaces as are beſt adapted to unite. From this it appears, that cryſtallization is entirely owing to the affinity of aggregation; and if the phenomena of cryſtallization be obſerved with a proper degree of attention, they will afford an idea of the manner in which the affinity of aggregation acts. For this purpoſe it is mentioned here; it ſhall be more particularly explained under ſeveral future articles of this work.

§ II. *Concerning that Species of Chemical Attraction which unites Particles of different Natures; or the Affinity of Compoſition.*

WHEN two bodies differing in nature have a tendency to unite, they enter into combination by virtue of a power ſomewhat different from that which we have been conſidering; it has been denominated *the affinity of compoſition;* but may be with more propriety named *the attraction of compoſition.* This ſpecies of attraction or affinity is of ſtill greater importance than the former, as it acts in all chemical operations, and none of theſe can be explained without it. The exiſtence of this power has been always known; but it was not obſerved with the attention which it juſtly merits, till ſuch time as it appeared to affect the practice no leſs than the theory of the ſcience of which we we are treating. A knowledge of this affinity is eſſentially neceſſary to direct the practitioner who purſues a train

train of experiments, as well as the philoſopher who collects and compares facts. This is the compaſs by which both muſt ſteer; and it may be affirmed, that whoever is well acquainted with the laws of chemical attraction, is acquainted with the extent and ſublimity of the ſcience.

Convinced of this truth, we ſhall here make it our buſineſs, firſt, to exhibit faithfully all the facts which can ſerve to illuſtrate the nature of this affinity; and, next, to give an account of thoſe hypotheſes which have been formed to explain its cauſe.

Obſervation, the parent not only of chemiſtry but of all experimental ſcience, has ſhown, that the attraction, or affinity of compoſition, preſents certain invariable phenomena; which may be conſidered as laws eſtabliſhed by nature, and which can eſcape the obſervation of none but ſuch as are incapable of examining them with due attention. Theſe laws, founded on a vaſt variety of well-eſtabliſhed facts, may be reduced to eight; which are as follows.

I. *Firſt Law of the Attraction of Compoſition.*

The attraction, or affinity of compoſition, cannot act but between bodies of different natures.

This firſt law is invariable, and admits of no exceptions. That two bodies may combine, and form a compound, it is indiſpenſably neceſſary for them to be different in kind. Join two bodies of the ſame nature, and you form only an aggregate, of which the bulk and extent are enlarged, but its eſſential properties remain unaltered; and their union is occaſioned and preſerved by by the affinity of aggregation, conformably to the explanation already given of the nature of that affinity. Thus, two pieces of wax, roſin, or ſulphur, may be united by the action of heat; and this inſtance is ſufficient to explain the difference between aggregation and compoſition.

This law holds ſo invariably, that the attraction of compoſition is never ſtronger than when the bodies between which it acts are, in nature, the moſt eſſentially different from one another. Thus acid ſalts and alkalis, though the properties of the one are directly oppoſite to thoſe of the other, enter into the moſt intimate mutual combination, and form the moſt perfect compound. The ſame oppoſition ſubſiſts between the properties of alkalis and ſulphur, of acid ſalts and oil, of acids and metals, of water and ſpirit of wine, &c.; all which ſubſtances have a ſtrong tendency to mutual union.

It is the more neceſſary for us to gain an accurate knowledge of this great law of the affinity of compoſition, becauſe a number of chemiſts, with Stahl at their head, have laboured to prove, that bodies never enter into combination, but in conſequence of a certain relation, or reſemblance between their properties: an opinion to which no perſon will agree who knows the full extent of this primary law. When reading the reaſonings even of the moſt eminent chemiſts on this ſubject, we cannot avoid obſerving, that the relations which they labour to point out between thoſe ſubſtances which have the ſtrongeſt tendency to mutual union, appear always extremely remote; and that, by the ſame means, reſemblances might be eaſily found out between bodies the moſt diſſimilar. It is eaſy to ſee, however, that thoſe ingenious men have propoſed this

this theory, merely from a deſire to ſimplify and illuſtrate the doctrine of chemical attractions: and thoſe who are ſenſible of the difficulty of eſtabliſhing ſyſtems in any of the departments of human knowledge, will always conſider them as intitled to the gratitude of every friend of ſcience. Their labours have not been without their uſe, as they have collected a number of facts, and pointed out their connection. But a regard to truth, which it becomes us to prefer to every other conſideration, obliges us to confeſs our ignorance of the cauſe of this important phenomenon, inſtead of referring it to an analogy, the exiſtence of which is inconſiſtent with thoſe ideas of the properties of bodies which we derive from experiment.

II. *Second Law of the Attraction of Compoſition.*

The attraction of compoſition acts only between the minuteſt particles of bodies.

In order to form a juſt idea of the nature of this law, it is neceſſary for us to diſtinguiſh chemical from phyſical ſubjects. Theſe laſt are bodies whoſe external qualities, ſuch as weight, bulk, ſurface, extent, and figure, are perceptible to our ſenſes, and may be eſtimated by their effects upon them. Aggregates are the bodies whoſe qualities are obſerved and compared by the naturaliſt. Chemical ſubjects, again, are ſubſtances which have loſt their aggregation; and which, of conſequence, no longer preſent to the ſenſes the phyſical properties of aggregates. They are minute particles, the extent of which cannot be meaſured, nor their bulk or form diſtinguiſhed. It is not till after bodies have been reduced to this ſtate of tenuity by the ſeveral preparatory operations above-mentioned, that they become ſubject to the affinity of compoſition; and the chemiſt cannot cauſe them to enter into combination, without preſenting them to one another in a ſtate of diviſion. This force ſeems to actuate none but the minuteſt particles of bodies: and in this manner does the attraction of compoſition appear to differ from that which acts between large maſſes of matter. The difference is ſtill more ſtriking when we conſider the conſtant oppoſition between the attraction of aggregation and that of compoſition. This oppoſition is ſo invariable, that we may even venture to advance it as a chemical axiom, that the attraction of combination is in the inverſe ratio of that of aggregation; theſe two forces being always in oppoſition, and forming a kind of counterpoiſe to each other. The attraction of aggregation always reſiſts the combination of different bodies; where it acts with the greateſt force, they have ſcarce any tendency to mutual union; and again, ſuch ſubſtances as are leaſt under the influence of the force of aggregation, have a ſtrong tendency to combine with others. The various kinds of *gas*, or air, for inſtance, of all known ſubſtances are the leaſt under the influence of the force of aggregation; and of them there are many whoſe tendency to combination is ſo ſtrong, that they combine with the greateſt facility with almoſt any natural body. Yet we ſhall afterwards ſee that this happens only when the heat which enters into the compoſition of elaſtic fluids is but ſlightly combined with a baſe; and that the aeriform ſtate often occaſions a contrary tendency; as for inſtance, in pure air.

III. *Third Law of the Attraction of Compoſition.*

The attraction of compoſition can unite more bodies than two.

THIS law of chemical attraction is one of thoſe which have been eſtabliſhed by the feweſt obſervations; and we are ſtill but very imperfectly acquainted with its extent. We are acquainted with a vaſt variety of thoſe combinations which are produced by the union of two bodies; with a few which are formed by the union of three bodies; but we know of ſcarce any inſtances in which four different bodies have an equal tendency to enter into mutual combination, and remain in that ſtate. Metals are the only bodies that are known to be capable of this laſt ſpecies of combination; and of which two, three, or four, may be effectually blended together. It is highly probable that there are in nature combinations made up of more than four bodies, of ſix or eight, for inſtance; but with ſuch we are hitherto unacquainted. The reaſon why ſo little progreſs has been made in the ſtudy of this law, ſhall be explained when we come to treat of the eighth law of the affinity of compoſition. The number of the ſubſtances of which any compoſition conſiſts is denoted by ſaying, the affinity of one, two, three, or four bodies, and ſo on. The rapid progreſs which chemiſtry has of late begun to make, the multiplicity of its reſearches, the variety of the objects to which they are directed, and the ſcrupulous accuracy of obſervation with which they are conducted, afford us reaſon to hope that thoſe affinities which are named *complicated* will ſoon be better known.

IV. *Fourth Law of the Affinity of Compoſition.*

That the affinity of compoſitton may take place between two bodies, at leaſt one of the two muſt be in a fluid ſtate.

This law has been long known to chemiſts, and has been long expreſſed in this axiom, *Corpora non agunt, niſi ſint ſoluta.* Uniform and accurate obſervation has ſhown, that two ſolid ſubſtances can never enter into mutual combination. Even bodies which have the ſtrongeſt tendency to unite, cannot be brought into union till either the one or the other of them be reduced to a fluid aggregate. Bodies enter into combination with more or leſs facility, according as they are more or leſs in a ſtate of fluidity, and conſequently poſſeſs more or leſs aggregative force: and therefore no two bodies enter into combination with ſuch rapidity as any two of the ſaline aeriform fluids; for inſtance, the muriatic acid gas and the alkaline gas.

Though no two ſolid bodies can enter into combination with each other; yet in ſome inſtances dry ſubſtances, reduced into a fine powder, react upon each other with ſo much energy, as to unite and form a new compound. Thus I have diſcovered that cauſtic fixed alkali, when reduced by trituration, unites in a cold dry ſtate with ſulphur, antimony, and kermes, as I ſhall elſewhere more particularly relate: but in this inſtance, the reduction of the bodies into their moſt minute particles by pulverization, and the moiſture of the atmoſphere attracted by the ſalt, which ſoon deliquiates, have a conſiderable ſhare in effecting the combination;

bination; and indeed bring this phenomenon under the law, which we are now engaged in examining.

But it is not always neceſſary that the bodies which you wiſh to combine be both fluids; it is enough that one of them be in that ſtate. When they unite, a phenomenon takes place, to which chemiſts have given the name of *ſolution.* It conſiſts in the attenuation, diviſion, and entire deſtruction of the ſolid body in contact with the fluid. The cauſe of this phenomenon is, that the attraction of combination between two ſubſtances, one of which is a liquid, the other a ſolid, ſuch as the ſulphureous acid, and a bit of calcareous ſpar, is ſtronger than the aggregative force which preſerves the particles of the ſolid in excluſive union with one another. Now ſince, by the third law, this ſpecies of attraction cannot act but on the moſt minute particles of bodies, the ſpar muſt neceſſarily loſe its aggregation, and be reduced into very ſmall particles, in order that it may combine with the *ſulphuric* acid, and form *calcareous ſulfate.* Formerly, chemiſts always diſtinguiſhed between the body which effected and that which ſuffered the act of ſolution: the former was the fluid, the latter the ſolid. But modern chemiſts refuſe to admit this diſtinction, as it ſuppoſes a force in the fluid ſuperior to what exiſts in the ſolid aggregate. M. Gellert was the firſt who obſerved that the two bodies contribute equally to the act of ſolution; and that in the above inſtance, the vitriolic acid could not deſtroy the aggregation of the ſpar, had not the ſpar a tendency to unite with the ſulphuric acid no leſs ſtrong than that of the acid to combine with it. The name *ſolvent*, therefore, given at preſent to fluids, is not ſtrictly chemical, as it conveys only the idea of a mechanical operation; and it were better to lay it aſide. But ſince it has been unluckily introduced, the ſtudent of chemiſtry muſt always remember, that when one body is ſaid to diſſolve another, no more is meant than that the former is in a fluid ſtate, and that the fluid can never poſſeſs greater activity or energy than the ſolid; but the ſolid may rather be conſidered as poſſeſſing theſe qualities in a ſuperior degree, ſince its tendency to combination is ſo powerful as to overcome its aggregative force

The falſe idea of ſolution which has prevailed till of late, aroſe no doubt from the mechanical theory by which ſome philoſophical chemiſts have ſought to explain this operation of nature. This theory, which appears in every page of Lemery's chemiſtry, conſiſts in conſidering the ſolvent, an acid, for inſtance, as an aſſemblage of very acute points, and the body to be diſſolved, as containing a vaſt number of pores, into which the points of the acid inſert themſelves, ſo as to disjoin the particles of the body, and reduce them to that ſtate of diviſion in which the aggregate diſappears. To mention this opinion is, at preſent, all that is neceſſary to ſhow its abſurdity and inconſiſtency with thoſe laws which accurate obſervation has eſtabliſhed in the experimental ſciences.

V. *Fifth Law of the Attraction of Compoſition.*

When two or more bodies are combined by this affinity, their temperature ſuffers a change at the inſtant of their union.

THIS phenomenon ſo invariably attends all the combinations effected by art, that we cannot help conſidering it as one of the laws of the attraction of compoſition. The temperature of bodies may be altered in two ways; new combinations ſometimes produce cold, ſometimes heat. The latter is oftener produced than the former: but as cold is certainly produced in ſeveral ſynthetic operations, we have thought proper to expreſs this phenomenon by the general term, Change of temperature.

It may be objected, that in certain ſolutions or combinations which are ſlowly effected, no change of temperature is perceived: But we would deſire thoſe people who are diſpoſed to offer ſuch an objection, to immerſe a good thermometer into thoſe ſolutions, and they will not fail to be convinced that a change of temperature is produced. It appears from ſome valuable obſervations of M. Beaumé's, which ſhall be elſewhere more particularly mentioned, that this phenomenon is occaſioned by the change of aggregation, which the bodies entering into combination undergo as they paſs from a ſolid to a fluid ſtate. But as that change is produced by the action of the affinity of compoſition, both the one and the other evidently depend on this principle.

Macquer has given it as his opinion, that the variations of the temperature of bodies entering into combination, are occaſioned by the motion of their component particles : but though we ſhould admit this as an happy account of the cauſe of the heat produced in new combinations, ſtill the cold which takes place in ſome of them remains unexplained. Several modern chemiſts, particularly Scheele and Bergman, conſider heat as a diſtinct body, acting a principal part in all chemical combinations ; and aſſert, that change of temperature ariſes from the abſorption or diſengagement of this body. This theory affords a good explanation of the cauſe of that change of temperature which takes place when a new combination is produced.

VI. *Sixth Law of the Attraction of Compoſition.*

Two or more bodies united by the attraction of compoſition, form a ſubſtance, the properties of which are different from thoſe which each of the bodies poſſeſſed before their union.

It is of importance to eſtabliſh the exiſtence of this law ; becauſe many celebrated chemiſts of the preſent age, have entertained opinions concerning the properties of compounds, which to us appear inconſiſtent with a great number of facts, and are directly contradictory to what we here offer as one of the principal phenomena of the affinity of compoſition.

Stahl and his followers, whoſe genius has, in other inſtances

inſtances, rendered ſo many important ſervices to chemiſtry, have aſſerted, that compounds always partake of the properties of thoſe bodies of which they are compounded, and poſſeſs a kind of middle nature between their principles. They have even carried this notion ſo far as to perſuade themſelves, that it is poſſible to determine the peculiar properties of any principles, by examining the compound formed by their union. Thus, Stahl pronounced ſalts to be a compound of earth and water, becauſe he thought he could diſtinguiſh their properties to be intermediate between the properties of theſe two ſubſtances. As we are to examine this leading doctrine when we come to conſider the general nature of ſalts, it would be improper to enlarge upon it here: We ſhall only obſerve, that thoſe chemiſts who have adopted this opinion of Stahl's, have not been happier than he in the proofs which they have adduced to eſtabliſh it; and that the intermediate properties which they have diſcovered in compound bodies, have always a very remote relation to thoſe of their principles, as ſhall be clearly ſhown to be the caſe, even in the chief inſtances adduced by Stahl. I muſt even acknowledge, that what firſt induced M. Bucquet and myſelf to examine this theory with particular attention, and finally to adopt one directly oppoſite to it, was our obſerving with what difficulty, and how ineffectually, Stahl had laboured to eſtabliſh it in his works. All that is neceſſary to prove the exiſtence of this law, for which we reject the theory of Stahl, is, to produce ſome inſtances in which the properties of compounds are totally different from thoſe of either of their principles. But the phenomena of all chemical combinations come under this deſcription; not one but affords an inſtance in behalf of that truth which we wiſh to eſtabliſh.

In order to ſhow, 1*ſt*, That bodies which enter into combination loſe their original properties; 2*dly*, That they acquire new properties totally different from thoſe that they before poſſeſſed; let us ſelect ſome properties of which the variations may be eaſily diſtinguiſhed. Taſte is often a very eminent property in two diſtinct bodies, which when united are almoſt inſipid in compariſon with what they were in that reſpect before. *Sulfate of potaſh*, or vitriolated tartar, which is produced by the combination of two potent cauſtics, the ſulphuric, or vitriolic acid, and pure *potaſh*, has only a bitter taſte; which is by no means an intermediate between the cauſtic poignancies of thoſe two ſalts. Again, two bodies with little or no taſte, often acquire by combination a very ſtrong taſte; a few grains of the *oxigenated muriatic acid*, or a few grains of mercury given in a glaſs of water, can produce no bad effects on the animal œconomy; whereas if combined ſo as to form the *oxigenated mercurial muriate*, or corroſive ſublimate, and adminiſtered in the ſame manner, they have a moſt pungent taſte, and produce the moſt fatal effects on the human conſtitution.

Bodies entering into combination are no leſs liable to change of form. Two ſubſtances, neither of which is by itſelf ſuſceptible of cryſtallization, often aſſume a regular form when combined together: thus the *muriatic acid gas*, and *ammoniac* or alkaline gas, when they enter into combination, form cryſtals of *ammoniacal muriate*. In other inſtances, the form ſuffers only a ſlight change of modification; as in the combination of certain neutral ſalts, in the union of ſulphur

ſulphur with metals, and in allayed metals; which laſt have been obſerved by M. l'Abbé Mongez to afford cryſtals ſomewhat different from thoſe of pure metals. *Laſtly*, Bodies that are, in a ſimple ſtate, highly ſuſceptible of cryſtallization, loſe that property when combined with other bodies. This happens to all metals when united with the *oxigenous* principle; and to ſome of them when combined with acids, &c *.

The conſiſtency of bodies is alſo affected by their combination; the conſiſtency of a compound being almoſt always different from that of either of the ſimple bodies of which it is compoſed. Thus, two fluids often produce a ſolid by their combination; for inſtance, the ſulphuric acid united with a ſolution of potaſh. And again, a fluid often reſults from the combination of two ſolids; as from a combination of neutral ſalts with ice, and from the mixture of an amalgam of lead with an amalgam of biſmuth. But the quality which ſuffers the moſt frequent alterations in the combination of bodies is colour. Sometimes it is loſt: thus the coloured muriatic acid, combined with a metal, becomes white. But it oftener happens, that two bodies deſtitute of colour, aſſume when united either a fainter or ſtronger colour, as when iron or copper are diſſolved almoſt in any of the acids, and when the calces of lead, mercury, or almoſt any other metal, are united with the oxigenous principle.

---

* We cannot avoid making uſe of terms and denominations not yet explained. But the reader may have recourſe to the table ſubjoined at the end of the laſt volume, and to the beginning of our account of the ſeveral articles to which ſuch names belong, for an explanation of them. This inconvenience, though it may perplex the beginner, cannot be otherwiſe obviated.

Many bodies which, in a ſimple ſtate, are ſtrongly odoriferous, become inodorous when brought into combination ; as for inſtance, the muriatic acid gas and the ammoniac or alkaline gas, which in a ſimple ſtate have a ſtrong ſuffocating ſmell, form in combination the ammoniacal muriate, a neutral ſalt that has ſcarce any ſmell. Again, from the union of two inodorous bodies, there often reſults a ſtrong-ſmelling compound ; ſulphur and fixed alkali, each of which is in a ſimple ſtate almoſt deſtitute of ſmell, form, when united, liver of ſulphur, or *ſulphure*, a ſubſtance which in a moiſt ſtate is extremely fetid.

The fuſibility of bodies is ſubject to the ſame changes. Two ſubſtances, not ſuſceptible of fuſion, or which cannot be reduced to that ſtate without the greateſt difficulty, when combined acquire the property of fuſibility in an high degree. Combine ſulphur with any of the metals, and you will have a ſtriking inſtance of the truth of this aſſertion. A variety of other facts, beſides thoſe which have been here adduced, concur to eſtabliſh this law in contradiction to the theory of Stahl.

VII. *Seventh Law of the Attraction of Compoſition.*

The attraction of compoſition is meaſurable by the difficulty of deſtroying the combination formed between two or more bodies.

Chemists know how to ſeparate bodies in union, however ſtrong their mutual attraction or adherence ; but

but the means which they employ for that purpoſe are more or leſs eaſy, more or leſs complicated. It has been uniformly obſerved, that in proportion as a compound is more or leſs perfect, its component parts are ſeparated with more or leſs difficulty: And the degrees of the difficulty with which any two ſubſtances are ſeparated, may be therefore conſidered as in direct proportion to the degrees of the attraction by which they mutually adhere; from the one we may form a juſt eſtimate of the other.

We conſider it as particularly neceſſary to inſiſt on this law, becauſe beginners are apt to fall into miſtakes in eſtimating the differences of the attraction which unites the principles of different combinations. From the rapidity with which ſome ſubſtances combine, we are ready to imagine that their mutual attraction muſt be very conſiderable. But long experience ſhows that this eagerneſs to enter into combination, inſtead of indicating a perfect compoſition, is rather a proof that the attraction between the bodies is extremely weak, and can produce but a very imperfect compound. In order, therefore, to determine accurately the degree of affinity with which bodies unite and remain in union, we muſt conſider the eaſe or difficulty with which they are ſeparated. This will be farther explained by an examination of the eighth and laſt law of this ſpecies of chemical attraction.

VIII. *Eighth Law of the Attraction of Compoſition.*

Bodies have not all the ſame degree of chemical attraction with regard to one another; and the degrees of that force ſubſiſting between different bodies may be determined by obſervation.

Natural bodies have not uniformly the ſame tendency to mutual combination. There are even ſome bodies which abſolutely refuſe to unite, or between which at leaſt art cannot effect a direct combination; ſuch as iron and mercury, water and oil, &c. though it is not true that theſe bodies have no mutual attraction. Others require long time and much pains to bring them into combination.

But the moſt important circumſtance of this variety of chemical attraction is, that ſince various bodies are united with various degrees of force, we may acquire ſuch an accurate knowledge of the particular degree of force which unites any two bodies, as to effect a ſeparation between them at pleaſure. Bergman has contrived the name *elective attractions,* to indicate that there is a kind of mutual choice between thoſe bodies, which in order to combine with one another, ſeparate themſelves from thoſe other ſubſtances with which they were before united, and entirely forſake their former ſtate. This decompoſition is even the grandeſt effect of the chemical art: by this the chemiſt is often able to perform what appears altogether miraculous to perſons unacquainted with the principles on which he proceeds. To comprehend the nature of this decompoſition,

ſition, let us ſuppoſe two bodies to be united with a force equal to four; as for inſtance, an acid and an *oxide*, or metallic calx: Let us bring a third body, ſuch as an alkali, which has an affinity with the acid equal to five or ſix, into contact with this compound; the conſequence will be, that the alkali, whoſe tendency to combine with the acid is greater than that of the acid to remain in union with the metallic *oxide*, will deſert the latter in order to combine with the former. This is preciſely the reſult of ſuch a mixture, the metallic *oxide* appears in a ſeparate ſtate, and a new combination is formed, conſiſting of the acid and the alkali. This decompoſition is commonly known by the name of *precipitation;* becauſe the ſubſtance ſeparated generally ſinks to the bottom of the fluid compound.

The ſubſtance that ſinks to the bottom of the veſſel in which this operation is performed, is named a *precipitate.* The ſubſtance by the addition of which the phenomenon is produced, is denominated the *precipitant.* There are four different kinds of precipitates. *A true precipitate* is formed, when the ſubſtance which ſinks to the bottom is one of the principles of the compound decompoſed by the addition of the new body. When ſulfate of lime, which is a combination of lime and the ſulphuric acid, is decompoſed by means of potaſh, which ſubſtance has a greater affinity with the acid than with lime, the lime being ſeparated falls to the bottom, and conſtitutes a true precipitate. A *falſe precipitate* is produced, when the new combination of the precipitant with one of the two ſimple bodies of the compound which it has decompoſed, falls to the bottom on account of its inſolubility, while the ſeparate body remains in a ſtate of ſolution. When *mercurial*

rial nitrate is decompoſed by the muriatic acid, with which the oxide of that metal has a ſtronger affinity than it has with the *nitric acid*, the new combination of mercury with the muriatic acid ſinks to the bottom of the mixture, forming a falſe precipitate, above which the nitric acid remains diſſolved in water. This phenomenon depends entirely, as ſhall be elſewhere ſhown, on the different degrees of the ſolubility of the different ſubſtances.

We cannot avoid obſerving, in this ſecond order of precipitates, an error of denomination which may tend to miſlead beginners. For, if this name be given to the ſubſtance ſeparated from the compound by the precipitant, it cannot with any propriety be applied to the new combination then formed. But though we ſhould even confine the term *precipitate* to denote the ſubſtance ſeparated by the precipitant, it might ſtill occaſion miſtakes; as it happens in many caſes that the inſulated ſubſtance, inſtead of ſinking, riſes and is volatilized. Thus, when the combination of the muriatic acid with volatile ammoniac or alkali, known by the name of ammoniacal muriate, is decompoſed by quicklime, with which the acid has a greater affinity than with volatile alkali, the alkali evaporates, and the mixture affords no appearance of any precipitate.

In order to produce theſe precipitates, it is neceſſary that the ſubſtances be in a liquid ſtate: The proceſs is then called precipitation effected in the humid way, to diſtinguiſh it from that which is accompliſhed by the action of fire, or in the dry way, either by means of fuſion or diſtillation; which operations ſhall be hereafter particularly explained.

Modern chemiſts have likewiſe taken notice of two other

other ſpecies of precipitate; the diſtinction between which is much more juſt and uſeful than that between the preceding. Theſe are *pure precipitates* and *impure precipitates*. The firſt comprehend all bodies which, after their ſeparation from thoſe compounds into which they entered, exhibit all their original properties, without appearing to have ſuffered any alteration, in conſequence either of exiſting in a compound ſtate, or of being expoſed to the act of decompoſition. The precipitates of this ſpecies are very numerous, but the impure precipitates ſtill more ſo.

In order that precipitates may be obtained very pure, it is requiſite that they ſhould have ſuffered no alteration by the action of the bodies with which they were combined before their precipitation; and that there ſubſiſt no affinity between them and the ſubſtance employed to precipitate them. For inſtance, when *alcohol*, or ſpirit of wine, is poured into a ſolution of ſulphate of potaſh, the ſpirit of wine having a ſtronger affinity with the water than the water has with the ſalt, the latter is left in a ſeparate ſtate, and becomes a pure precipitate, becauſe it has ſuffered no alteration from the water, and has not the moſt diſtant affinity with the alcohol. But when two bodies by combination have produced mutual alterations on each other, as happens in the combination of acids with metals, the third body, ſuch as an alkaline ſalt, employed to effect a ſeparation between them, will give the metal in a ſtate very different from its original character, and will thus produce an impure precipitate. The ſame reſult takes place when the precipitant has any tendency to unite with the precipitate: thus, in the abovementioned inſtance of a metallic ſolution decompoſed by an alkali, part

part of the alkali entering into combination with the metallic oxide renders it an impure precipitate. Theſe two cauſes of the impurity of precipitates are almoſt always found to act together. We can ſometimes diſtinguiſh at once whether a precipitate be pure or impure, by adding a much greater quantity of the precipitating body than is neceſſary to decompoſe the compound. This extraordinary quantity then enables the precipitant to combine with the precipitate, if there be any affinity between them, and diſſolves it ſo entirely as to make it diſappear. If a quantity of volatile alkali or ammoniac be poured upon a ſolution of copper with the nitric acid, the copper is precipitated in the form of light blue flakes. The colour of this precipitate, ſo very different from the natural brilliancy of copper, ſhows it at once to be an impure precipitate: If we add more ammoniac, this will ſtill more plainly appear. The blue flakes are again diſſolved by the ſalt, the fluid becomes gradually homogeneous and tranſparent, and aſſume a very fine deep blue colour; a ſure proof of the combination of the oxide of copper with the alkaline ſalt.

For our preſent accurate knowledge of theſe impure precipitates, which occur much more frequently than the pure, we are indebted to the reſearches of M. Bayen, concerning the decompoſition of mercurial ſolutions with alkalis, and the ſtate of mercury precipitated in thoſe operations.

It is now eaſy to underſtand the theory of the decompoſition of compounds of two bodies by means of a third brought into contact with them: they all depend upon ſimple elective attractions.

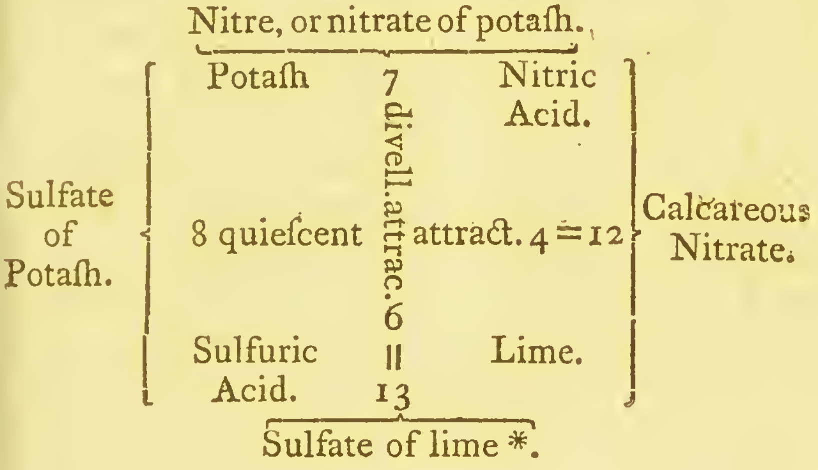
But beginners will find more difficulty in acquiring a diſtinct idea of that complicated phenomenon to which

which chemiſts have given the name of *double elective attraction.* It often happens that a compound of two bodies cannot be deſtroyed by a third or fourth body individually; while, if a compound of the two laſt be brought into contact with the firſt compound, both compounds are inſtantly decompoſed. An example will make this better underſtood: Sulphate of potaſh, or a combination of the ſulphuric acid with potaſh, cannot be decompoſed by either quicklime or the cold nitric acid individually; but pour into a ſolution of the former neutral ſalt a proper quantity of the *calcareous nitrate,* formed by the union of the nitric acid with quicklime, the two combinations will be mutually decompoſed; the nitric acid uniting with the potaſh to form common nitre, while the ſulphuric acid uniting with the lime, forms ſulphate of lime; which being leſs liable to ſolution than the nitre, is therefore precipitated. This affinity may poſſibly appear ſtrange and unaccountable; but it may be explained in the following manner: The ſulphuric acid cannot be ſeparated from potaſhes, either by lime or by the nitric acid, becauſe it has a ſtronger affinity with that alkaline ſubſtance than either of the two latter bodies has with it or with the alkali. But when you preſent to the ſulfate of potaſh a compound of the nitric acid with lime, the nitric acid immediately exerts its tendency to combine with the potaſh, while the ſulphuric acid is at the ſame time attracted by the lime; ſo that the decompoſition of the ſulfate of potaſh is begun by the action of the nitric acid, and completed by that of the lime. To explain this double affinity ſtill more clearly, let us ſuppoſe the force of adheſion, which unites the ſulphuric acid with potaſh, to be equal to eight; the nitric acid tending to unite with that alkaline ſubſtance with a leſs degree of force, which we may eſtimate at ſeven, would be inſufficient of itſelf to decompoſe the ſulfate of potaſh; but the lime, by its tendency to combine with the ſulphuric acid, aids it with a force which we may conſider as equal to ſix; and theſe two forces together amount to thirteen; which ſum of forces is exerted againſt the force eight, to ſeparate the ſulphuric acid from the potaſh. This compound force will alſo be greater than that which maintains the union between the lime and the nitric acid.

There are therefore two kinds of attraction in double elective attractions, which muſt be carefully diſtinguiſhed from each other: 1. The firſt is that by virtue of which the principles of each of the two compounds adhere to one another, which in the above inſtance retains the ſulphuric acid in union with the potaſh, and cauſes the nitric acid to adhere to the lime. I ſhall follow Mr Kirwan in giving to this force the name of *quieſcent attractions;* becauſe its tendency is to preſerve the two compounds in their firſt ſtate. 2. The ſecond is that by which the four principles of the two compounds reciprocally change their ſituations, and are combined in a different order: it is by virtue of this affinity, that in the above inſtance the potaſh combines with the nitric and the lime with the ſulphuric acid. This ſecond force I ſhall denominate *divellent attractions;* becauſe it counteracts and deſtroys the firſt. From this uſeful diſtinction, it becomes eaſy to explain the cauſe of this double decompoſition, by exhibiting in a table, as Bergman has done, the forces of the attractions by which it is produced. Place the two compounds which mutually decompoſe one another between two braces directly oppoſite, the acids

acids ſtanding in oppoſition to the baſes on which they act; between theſe four bodies note down the particular degrees of the attractive force which they exert upon each other; add together the two horizontal numbers, expreſſing the quieſcent attractions; add alſo the vertical numbers which are employed to mark the divellent attractions: if the ſum of the latter exceed that of the former, a double decompoſition and a double combination will be effected. The uſefulneſs and accuracy of ſuch a table may be ſhown at once by giving an example of it in the laſt mentioned compounds.

EXAMPLE.



Chemiſts have but lately begun to take notice of theſe double elective attractions; and we are far from knowing them all. Thoſe who are engaged in chemical re-

---

* I have given ten ſimilar examples of double decompoſitions which take place in the mixture of neutral ſalts, in two diſſertations; which the reader may conſult. *See my Memoirs and Obſervations on Chemiſtry*, Vol. I. 8vo, Paris, 1784, page 308 and 438. A.

reſearches, will frequently obſerve this kind of decompoſition in circumſtances where no ſuch phenomenon was before ſuſpected to take place. In the hiſtory of ſaline ſubſtances we will repeatedly have occaſion to take notice of ſeveral of thoſe double elective attractions which have been lately obſerved by Bergman, Scheele, &c. and by ourſelves.

Before concluding our account of this tenth and laſt law of the attraction of compoſition, we cannot help taking notice of an ingenious method contrived by a French chemiſt, to exhibit at once all the more regular phenomena of chemical decompoſition. Geoffroy the elder, obſerving the various relations which ſubſiſt between different bodies, and the precipitations produced in conſequence of thoſe relations, with more attention than had been applied to that object by former chemiſts, contrived, in the year 1718, to exhibit them in a table; in which he arranged thoſe bodies whoſe affinities he had obſerved, in the order of their affinities. We only mention that fine contrivance in this place; but will have many future occaſions in the courſe of this work of explaining it more particularly. Geoffroy gave that table only as a firſt attempt, to which he well knew much might be added. A number of chemiſts have adopted and enlarged his plan. Rouelle the elder made ſome corrections on his table, and added ſeveral columns to it. M. de Limbourg, a phyſician at Spa, in an excellent diſſertation on the affinities, which, in conjunction with another by M. Sage of Geneva, gained the prize offered in 1758 by the academy of Rouen, has formed one ſtill more extenſive. M. Gellert, in his Metallurgic Chemiſtry, has likewiſe given a new table of affinities. But none has contributed more to the advancement of this part of the ſcience

ſcience than Bergman, profeſſor of chemiſtry at Upſal; whoſe labours have been ſo beneficial to the ſcience in general. That celebrated chemiſt has followed M. Baumé, in diſtinguiſhing the attractions which operate in the humid way, from thoſe which effect combinations in the dry way. He has given two very extenſive tables, in which he exhibits the elective attractions of a vaſt number of natural bodies. To the ſame philoſopher we are indebted for a very ingenious table, in which he has found means, by a peculiar diſpoſition of the chemical characters, to expreſs the phenomena of double elective attraction: Of this we gave an example above.

After giving this view of the leading phenomena of chemical attraction, and unfolding the laws by which that force appears to be regulated, we muſt obſerve, that in ſome caſes thoſe laws ſeem liable to certain variations. We need not here mention all the facts on which this aſſertion is founded, as we ſhall be careful to take notice of them wherever they occur; only we may obſerve, that thoſe ſeeming anomalies of chemical attraction ariſe from the influence of particular circumſtances; ſuch as the quantity of the ſubſtances, the temperature of the atmoſphere, motion or reſt, ſolution by water or fire, that is, in the humid or in the moiſt way, the ſtate of aggregation proper to each body, &c. Bergman has conſidered all theſe circumſtances with peculiar care; and has ſhown how far they may be expected to vary the laws of attraction. From the various facts which he has collected relative to this ſubject, he concludes, that theſe variations can be regarded only as exceptions, by no means ſufficient to weaken the evidence on which the doctrine of chemical attraction is founded.

We are led to conſider two other ſpecies of affinity that have been admitted by ſome authors, in the ſame light, the affinity of *intermediates* and the *reciprocal* affinity. By the firſt, they underſtand that by which bodies, which have no natural tendency to mutual union, are capable of being united after one of them has been combined with a third body, which ſerves as an intermediate between them: Oil, for inſtance, does not combine with water; but a combination of oil with a ſalt conſtitutes a ſoap, which is ſoluble in water, the ſalt acting as an intermediate. But it is not the ſalt which renders the ſoap ſoluble, for its properties are entirely loſt in the ſoap; the ſolubility of this compound in water is owing to the new properties it has acquired. This phenomenon falls evidently under the eighth law of chemical attraction; by which it is eſtabliſhed, that compounds acquire new properties totally different from thoſe of their component principles.

The *reciprocal affinity* takes place when a compound conſiſting of two bodies is decompoſed by a third, and the ſeparated principle again decompoſes the new combination; ſo that the principles ſeem to act reciprocally. The ſulphuric acid has a greater affinity than the nitric acid with potaſh, and accordingly decompoſes a combination of theſe two principles; but the nitric acid, when left in a ſeparate ſtate, has power to divide the ſulphuric acid from the alkali; for by heating ſulfate of potaſh with the nitric acid, nitre is again obtained. This kind of affinity, admitted by M. Baumé, is occaſioned by two circumſtances, whoſe influence diſturbs the general laws of chemical affinity. The common nitric acid muſt be warmed before it can decompoſe ſulfate of potaſh; and the nitre obtained by this proceſs is again decompoſed by the ſulphuric acid, aſſoon as the mixture returns to a cold ſtate. The fuming, or or *nitrous acid,* decompoſes ſulfate of potaſh cold; fuming ſpirit of ſalt or muriatic acid effects the ſame decompoſition, according to M. Cornette: but Bergman has very properly obſerved, that the odorating and fuming acids, which he calls *phlogiſticated,* have affinities different from thoſe which belong to them in their ſimple ſtate. Beſides, in theſe caſes but a very trifling part of the ſalt is decompoſed.

In all theſe inſtances, the order of elective attractions is changed and modified by particular circumſtances. The reſt of the facts on which Mr Baumé eſtabliſhes the exiſtence of the reciprocal affinity, ſuch as the decompoſition of ammoniacal muriate by chalk, and of calcareous muriate by *concrete volatile alkali,* come properly under the double affinities; as ſhall be ſhown when we treat of thoſe ſalts.

All that now remains to be ſaid on chemical attraction is, to give ſome account of the different opinions which have been advanced by philoſophers concerning the cauſe of this force.

The firſt who attempted to form a theory on this ſubject, thought that it muſt ariſe either from the elementary particles of bodies being all of the ſame form, or from the phyſical configuration of the parts, or laſtly, from ſome occult relations of their intimate compoſition. Theſe notions proceeded naturally from the mechanical explanations which were applied to all the phenomena of nature, in the infancy of the ſcience of natural philoſophy.

Moſt of the modern chemiſts who have attempted to explain the cauſe of chemical attraction, have obſerved a remarkable analogy between this force and the general attraction diſcovered by Newton. Conſidering nature as ſimple and uniform, they have been led to conclude, that the power poſſeſſed by bodies of entering into mutual union, muſt depend on the ſame general laws with that by which all bodies are attracted towards each other. They have compared the minute bodies on which the force of affinity acts, with thoſe enormous maſſes which compoſe the ſyſtem of the univerſe; and have ventured to affirm, that it is the force of gravitation which cauſes the former to approach each other, and enter into combination. Several perſons, adopting this opinion, but modifying it in a particular manner, have concluded, that chemical attraction was in the ratio of the gravity of bodies, and thoſe bodies which were of the greateſt ſpecific gravity poſſeſſed always the ſtrongeſt affinities. This hypotheſis is ſometimes indeed juſtified by facts, and agrees with the affinities of many of the acids; but is contradicted by the phenomena of a vaſt number of decompoſitions, particularly of all thoſe in which metallic ſubſtances are concerned. Some chemiſts have been even ſo ſtrongly perſuaded of the exiſtence of an analogy between the attraction of large bodies and chemical attraction, as to imagine it poſſible to meaſure and calculate the former in conſequence of our knowledge of the latter. M. de Morveau, whoſe opinions are likely to have conſiderable weight with other chemiſts, has made a number of experiments with a view to prove the truth of the above aſſertion. Applying to a ſurface of mercury metal plates of the ſame diameter, ſuſpended from the arm of a balance, the other arm of which carried a diſh, he next put weights into the diſh ſufficient to raiſe the plate of metal over the mercury; and he actually found, by making comparative trials of different metals, that theſe adhered to the mercury with different degrees of force, proportioned to the affinities known to ſubſiſt be-

between them and that ſubſtance. Gold adhered with the greateſt force to the mercury, a greater weight being neceſſary to raiſe it than to raiſe any of the other metals: Cobalt, again, which is known to have no affinity with mercury, ſeemed to have no adheſion with that ſurface, and was elevated above it with the greateſt eaſe. But we muſt uſe the freedom to obſerve, that from ſeveral circumſtances, ſuch experiments cannot but be in ſome degree fallacious: the inferior ſurface of the ſmooth plates of metal applied to the mercury, cannot but combine with that ſubſtance; and the amalgam formed by that event being more or leſs, according to the eaſe or difficulty with which the metal unites with the mercury, this combination increaſes the weight of the plate, and renders a greater force requiſite to raiſe it above the mercury. A plate of metal adhering to a ſurface of mercury, cannot be raiſed above it without dividing the mercury into two layers; ſo that the force neceſſary to raiſe this plate is employed rather in overcoming the mutual adherence of the particles of the mercury, than in dividing the mercury from the metal.

It muſt be acknowledged then, that if chemical attraction be the ſame with general attraction; yet the difference of the laws by which theſe two forces are regulated, proves the former to be a particular modification of the latter. This truth becomes evident from a compariſon of thoſe laws of the Newtonian attraction with which we are acquainted, with the general facts relative to chemical attraction which have of late been diſcovered: The former acts only upon large bodies, and in the direct ratio of their maſſes; the latter affects only minute bodies, and has abſolutely no influence on ſuch as are of any conſiderable bulk. Attraction acts between bodies placed at immenſe diſtances from each other: affinity never acts but between bodies in mutual contact. In deſcribing the laws of chemical attraction, we have laid before our readers the facts on one ſide of this compariſon; and we are induced to conclude, that the phenomena which thoſe two great laws preſent, are ſtill ſo ſtrikingly different. as to render it highly proper for philoſophers to diſtinguiſh between them.

C H A P. IV.

Concerning the Principles of Bodies.

IT has been the opinion of philoſophers in all ages, that notwithſtanding the vaſt diverſity of the bodies of nature, they are all compoſed of a few primary ſimple ſubſtances; and to theſe they have given the name of *Principles.* The analyſes of chemiſtry, which afford the ſtrongeſt facts in proof of this doctrine, having enabled chemiſts to form pretty accurate notions concerning the nature and differences of thoſe principles; they have admitted ſeveral kinds of them. But it muſt be remarked, that they have taken the word *principles* in an acceptation different from that in which it was uſed by the philoſophers of antiquity. Ariſtotle and Plato applied the name *principles* to a claſs of ſubſtances, which being of ſuch ſubtlety as to eſcape the obſervation of the ſenſes, conſtituted, as they thought, by their union, thoſe bodies of a leſs ſimple nature, and perceptible to the ſenſes, which ſtill continue to be known by the name of *elements.* Theſe are the ſame ſubſtances which have been by other philoſophers denominated *atoms,* or *monads.* But chemiſts, not preſuming to extend their ſpeculations to ſuch ſublime and

and ſubtle objects, comprehend under the general name of *principles*, all thoſe ſubſtances, whether ſimple or compound, which they obtain by the analyſis of bodies. But as the principles of bodies, when conſidered under this point of view, muſt be extremely various, they have divided them into *proximate* and *remote*. The firſt are obtained by a firſt analyſis, and are capable of being reſolved into other principles; thus, by decompoſing a vegetable ſubſtance, we obtain oils, mucilages, ſalts, and coloured particles; all which are proximate principles of the vegetable ſubſtance, and each of them may by a new proceſs be decompoſed into other principles. By remote principles, they underſtand thoſe ſubſtances which, being ſimpler than the proximate, enter into their compoſition. Thus, mucilage, one of the proximate principles of vegetables, affords by a new proceſs, oil, water, earth, &c. and theſe are the remote principles of the vegetable. Theſe two kinds of principles have been alſo diſtinguiſhed by other names; ſuch as *principiated*, applied to the proximate principles; and *principiant*, to the remote. Theſe epithets diſtinguiſh the former as ariſing from the combination of more ſimple principles; and the latter, as ſerving by their union to conſtitute bodies, which though of a leſs ſimple nature, may yet become the principles of new compounds. Some chemiſts, to render theſe diſtinctions more juſt and accurate, admit more than two kinds of principles: They call thoſe principles which appear ſo ſimple as to be incapable of farther decompoſition, *primary*, or principles of the firſt order: *ſecondary* principles are formed by the combination of the *primary*; the combination of the *ſecondary* conſtitutes *ternary*

prin-

principles; and theſe united in a new compoſition, afford *quaternary* principles, &c.

Philoſophers have not uniformly agreed with regard to the number of the elements. The followers of Thales the Mileſian, who for his ſuperior knowledge was ranked among the ſeven wiſe men of Greece, and, according to Cicero, was the firſt among the Greeks who cultivated the ſcience of phyſics, conſidered water as the great principle of all material bodies. Anaximenes, aſcribing this character to air, ranked it, on that account, among the number of the gods. Others conferred this important function on fire; while ſome, among whom was Anaximander, the ſcholar of Thales and maſter of Anaximenes, believed earth to be the principle of all things. Each of them ſupported his opinion by reaſonings more or leſs plauſible: But as the experimental ſciences of natural philoſophy and chemiſtry were then unknown, we can regard theſe notions in no other light than as bold conjectures, which unfortunately happen to be totally deſtitute of foundation. About three centuries after theſe philoſophers, Empedocles, a phyſician of Agrigentum, imagined that the four ſubſtances, each of which had been in its turn held to be the principle of all things, were of equal ſimplicity; and therefore combined thoſe various opinions into one ſyſtem, admitting four elements, fire, water, earth, and air. His opinion was adopted by Ariſtotle and Zeno in the following century. What induced thoſe philoſophers to conſider fire, water, earth, and air, as elements, ſeems to have been rather the bulk, quantity, and apparently uniform properties of theſe ſubſtances, than any accurate notions concerning their eſſential compoſition. Fire ſeems diffuſed through all nature, and its effects are always the ſame: Our

globe

globe is ſurrounded with a maſs of air, of which the quantity and eſſential properties ſeem to remain unvaried: An enormous maſs of water, whoſe depths are often unfathomable, covers more than half the globe: Laſtly, this globe itſelf, the bulk of which is more than equal to that of all the beings who inhabit it taken together, ſeems to be formed of a ſolid matter little ſubject to change, and of ſuch a nature as renders it a proper baſe to fix the other elements. It ſeems to have been on account of the bulk and unvarying properties of thoſe bodies, that the firſt philoſophers were induced to conſider them as the primary materials of which all natural bodies were compoſed.

The peripatetic doctrine of the ſchools ſupported the Ariſtotelian diſtinction of the elements till the ſixteenth century. The ſect of chemiſts who then began to prevail, introduced a new diſtinction of the elements. Paracelſus, who was rather an artiſt than a philoſopher, haſtily inferred from the reſults of his operations, that there were five principles: namely, ſpirit, or mercury; phlegm, or water; ſalt; ſulphur, or oil; and earth. By ſpirit, or mercury, he underſtood all volatile odorate bodies; but theſe properties are far from being peculiar to ſimple bodies. Water, or phlegm, comprehended all aqueous, inſipid, products; but theſe properties are no ſurer indications of ſimplicity than the former. The word ſulphur, or oil, he applied to all inflammable liquid ſubſtances, and of conſequence to a great number of compounds, ſuch as the unctuous and eſſential oils, &c. By ſalt, he meant all bodies poſſeſſing the three properties of dryneſs, taſte, and ſolubility; which properties likewiſe belong to many compounds. Laſtly, Paracelſus applied the word earth to all thoſe fixed, dry, and inſipid, reſidues which are obtained

obtained in moſt operations, and are now known to be very different in their natures.

Beccher, who has treated of the ſcience of chemiſtry in a very philoſophical manner, being aware of the objections to which this ſyſtem of Paracelſus was liable, and convinced of its inaccuracy, attempted to diſtinguiſh the elementary principles of bodies in a different manner. He firſt aſſumed two principles very different from one another; moiſture and dryneſs, earth and water. The latter of theſe he divided into three ſpecies; namely, vitrifiable, inflammable, and mercurial earth. His vitrifiable earth was that which, taken alone, was not ſuſceptible of any alteration, but poſſeſſed the property of forming fine glaſs when mixed with a certain ſaline ſubſtance: he likewiſe aſcribed to it the quality of rendering thoſe bodies into the compoſition of which it entered ſolid, and almoſt incapable of alteration. Inflammable earth was that which rendered all the bodies into which it entered capable of combuſtion: Beccher conſidered it as being likewiſe the cauſe of odour, colour, and volatility. Mercurial earth he conſidered as exiſting in mercury, arſenic, the muriatic acid, &c.; and the diſtinguiſhing characteriſtic which he aſſigned it, was to communicate an high degree of both gravity and volatility to thoſe bodies of which it conſtituted part, though theſe two qualities ſeem directly oppoſite and inconſiſtent. Stahl adopted and illuſtrated the doctrine of Beccher. He conſidered inflammable earth as fire exiſting in a fixed ſtate, and gave it the name of *phlogiſton*. He found himſelf unable to demonſtrate the exiſtence of mercurial earth; and we have hitherto obtained no certain knowledge concerning that principle. Stahl paid great attention to combinations of earth and water,

water, and ſtill more to phlogiſton, but has ſaid ſcarce any thing of thoſe which contain air; which Hales, nearly about the ſame time, diſcovered to act an important part in chemical phenomena.

From the days of Beccher and Stahl to the preſent time, chemiſts have made no change on the doctrine of the elements eſtabliſhed by the philoſophers of antiquity. They have followed Empedocles in acknowledging four principles, each of which they have conſidered as exiſting in two different ſtates. 1. As free and inſulated; and in this ſtate have the atmoſphere, large maſſes of water, fire in general, and the globe viewed as one whole been conſidered: 2. As combined; and then the air, water, and earth obtained by the laſt analytical operations that can be performed on bodies, are the ſubjects of inquiry.

Such nearly were the opinions concerning the principles and elements of things that prevailed from the time of Beccher and Stahl, till the noble diſcoveries of Prieſtley and Lavoiſier, concerning fire, air, and combuſtion, exploded theſe, to make way for others better founded. In fact, if immutability of properties, unity and ſimplicity, are the genuine characteriſtics of elements, and if that ſimplicity of character belongs only to ſuch bodies as we cannot reduce by decompoſition, it is to be remarked, *1ſt*, That of the four elements there are two, air and water, which art has at length found means to decompoſe and ſeparate into ſeveral principles. *2dly*, That elementary earth is merely the creature of fancy; as there are a variety of earthy ſubſtances all equally ſimple and incapable of decompoſition, as ſhall be ſhown in the laſt chapter of this firſt part: *3dly*, That there are many natural bodies, ſuch as ſulphur and the metals, which no art has yet been able to decompoſe, and which muſt therefore, in the preſent ſtate of our knowledge, be conſidered as ſimple ſubſtances.

From theſe general conſiderations, ariſing from facts which ſhall be more particularly related in the following chapters, and through the ſeries of the work, it appears, that the true principles, or primary elements of natural bodies, eſcape the obſervation both of our ſenſes and of thoſe inſtruments which we employ to aid the imperfection of our ſenſes: that many of thoſe ſubſtances which have been called elements on account of their bulk, their influence on the phenomena of nature, and their being found to exiſt in many of its productions, are far from being ſimple and unchangeable: and that, in truth, none of the bodies with which we are acquainted is a ſimple ſubſtance, though we may aſcribe that character to ſuch as we have not hitherto been able to decompoſe. And theſe aſſertions entirely agree with the opinions of ſome ancient philoſophers, who conſidered not the elements as the ſimpleſt of ſubſtances, but believed them to be formed of principles infinitely more ſubtle and immutable.

What we advance concerning thoſe ſubſtances which have for ſo many ages enjoyed the excluſive title of elements, but are now diveſted of that prerogative, does not hinder us from conſidering fire, water, earth, and air, as forming the component principles of moſt natural bodies.

Let us diſmiſs this ſubject with an account of the terms which have been employed by ſome perſons to diſtinguiſh bodies, according as their compoſition is more or leſs complicated.

The

The combination of two elements forms a body that is called a *mixt;* the union of ſeveral mixts conſtitutes a *compound;* two compounds make a *ſurcompound;* the combination of ſurcompounds gives a *decompound;* two or more of theſe united make a *ſurdecompound.* It would be pretty difficult to give inſtances of theſe ſeveral kinds of compoſitions; we could indeed go no farther than to the ſurcompound. Theſe diſtinctions are, therefore, merely fanciful, and can be of no real uſe in ſcience. Macquer, to whom chemiſtry is much indebted for the preſent perſpicuity of its doctrines, propoſes to explode this barbarous and inaccurate nomenclature, and to adopt in its room, Firſt, Second, Third, and Fourth Order. We might even purſue the ſame thought, ſo far as to adopt theſe names to diſtinguiſh principles according to the order of the analyſis by which we obtain them.

CHAP. V.

Of Fire.

THOUGH we cannot agree to receive the word *element* in the ſame ſenſe in which it was generally underſtood till the preſent time; though we cannot conſider thoſe four bodies as the firſt principles of all others, and the ſimpleſt productions of nature; yet we are willing to inquire into their nature before proceeding to others; becauſe a knowledge of their properties is neceſſary to enable the reader to underſtand our account of the properties of other ſubſtances, and becauſe they cannot be arranged under any of the diviſions of natural hiſtory, being confined to no particular departments in nature, but extending equally through all.

None of the four elements diſplays greater activity or ſimplicity than *fire.* The more ancient philoſophers, who in this particular have been uniformly followed by their ſucceſſors, gave this name to a ſubſtance which they ſuppoſed to be fluid, active, penetrating, conſiſting of particles actuated by a lively and inceſſant motion, and the firſt principle of all fluidity and motion. Whoever conſiders this ſubject, muſt readily perceive, that it was merely by conjecture they aſcribed theſe properties to a particular elementary body: for though the exiſtence of the other three elements has always been undeniably eſtabliſhed, yet the exiſtence of this has never been demonſtrated. There is reaſon to think, that in all languages, and among all nations, the firſt uſe of this word was to denote the impreſſion which hot bodies make upon the ſkin; and that it is ſignificant of the light which iſſues from bodies in combuſtion, as well as ſynonymous with the word *heat*. Many have conſidered it in this view, admitting the exiſtence of fire only where heat is felt or combuſtion carried on. Chancellor Bacon was among the firſt that began to doubt the exiſtence of fire as a particular fluid; and obſerved, that natural philoſophers, in defining it, had always miſtaken a property for a ſubſtance. Boerhaave, whoſe Treatiſe on Fire will be ever regarded as a maſterpiece, was ſenſible of this difficulty; and in order to diſcover the properties of this pretended element, examined what effects it produces on thoſe bodies in which it is believed to exiſt; ſo, like former philoſophers, he has rather given the hiſtory of hot, luminous, rarefied, and burning bodies, than of fire. This difficulty muſt even continue to perplex the philoſopher. The properties of fire cannot but be intimately connected with thoſe of the bodies on which it acts; we can form no idea of it as exiſting in a ſeparate ſtate. Notwithſtanding the preſent advanced ſtate of chemiſtry, the exiſtence of this ſubſtance is ſtill undetermined. Philoſophers continue to believe in its exiſtence, but are able to give a ſatisfactory explanation only of its effects. Theſe difficulties have induced ſeveral chemiſts, among whom was the celebrated Macquer, to conſider fire as being nothing

nothing more than light, and heat as a certain modification of bodies, produced by the motion and colliſion of their component particles. But this opinion no longer prevails among thoſe who cultivate chemiſtry. In order to enter into the ſeveral theories which have of late been advanced concerning fire, we muſt conſider it in a more particular manner. To acquire an accurate knowledge of this matter, and to comprehend that immenſe ſeries of facts which at preſent conſtitute the body of the ſcience of chemiſtry; we muſt make a methodical diviſion of our ſubject, examine and diſcuſs with pains its ſeveral parts and ſubdiviſions, and conſider in ſucceſſive order, as ſo many diſtinct effects of fire, light, heat, rarefaction, the changes produced on bodies by heat, and the particular qualities aſcribed to fire in a ſtate of combination, when it obtains the name of Phlogiſton, &c.

§ I. *Of Light.*

THE exiſtence of light is not doubtful, like that of fire: both its exiſtence and its properties are at preſent well known. This body, which is thought to iſſue from the ſun and the fixed ſtars, is the principle which enables the organs of ſight to inform us of the preſence of other bodies. Without it we ſhould be involved in perpetual darkneſs, and our eyes would be entirely uſeleſs. Being reflected in right lines from the ſurfaces of thoſe bodies on which it falls, it ſtrikes the eyes in ſuch a manner as to paint on the retina the images of thoſe objects from which it is reflected.

Means have been found to collect its rays in a darkened chamber, in ſuch a manner as to render their properties ſubject to examination, by exhibiting them diſtinct from the bodies which they illuminate.

The motion of light is ſo rapid, that it paſſes through the ſpace of eighty thouſand leagues * in a ſecond of time, according to the moſt eminent aſtronomers. It moves in a rectilinear direction, and conſiſts of rays, which, after iſſuing from the ſtars, ſeparate and diverge in obedience to the impulſe originally communicated to them. Such is their elaſticity, that when they fall on a ſurface capable of reflecting them, the angle of their reflection is nearly equal to that of their incidence; as is ſeen in the ſtudy of catoptrics. When light paſſes near any body, it is more or leſs inflected towards that body; which inflection, by evincing its gravitation, ſhows it to be a diſtinct ſubſtance.

However great its ſubtlety and velocity, yet it does not move invariably in a right line. Such bodies as meet and obſtruct its paſſage, cauſe it to deviate from its original direction. When paſſing obliquely out of a rare into a denſe medium, it is refracted like any other ſolid body; but Newton † diſcovered its refrangibility to be directly contrary to that of other bodies. Other bodies recede from the perpendicular line whenever they paſs into a denſer medium; but light, on ſuch an occaſion, approaches nearer to the perpendicular. To explain the laws of the refraction of light is the province of dioptrics.

When light reaches the ſurface of the earth, it diſcovers

---

* Twenty-five of which make a degree; equal to 167,000 geog. miles.

† We owe the firſt accurate account of theſe phenomena to Des Cartes.

covers to animals the preſence of material bodies, and enables them to diſtinguiſh them into opaque. tranſparent, and coloured. Its preſence is ſo neceſſary to render theſe properties perceptible, that in darkneſs bodies become totally undiſtinguiſhable. Difference of opacity, tranſparency, and colour in bodies, depends, therefore, on the manner in which they are affected by light, or in which they affect that ſubſtance. A body is tranſparent when the rays of light paſs eaſily through it; which depends no doubt on the form of its pores. As many tranſparent ſubſtances have great hardneſs and ſpecific gravity, the particles of light which penetrate through them muſt therefore be extremely ſubtle. As the particles of light paſs through thoſe ſubſtances, they are refracted in the ratio of their denſity, if they be ſtones, ſalts, or vitreous ſubſtances: but tranſparent bodies of the combuſtible claſs reflect the particles of light in a different ratio. Thus, yellow amber has a much greater refringent power than a ſaline cryſtal of equal denſity.

By examining the various refractions and reflections of light, the great Newton was at length able to dedecompoſe, or rather to diſſect, this body, ſo far as to diſcover that the rays which compoſe a beam of light were each of a peculiar colour. Before him mens notions of the cauſe of colours were very obſcure and indiſtinct. The refraction and reflection of each ray of light are determined by particular laws; and therefore when a ſtream of light is directed ſo as to fall on the angle of a triangular glaſs priſm, and the priſm turned round on its axis, the rays which compoſe the ſtream of light being refracted according to different laws, are ſeparated in paſſing through the glaſs, and if received on a plane white ſurface, form a long ſpectrum, conſiſting of the ſeven following colours; red, orange, yellow, green, blue, purple, and violet.

The ſurfaces of opaque variegated bodies produce the ſame effects as the priſm on light. Such ſeems to be the cauſe of that diverſity of colours which conſtitutes ſo conſiderable a part of the beauties of nature. When all the rays which fall upon any opaque body are reflected, without ſuffering any abſorption or ſeparation by that ſurface, they ſtrike our eyes with all their luſtre, and the colour produced is a white: But again, if the ſame rays fall on a ſurface by which they are all abſorbed, the eye then beholds a deep ſhade; which being a direct contraſt to the former, conſtitutes black, or rather abſolute negation of colour. In ſhort, as every beam of light conſiſts of ſeven different coloured rays, of various degrees of refrangibility, what diverſifies the colours of natural bodies is the various diſpoſition of the particles of their ſurfaces; ſome of which reflect one ray, abſorbing all the reſt, others another, and ſo on. Colour depends, therefore, on the nature of the ſurfaces of bodies, and tranſparency on the form of their pores; and both are occaſioned by the modifications produced on light, either by the ſuperficies or the interior parts of the bodies on which it falls. A blue or red colour is produced by the decompoſition of a beam of light, and the abſorption of all its rays, excepting the blue or the red.

Theſe are the chief properties of light, when conſidered in a free ſtate, or as it iſſues from the ſun and the fixed ſtars. But are we to examine it only in this free and inſulated ſtate? Is not this body, as well as all the reſt with which we are acquainted, ſubject to the laws of chemical attraction? The phenomena of light are not confined to the modifications which it ſuffers from the ſurfaces of bodies. Subſtances expoſed to its influence, by being plunged in its ſtreams, often ſuffer an alteration and entire change of nature, without any other known cauſe; and it is reaſonable to think that ſuch changes are produced by the operation of light, which is enabled to effect them by being capable of chemical attraction. Art, indeed, has not yet been able to determine whether theſe alterations be occaſioned by the decompoſition of light, or by that of the bodies in contact with it, or by the mutual decompoſition of both; which laſt is highly probable: but they are too numerous and too ſtriking to be paſſed over unnoticed. We ſhall here mention only a few of the moſt remarkable; becauſe our attention will be more particularly turned towards this object in the hiſtory of natural bodies.

Naturaliſts have long obſerved the influence of light on vegetation. Thoſe engaged in the cultivation of plants firſt obſerved that ſuch as grow in the ſhade are of a paler colour. This phenomenon has received the name of *ætiolation*; and the plants on which it takes place are ſaid to be ætiolated. Herbs growing under ſtones are white, ſoft, aqueous, and inſipid. Gardeners take advantage of this circumſtance to ſupply our tables with white and tender herbs and pulſe; for they bind their leaves ſo cloſely together, that the exterior defend the interior from the contact of the light. The colour of herbs is pale or deep in proportion as they are leſs or more expoſed to the rays of the ſun; and in conſequence of this, the nations of the eaſt obtain from the wood, bark, or roots of trees, many of the moſt valuable colouring ſtuffs, both for permanency and luſtre, which all the ingenuity of European dyers has never been able to imitate.

Colour is not the only property that vegetables derive from the influence of light. From the ſame ſource they acquire taſte, ſmell, and combuſtibility. Thus light contributes to the ripening of fruits and ſeeds; and under the torrid climate of America, vegetables in general are highly odorous, ſapid, and reſinous, &c. Laſtly, light exerts ſo powerful an energy on the organization of vegetables, that when the rays of the ſun fall upon them, their leaves pour from their ſuperior pores copious ſtreams of vital air ; but when hid from the influence of that planet, they exhale a deleterious mephitic, or rather a real acid, of the ſame nature with that which is extracted from chalk. This important diſcovery was firſt made by Dr Prieſtley. M. Ingenhouſze has proſecuted it much farther ; and from the experiments and obſervations of both, it appears how powerful the influence of light is on vegetation. In a great number of chemical operations, light is found to act with the ſame energy as in theſe more general inſtances. There is not one ſubſtance in nature, that, if put into a cloſe glaſs veſſel, and expoſed to the rays of the ſun, will not ſuffer ſome alteration from their influence. Theſe alterations are moſt remarkable in mineral acids, oxides or metallic calces, vegetable powders, and volatile animal oils. Not a ſingle metallic oxide, though more eſpecially that of mercury, but ſuffers a change of colour, aſſuming generally a deeper ſhade from being expoſed to the rays of the ſun. Painters' colours which are kept by merchants in glaſs bottles, afford a good inſtance of this. Mineral acids expoſed to the ſun become fuming, higher coloured, and more volatile ; metallic ſalts become black ; animal oils aſſume a brown, duſky colour. All of theſe changes merit the moſt careful attention of chemiſts ; they

they afford vaſt ſcope to reſearch, and have not hitherto been obſerved with ſufficient care. Scheele was the firſt who deſcribed any of them. M. Berthollet has alſo turned his views to this object; and we ſhall afterwards ſee that he has determined accurately what paſſes in many of theſe alterations.

§ II. *Of Heat.*

TO examine the properties of heat is a much more difficult taſk than to examine thoſe of light. Bodies when heated acquire no additional gravity; which might ſerve to prove that heat is a diſtinct ſubſtance. Bacon, and many other great men, have thought heat to be only a certain modification of which bodies are ſuſceptible. It is certain that natural philoſophers, as well as other men, have always conſidered its preſence as a ſure indication of the preſence of fire; have ſometimes confounded it with that element; and ſometimes conſidered heat as one of the diſtinguiſhing properties of fire.

Its leading properties are, to penetrate through all bodies; to diffuſe itſelf equally, and to tend to an equilibrium; to dilate all ſubſtances into which it inſinuates itſelf, cauſing them to paſs from a ſolid to a fluid ſtate, and from that to aſſume the form of elaſtic fluids.

Heat is uſually communicated to bodies in one or another of theſe three ways; by contact, by motion, or by combination. Every perſon muſt have obſerved, that when two fluids different in temperature, the one ſenſibly

ſenſibly warm, and the other ſenſibly cold, are mingled together, the former loſes part of its heat, which is communicated to the ſecond, ſo that the temperature of both become the ſame. It is equally well known, that when two ſolids, one warm the other cold, approach each other, the latter robs the former of part of its heat, and the temperatures become equal. As to the calling forth of heat by motion; the friction of any two ſolid ſubſtances, ſuch as two hard ſtones, two pieces of wood, ivory, or metal, produces a heat which often riſes to inflammation. The production of heat by combination is no leſs undeniable. The union of concentrated acids with water, quicklime, pure alkalis, or metals, is productive of a ſtrong heat: the combination of certain fluids, ſuch as oil and ſpirit of nitre, is even ſo powerful this way as to cauſe inflammation.

The laws of the communication of heat were conſidered as analogous to thoſe of motion, till the labours of Meſſrs Wilcke of Stockholm, Irvine of Glaſgow, Crawford and Kirwan of London, Lavoiſier and De la Place of Paris *, gave us new and more accurate ideas on the ſubject. The reſearches of theſe philoſophers have ſhown, that nothing was leſs known, or involved in greater difficulties, than the progreſs and communication of heat among bodies unequally heated. Their experiments, though highly ingenious, are not yet ſufficiently numerous. They themſelves do not preſume to conſider their obſervations as of ſufficient weight to form an elementary part in the ſcience of chemiſtry: But it is highly probable that theſe will lead to the eſtabliſh-

---

* Dr Black of Edinburgh is certainly the author of the modern doctrine of Heat.

eſtabliſhment of a general theory, which may be applied to all the phenomena of chemiſtry ; in every one of which heat acts a part, by either its abſorption or diſengagement.

Even the niceſt and moſt accurate obſervations have been hitherto inſufficient to afford us any determinate ideas of the nature of heat ; and both chemiſts and natural philoſophers are ſtill divided in their opinions on that ſubject. Part follow Bacon of Verulam, in conſidering heat to be nothing more than a modification of which all natural bodies are ſuſceptible ; which has no ſeparate exiſtence, but conſiſts in the oſcillation of the minute particles of bodies. This was Macquer's opinion. The philoſophers who maintain it, ſupport it on the following facts. Heat accompanies all the phenomena of motion, and appears ſubject to the ſame laws : It is increaſed with the increaſe of motion, and diminiſhed by its diminution. Excepting its communication or paſſage from one body into another, in which it follows laws different from thoſe of motion ; in all other reſpects there is a ſtriking analogy between the two ; and when this cauſe acts with leſs force, or entirely ceaſes to act, heat is inſtantly diminiſhed, and ſoon totally loſt. To explain this hypotheſis, the philoſophers by whom it is maintained obſerve, that even bodies of the greateſt denſity are full of ſmall cavities or pores, the ſum of which if they were taken together would perhaps occupy a larger ſpace than the ſolid matter of the body that contains them. Theſe void ſpaces afford room for the particles to move one againſt another in a continual oſcillation. The oſcillations are not obſerved, becauſe both the particles and pores are ſo ſubtle and minute as to elude our ſenſes. Laſtly, The philoſophers who regard heat as an internal motion,

tion, urge, that no experiment has hitherto demonſtrated its exiſtence in a ſeparate ſtate, and that it makes no addition to the gravity of bodies, &c.

On the contrary, many other philoſophers, and ſome modern chemiſts, are of opinion, that heat is a particular fluid, diffuſed through all nature, of which every body contains more or leſs. They diſtinguiſh that fluid as exiſting in two different ſtates,—in combination, and at liberty. In the former ſtate, it neither affects our ſenſes nor the thermometer, but remains quieſcent in thoſe bodies of which it conſtitutes a principle; it is then more or leſs in a ſtate of confinement. In the decompoſition of the bodies it is often diſengaged, and eſcapes into a ſtate of liberty: it now becomes capable of acting on bodies expoſed to its influence; and its force is meaſurable by a graduated thermometer. As all bodies that paſs from a ſolid to a fluid ſtate, and from thence into a vaporous form, excite cold in the ſurrounding atmoſphere, they ſuſpect that ſuch bodies abſorb a great quantity of heat; and when fluids, by aſſuming a concrete form, generate heat, they think that heat is then diſengaged from thoſe ſubſtances, and paſſes from a ſtate of combination into a ſtate of liberty.

Scheele, as well as Bergman, being perſuaded that heat is a diſtinct ſubſtance, has examined with great attention all the phenomena which it diſplays as a chemical agent ſuſceptible of combination. He has even thought himſelf warranted by his experiments to conclude, that it is a combination of vital air, which he calls *empyreal fire*, and fixed fire or phlogiſton, and differs from light only in the relative quantity of the laſt principle. But however ingenious and accurate his experiments, the inductions which he has drawn from

from them concerning the nature and principles of heat, do not appear to be naturally deducible from the facts; and we cannot conſider his analyſis of heat as fully demonſtrated to be juſt. Some philoſophers are of opinion, that light and heat are the ſame ſubſtance, only exiſting in different ſtates. This ſubſtance becomes light, when its particles being collected together, and poſſeſſing all their attractive force, are violently darted to a diſtance: it aſſumes the character of heat, when the ſame particles exiſt in a ſtate of diviſion, move gently, and tend towards an equilibrium. Heat may be converted into light, and light again into heat. It muſt be acknowledged, however, that light often produces effects very different from thoſe of heat; as on the nitric acid, the oxigenated muriatic acid, the calces or oxides of metals, and the leaves of vegetables dipped in water; all of which bodies afford vital air or oxigenous gas when expoſed to the rays of the ſun, which can be obtained from ſcarce any of them by the operation of heat. Thus the artificial light of our fires in paſſing through veſſels, changes the nature of the products which it diſengages. Laſtly, Meſſrs Lavoiſier and De la Place ſeem to think both theſe opinions true: they conſider heat as a diſtinct ſubſtance, which by its preſence in natural bodies occaſions an oſcillation of their component particles.

But though the nature of heat be not certainly known, the phenomena to which it gives riſe in chemical combinations and decompoſitions are not the leſs certain on that account, and are worthy of careful obſervation. It appears from a vaſt variety of facts, that whether a body or a modification, it is of itſelf liable to no alteration, and is never loſt; and the conſideration of this has induced Meſſrs Lavoiſier and De la Place

Place to form an axiom or general principle concerning its appearance or diſappearance. As that axiom is of the higheſt conſequence, we ſhall inſert it here.

"If in a combination, or in any change of ſtate whatſoever, there be a diminution of free heat, the whole of that heat will again appear when the ſubſtances are reſtored to their former ſtate; and on the contrary, if in any combination or change of ſtate there be an increaſe of free heat, this additional heat will diſappear when the ſubſtances return to their original ſtate."

They generalize this principle ſtill farther, ſo as to make it extend to all the phenomena of heat; and they then expreſs it in the following terms. "All the variations of heat, whether real or apparent, that any ſyſtem of bodies can ſuffer, are reproduced in an inverſe order when the ſyſtem returns to its original ſtate."

In order to meaſure the quantity of heat that is abſorbed or diſengaged in the various phenomena of chemiſtry, which appears from what has been ſaid to be an object of the higheſt importance; modern philoſophers have endeavoured to find means for correcting the obſervations of the thermometer, and extending its ſcale. M. Wilcke propoſed to eſtimate the heats of bodies by obſerving what quantities of ſnow they could melt in a given time. Meſſrs Lavoiſier and De la Place have contrived a method which is more certain and more eaſily practicable; reducing ſubſtances that produce heat by their combination, as well as the veſſels in which they are contained, to the temperature of 32° Fahrenheit; they then put them into a veſſel laid round with ice; and as the interior ſurface of the ice cannot be melted but by the heat which is diſengaged while the ſubſtances

ces are entering into combination, the quantity of the heat thus diſengaged may be meaſured by the quantity of the water obtained by the melting of the ice, which muſt be carefully collected *. By this proceſs they have been able to eſtimate the ſpecific heats of various bodies, to meaſure the quantity of heat abſorbed in various combinations, and even to determine how much is diſengaged in combuſtion and reſpiration. We are obliged to refer our readers to the work of thoſe learned academicians themſelves, for an account of this ingenious inſtrument, and the manner in which it is to be applied to the various purpoſes for which it is adapted; as the detail of particulars neceſſary to explain it would be inconſiſtent with that brevity which we mean to follow through the courſe of this work †.

Here let us conſider more particularly the reſemblance that appears in ſome inſtances between light and heat, as well as thoſe peculiarities by which they are diſtinguiſhed from each other in the operations both of nature and art. Though the light of the ſun's rays warms thoſe bodies on which it falls; yet we muſt not conclude from that circumſtance that light and heat are the ſame; there are a great many inſtances in which light is totally deſtitute of heat, and others again in which heat is not accompanied with light; and a number of philoſophers therefore conſider them as eſſentially different. In fact, phoſphori, diamonds, pu-

---

* We underſtand from the Philoſophical Tranſactions, that in ſome attempts made by an ingenious Engliſhman, it was found that even this method may be fallacious.

† See a Memoir on Heat, read before the Royal Academy of Sciences on the 28th of June 1783, by Meſſrs Lavoiſier and De la Place of that academy. A.

putrid wood, animal ſubſtances in a ſtate of putrefaction, luminous inſects and worms, as well as the rays of the moon, concentrated on metallic mirrors or lenſes, afford a ſtrong ſparkling light, but no ſenſible heat: and all the bodies in nature may be ſtrongly heated without becoming luminous.

The rays of the ſun appear to produce heat merely by their impulſe on the bodies on which they fall, or by the friction which they ſuffer from thoſe through which they paſs. Red, and more particularly black opaque bodies, are ſooner heated than white, bright ſurfaces; doubtleſs becauſe they refract the rays more powerfully, and perhaps even becauſe light enters into combination with thoſe high-coloured ſubſtances, while white ſurfaces do not abſorb, but reflect the rays which fall upon them.

With regard to the production of light by a ſtrong continued heat, as in the combuſtion of oils, wood, or greaſe, and the ignition of metals and ſtones; this may alſo be accounted for without allowing the identity of light and heat. When combuſtible bodies are ſtrongly ignited, they at length produce flame; which has the ſame effects as the rays of the ſun, and ſupplies their abſence. But this light, which is produced by inflammation, may have before ſubſiſted either in the combuſtible body or in the air, the preſence of which is neceſſary to its production: and this fact, therefore, affords no proof that heat may be changed into light. The ignition of incombuſtible bodies, ſuch as ſtones, in which light cannot ſubſiſt in a combined ſtate, not at leaſt in the ſame manner as in combuſtible bodies, has been very ingeniouſly explained by Macquer. In his opinion it depends on the ſtrength of the vibrations communicated to the particles of thoſe bodies by the im-

impulſe of heat. Thoſe vibrations diſpoſe the particles in ſuch a manner, that their facets, acting like ſo many little mirrors, reflect upon our eyes the rays of light, which exiſt in the air by night as well as by day; for we are involved in darkneſs during the night, for no other reaſon but becauſe theſe are not then ſo directed as to fall upon our organs of ſight. Such were the notions of Macquer and of many other philoſophers. But a very numerous ſeries of accurate facts concerning the differences of heat in bodies, the capacity of bodies to abſorb it, and the elective attractions to which it is ſubject, render the exiſtence of heat as a diſtinct body much more probable than ever. It is thought to be often a principle in compound bodies, and the lighteſt of all the ſubſtances in nature; and this laſt property is conſidered as the reaſon why we cannot determine its exiſtence by its weight. Heat is diſtinguiſhed into two kinds, or rather as exiſting in two different ſtates; in the one, it is intimately combined with other principles, and is denominated *latent heat*, or the *caloric* principle, becauſe it is not perceptible to the ſenſes; in the other, it is only diffuſed without combination. This laſt kind of heat may be expelled by preſſure: thus, when a bar of iron is ſtruck, the ſtroke compreſſes its particles and cauſes the heat to iſſue out, in the ſame manner as water iſſues from a wet ſponge when it is preſſed together with the hand. Combined heat cannot be ſeparated from the bodies of which it forms a part, but by means of new chemical combinations. All ſolid bodies that contain any portion of theſe two kinds of heat, are capable of receiving more of both. When you add a quantity of the ſecond ſpecies to any body, its firſt effect is to enlarge the pores that ſeparate its component particles, by which means it ſoftens a ſolid; next, as it gradually accumulates, it produces fuſion or liquefaction; and as the quantity of heat continues to increaſe, elaſtic fluidity follows: But we ſhall treat of theſe phenomena in the two following ſections.

§ III. *Of Rarefaction.*

RAREFACTION is the moſt remarkable of all the effects which philoſophers aſcribe to fire, and is conſtantly produced by heat. We have already taken notice that the chief effect of heat is to diminiſh the ſpecific gravity of bodies, by extending their bulk, without adding any thing to their abſolute weight. This rarefaction ſhows, that ſome new ſubſtance is introduced into the cavities of the rarefied body. This ſubſtance, which is no other than heat, acts in proportion to the interſtices which ſeparate the component particles of the body. Bodies when rarefied by heat gain no additional weight, and have their ſpecific gravity diminiſhed; becauſe rarefaction conſiſts ſimply in the ſeparation of the parts of the warm body, its pores being enlarged, ſo that there is more vacuity and leſs ſolid matter than before in a given ſpace. That ſeparation of parts is effected by heat, which is to us, in point of weight, a mere non-entity.

When we conſider, that the particles of bodies rarefied by heat, ſuffer an internal motion, which tends to divide them from one another; and that cold, on the contrary, compreſſes and condenſes them; we are led to conſider heat as a force oppoſed to the mutual gravitation

vitation of thoſe particles, which weakens their particular attraction: For it is to be obſerved, that there are three modifications of the Newtonian attraction which ought to be carefully diſtinguiſhed from one another. The firſt ſtate of attraction is that which cooperates with a primary impulſe to retain the planets in their orbits, preventing them from approaching the ſun, upon whom they would ſoon fall were it not for the centrifugal force which they have received from primary impulſe; this may be called *planetary attraction*, to diſtinguiſh it from the other two. The ſecond ſtate or modification of attraction is that which cauſes bodies projected into the atmoſphere of our globe to tend towards the centre: this is *terreſtrial gravitation.* The third modification of this general force is that by which the ſeveral parts of any body tend to their common centre; ſuch as a ſtone or any other conſiſtent body: this force produces aggregation, and in its various degrees is the cauſe of ſpecific gravity: It is this laſt ſpecies that heat diminiſhes and tends to annihilate; and by acting in oppoſition to this force, it produces an infinite variety of effects in combination, decompoſition, vegetation, animalization, &c.

Boerhaave, who has examined the effects of fire rather as a philoſopher than a chemiſt, has eſtabliſhed three general laws concerning rarefaction, which we ſhall examine.

FIRST LAW.

All bodies are dilated by heat.

THOUGH it be a general truth, that heat dilates and rarefies almoſt all natural bodies, yet we may make a few remarks on this phænomenon. Firſt, all mineral ſubſtances without exception are dilated and rarefied in the direct proportion of the ſtrength of the heat to which they are expoſed. This rarefaction may even be carried ſo far as to deſtroy the aggregation of many among them; but vegetable and animal ſubſtances afford ſome exceptions to this law. A gentle heat indeed dilates their fibres, divides them, and thus diminiſhes their conſiſtency; but a ſudden ſtrong heat cauſes parchment, membranes, and tendons, to ſhrink and contract their bulk, which ſeems to be occaſioned by the irritability, or more properly the contractive force, of animal fibres, on which heat appears to act as a ſtimulus, till their organization be deſtroyed.

SECOND LAW.

All the dimenſions of bodies rarefied by heat, are dilated.

A BAR of iron ignited becomes both longer and thicker. Philoſophers have contrived ſeveral inſtruments for eſtimating, and even for meaſuring preciſely this effect of rarefaction. The pyrometer invented by Muſchenbroek, ſhows, by the dilatation of ignited bars of of metal, ſo accurately as to diſtinguiſh the 1080th part of an inch. The communication of the expanſive motion through various levers, whoſe arms are of unequal lengths, occaſions this nice ſenſibility. The laſt of theſe moves through ſo large a ſpace, that it eaſily indicates, by means of a hand or index carried round by a wheel, the extremity of which points to a ſeries of numbers arranged round a circular plate of metal, the ſmalleſt degrees of dilatation that the bar ſuffers. As the pyrometer meaſures only the lengthening of bars of metal, philoſophers have made an experiment with a cylinder, which paſſes through a ring when both are cold; but when the cylinder is heated the ring cannot contain it; and it thence appears, that the diameter of bodies is dilated as well as their length.

On account of this fact, which is well known to chemiſts, it becomes neceſſary to leave room in the grates that are placed in furnaces, and not to crowd veſſels expoſed to heat too cloſely together; otherwiſe you are in danger of having them broken, and ſuffering various other inconveniences in your proceſſes.

THIRD LAW.

The dilatation of bodies is in the direct ratio of their rarity, or the inverſe ratio of their denſity.

Boerhaave laid down this law after comparing the effects of heat on no more but three ſolid bodies very different from one another, wood, ſtones, and metals. He had obſerved, that in proportion to their denſities wood was the moſt dilated by the ſame degree of heat, ſtones next, and after that metals. From this he ventured

tured to conclude, that the more rare the conſiſtency of any body, the more eaſily is it dilated; and that the greater the denſity of a body, the leſs is it liable to rarefaction. But by examining the rarefaction produced by heat on a great number of bodies, M. Buffon has found that the dilatation of ſolid bodies by heat is in direct proportion to their alterability by fire; ſtones are dilated in proportion as they are ſuſceptible of calcination, and metals in the ratio of their fuſibility. Boerhaave had likewiſe extended this law to fluids, without examining the dilatation of any fluid bodies but air, ſpirit of wine, and water. Had he compared the rarefaction of mercury with that of theſe bodies, he would ſcarce have ventured to lay down this general law. For mercury, though its denſity be greatly ſuperior to that of water or ſpirit of wine, admits of much eaſier dilatation than either of them. And from this fact it appears that the quickneſs or ſlowneſs of the rarefaction of fluids by heat depends on neither their inflammability nor fuſibility. Meſſrs Lavoiſier and Bucquet, who have made a long train of experiments on the dilatation and rarefaction of bodies by heat, have found themſelves unable to determine the cauſe of that amazing diverſity which appears among thoſe phænomena, and have contented themſelves with deſcribing their experiments, without preſuming to deduce any induction from them.

Beſides theſe laws of the rarefaction produced by heat, which are ſtill but very imperfectly known, it is of importance to know, 1. That bodies always produce cold when they paſs from a ſolid to a fluid ſtate; as for inſtance, ſalts when diſſolved in water evaporating æther, &c. 2. That fluids capable of aſſuming a concrete form, generate heat as they become ſolid: thus water,

water, which freezes when put into a freezing mixture, never affords ſo high a degree of cold as ſpirit of wine put into the ſame mixture. It may be underſtood from what has been ſaid, that when a ſolid body becomes liquid, it abſorbs an additional quantity of heat; and when a liquid body becomes ſolid, part of the heat which it contained is diſengaged.

§ IV. *Of the Phlogiſton of Stahl.*

BECCHER, ſtruck with that property of certain bodies which enables them to produce fire, that is to ſay light and heat, in conſequence of continued motion, or by coming into contact with other bodies in a ſtate of ignition, imagined it to depend on a diſtinct principle, to which he gave the name of *inflammable earth*. Stahl, whoſe attention was ſtrongly engaged by this doctrine, underſtood this principle to be pure fire, or the matter of fire, fixed in combuſtible bodies. To this element, exiſting in ſuch a ſtate of combination, he gave the name of *phlogiſton*, or the *inflammable principle*, to diſtinguiſh it from fire in a free or active ſtate. Its properties, when combined, are totally different from thoſe which it diſplays when at liberty: it then gives neither heat nor light, tho', in the latter ſtate, theſe are its conſtant attendants: But, when freed from confinement, it inſtantly regains its characteriſtic properties, and its preſence is indicated by both heat and light. Such was the ſublime and ſimple idea of Stahl concerning the nature of combuſtible bodies. It is indeed natural to think, that thoſe ſubſtances which, when ſtrongly heated or forcibly ſtruck, become inflamed, and continue to burn till they be conſumed, owe this property to their latent fire; and that the combuſtion of ſuch bodies is nothing but the diſengagement of the fire, and its paſſing to a ſtate of liberty. According to Stahl, therefore, all combuſtible bodies contained fire in a fixed or combined ſtate, on which principle their inflammability depended. He alſo conſidered this principle as being perfectly the ſame in all the ſubſtances into which it entered, whatever their nature, or however different they might be from one another. The combuſtibility of any body appeared to him a ſufficient proof that it contained a quantity of phlogiſton. Thus, in his opinion, ſulphur, charcoal, metals, oils, and phoſphorus, owed all their properties to phlogiſton; and their differences in point of form, colour, conſiſtency, gravity, &c. might depend, he thought, on the variety of the principles to which the phlogiſton was united; for the phlogiſton itſelf was always the ſame, and could ſuffer no variation but by being diſmiſſed from a combined into a free ſtate.

In order to diſtinguiſh the properties of phlogiſton or fixed fire, Stahl inſtituted a compariſon between bodies into the compoſition of which it enters, and others that ſeem deſtitute of it. He obſerved the former to poſſeſs in general, colour, ſmell, fuſibility, volatility, and combuſtibility; while he found the latter to be commonly deſtitute of colour and ſmell, fixed in a greater or leſs degree, incapable of fuſion, and ſtill more incapable of combuſtion. He likewiſe obſerved, that ſuch bodies as evidently appeared to be phlogiſticated, loſt moſt of their properties when deprived of their phlogiſton, but regained them when it was reſtored.

He applied his doctrine chiefly to ſulphur and metallic ſubſtances: the phænomena which theſe afforded were the leading facts on which it was eſtabliſhed. Metals he conſidered as compounds of certain earths with phlogiſton. When calcined, their phlogiſton is diſengaged, and eſcapes into a ſtate of freedom; and they loſe, of conſequence, their fuſibility, ductility, and inflammability. You may cauſe them to recover theſe properties by heating them with oils, charcoal, or any other phlogiſticated ſubſtance, ſo as to reſtore to them what they before poſſeſſed of that principle. Sulphur is a combination of the ſulphuric acid and phlogiſton: its combuſtion conſiſts in the diſengagement of the latter principle; and when this is entirely diſengaged, nothing but the acid remains. By applying charcoal, oils, or metals to this acid, we can deprive them of a part of their phlogiſton; which being communicated to it, forms a new quantity of ſulphur, or a coloured, odorous, fuſible, volatile, and inflammable body.

However plauſible this theory may be eſteemed, yet, in conſidering it, one important difficulty occurs: Stahl and his followers have never told us preciſely what phlogiſton is, but have always expreſſed themſelves on that head in obſcure and indeterminate terms. Macquer, who was ſenſible of this difficulty, after having long conſidered the nature of fire and phlogiſton, concluded that light poſſeſſed all the properties aſcribed to it, either when in a ſtate of freedom and activity, or when united with other principles in compound bodies, and labouring to diſengage itſelf. When we exhibit a view of a theory that has obtained a place in ſcience, it is but fair to point out what difficulties attend it, and to examine whether it be founded

ded in error, or on the ſolid baſis of truth. We ſhall, therefore, mention the objections that are now made to the doctrine of that great chemiſt; a doctrine which has now loſt its luſtre, after having long made an illuſtrious figure in the ſcience.

The leading difficulties which occur in conſidering the theory of phlogiſton may be reduced to three heads: 1. The properties which Stahl attributes to that principle do not always appear in the bodies in which he ſuppoſes it to exiſt. Charcoal, and particularly that of reſinous bodies, which he conſiders as pure phlogiſton, is neither odorous, volatile, nor fuſible: there are even ſome ſpecies of charcoal which are ſcarce combuſtible. Diamond, an extremely fixed, tranſparent, inodorous, and infuſible ſubſtance, is perhaps the moſt combuſtible body known, as it burns entirely, without leaving any reſidue. Spirit of wine, æther, and ſeveral of the eſſential oils, are without colour.

2. Many bodies, upon loſing their phlogiſton, acquire new properties, which Stahl conſidered as depending upon that principle. Moſt metals, when calcined, aſſume a deeper colour; cobalt, mercury, lead, iron, copper, &c.

3. Stahl paid ſo much attention to combuſtible bodies, as he hoped, from the examination of their nature, to determine the character of phlogiſton, that he ſeems to have forgot that air is eſſentially neceſſary to combuſtion. In conſequence of this, he has overlooked this objection againſt his theory, which was not indeed urged againſt him by any cotemporary chemiſt. If combuſtion be nothing but the diſengagement of phlogiſton, it is plainly an act of decompoſition, in which the combuſtible body loſes one of its principles: But

But how is it poſſible for a body, after having loſt one of its component principles, to poſſeſs conſiderably more abſolute weight than before? An hundred lib. weight of lead affords an hundred and ten of minium; the weight of the ſulphuric acid obtained by the combuſtion of ſulphur, is greater than that of the ſulphur from which it was obtained: and, in the ſame manner, we learn from the fine diſcovery of M. Lavoiſier, that eighteen ounces of pure water are obtained by burning ſixteen ounces of ſpirit of wine *.

The ſtrength of this objection, together with the difficulty that is found in every attempt to demonſtrate the exiſtence of phlogiſton, have induced ſome modern chemiſts to deny that there is ſuch a ſubſtance in nature. But they muſt not be implicitly liſtened to; even that numerous train of experiments which have been of late made on combuſtible bodies and combuſtion, have not fully demonſtrated that there is no ſuch principle as fixed fire in material bodies: its exiſtence ſeems to be allowed, while its name is changed; and inſtead of the phlogiſtic, it is called the *calonic*, principle. It is diveſted, however, of the property of producing combuſtion; and though it be allowed to exiſt in inflammable bodies, it is not conſidered as the cauſe of their inflammability.

Since chemiſts began to enquire how far the preſence of air is neceſſary to combuſtion, they have made ſeveral important diſcoveries; the chief of which is, that a certain quantity of atmoſpheric air is always abſorbed by burning bodies, and that it is the acquiſition of this air, which becomes fixed or combined, that augments the abſolute gravity of metals, ſulphur, phoſphorus,

---

* Meeting of the Royal Academy of Sciences on the 4th of September 1784. A.

phorus, inflammable gas, and ſpirit of wine, when expoſed to combuſtion. As this increaſe of gravity has been likewiſe found to correſpond preciſely with the weight of the air abſorbed, ſeveral chemiſts, at the head of whom may be reckoned Meſſrs Lavoiſier and Bucquet, were led to adopt a new theory, founded ſolely on this abſorption of air, in which they entirely rejected phlogiſton. This theory was directly oppoſite to Stahl's, and conſiſted of the four following principles:

1. Stahl's phlogiſticated bodies are, according to this doctrine, ſubſtances which have a ſtrong tendency to combine with air; for on this tendency the combuſtibility of bodies entirely depends.

2. All the phænomena which Stahl aſcribed to the diſengagement of phlogiſton are produced by combinations with pure air: ſuch are combuſtion, calcination, reſpiration, and the formation of the ſulphuric and phoſphoric acids, by the combuſtion of ſulphur and phoſphorus.

3. On the other hand, according to the pneumatic theory, all thoſe phænomena in which the doctrine of Stahl repreſents the phlogiſtic principle as entering into new combinations, are produced by the diſengagement of air. Such are the reduction of metals, effected by the mutual action of metallic calces and charcoal, the decompoſition of acids by combuſtible bodies, and particularly the decompoſition of the ſulphuric and the nitrous acids by iron, charcoal, &c.

4. This theory views all thoſe bodies which Stahl thought to be compounds, with phlogiſton for one of their principles, as ſimple ſubſtances, having ſo ſtrong an affinity with pure air, that they attempt to enter into combination with it whenever they are expoſed to

its contact. Combuſtion is, therefore, nothing but the combination of air with the combuſtible body; and all operations in which bodies are thought to regain their phlogiſton, are merely the diſengagement of pure air, or its paſſing out of one body into another.

This opinion, which was adopted by M. Bucquet in his latter courſes of lectures, explains indeed moſt of the phænomena of combuſtion, calcination, and the reduction of metallic calces; but it gives no ſatisfactory reaſon why flame is ſeen to proceed from combuſtible bodies in a ſtate of ignition; nor does it account for the rapid motion produced in inflammation, and the other changes which attend that phenomenon. Macquer, after carefully examining how far the modern diſcoveries could affect the received theories, was of opinion that they were inſufficient to explode the theory of Stahl, and has therefore combined the pneumatic with the phlogiſtic doctrine, by repreſenting phlogiſton as light in a ſtate of fixation. After ſhowing that pure light, ſuch as that which the ſun diffuſes over our globe, may be conſidered as the genuine ſubſtance of fire, and, by being fixed in bodies, may actually conſtitute the phlogiſton of Stahl; he next gives it as his opinion, that in every act of combuſtion, pure air diſengages the light or phlogiſton of combuſtible bodies, and poſſeſſes itſelf of its place; and that the calcination of metals may therefore be regarded as the precipitation of air, and the diſengagement of light. Again, when phlogiſton is reſtored to the calces of metals by reduction, light, in its turn, diſengages or ſeparates the air which was fixed in thoſe ſubſtances, and by that means cauſes them to reſume the character of metals. Macquer alſo thought, and it was neceſſary to this theory, formed with a view to reconcile Stahl's with the modern doctrine, that phlogiſton may combine with bodies even in cloſe veſſels, ſince light is well known to penetrate through glaſs, and even through metal and earthen veſſels, when theſe are made red-hot. Scheele has propoſed a different theory, which has alſo been adopted by ſome northern chemiſts. He conſidered fire, heat, and light, as compounds of vital air with phlogiſton; and thought that light, in paſſing through veſſels, ſuffered decompoſition, the phlogiſton in the reduction of metallic calces or oxides being communicated to the calx, while the vital air was diſengaged. But that ingenious theory, by which Scheele accounted for the effects of ſolar light, and of the various modifications of heat on a great many chemical phenomena, affords no explanation of the increaſe of the weight of metals, ſulphur, and phoſphorus, &c. after combuſtion.

M. Lavoiſier, whoſe experiments have contributed ſo highly to the advancement of chemiſtry, and whoſe opinion muſt therefore have conſiderable weight, has propoſed a new theory that has been adopted by moſt French chemiſts, and appears to me to afford an happier explanation of the phenomena of Nature than any other. He thinks that light, heat, and all the other remarkable phenomena of combuſtion, depend rather on a certain action of the air than on the peculiar nature of combuſtible bodies; that the flame which then ariſes is occaſioned by the diſengagement of the light which was combined with the pure air, not of that which exiſted in the combuſtible body. He aſcribes to pure air that decompoſition which, according to Stahl and Macquer, takes place on the inflammable ſubſtance. Pure air he conſiders as a compound of the ſubſtance of of fire and another principle which ſhall be afterwards deſcribed; and fixed fire, the diſengagement of which is the principal act on ſuch occaſions, is, in his opinion, ſeparated from the pure air, not from the combuſtible body. We cannot enter more particularly into this ingenious ſyſtem in this place. In the hiſtory of air, in the following chapter, it will come more properly under our examination. At preſent, we will content ourſelves with obſerving, that fire or heat, which M. Lavoiſier allows as a principle of pure air, and the diſengagement of which he takes to be the cauſe of the ſparkling flame and vivid heat which accompany the rapid combuſtion produced by that air, act nearly the ſame part with Stahl's phlogiſton, or Macquer's fixed light; and that chemiſts ſeem to be univerſally agreed concerning the exiſtence of this principle, the only difference among them being, that one party believe it to exiſt in combuſtible bodies, and to be the cauſe of inflammability; while another conſider it as a principle of air, and aſcribe inflammation to a different cauſe. In the following chapters, we ſhall explain the reaſons which induce us to prefer the latter of theſe opinions.

§ V. *The Effects of Heat on Bodies conſidered Chemically.*

IN the third ſubdiviſion of this chapter, it was ſhown that one of the chief effects of heat is to rarefy bodies, to increaſe their bulk, and diminiſh their ſpecific gravity, by ſeparating their particles, and enlarging their pores. Such was the ſimple phyſical or mechanical idea which we gave when ſpeaking of rarefaction in general; but when we attend more carefully to this primary act of heat, we ſhall find that it produces ſeveral other important effects.

The firſt and moſt ſtriking effect of heat, is its diminiſhing the aggregation of bodies, by ſeparating their particles. As the force of aggregation, and that of the attraction of compoſition, are always in the inverſe ratio of one another, as has been ſhown in the third chapter, it will be readily underſtood that heat, in deſtroying aggregation, muſt be ſingularly favourable to combination. This has cauſed fire to be conſidered as the principal chemical agent, and has even induced chemiſts to aſſume the title of *philoſophers by fire.* It will afterwards appear, however, that they make much leſs uſe of it at preſent than they formerly did.

The action of heat, when conſidered in this point of view, as tending to deſtroy aggregation, and favouring combination, appears liable to four different modifications, according to the nature of the bodies on which it exerts its energy.

1. There are ſome bodies on which it produces no alteration, nor any effect but dilatation. Subſtances of this nature are unalterable and *apyrous.* Thus rock-cryſtal, however long expoſed to the utmoſt violence of fire, ſuffers no alteration: it loſes neither its hardneſs nor tranſparency, and appears, after this aſſay, with all its former denſity and beauty. But there are very few ſubſtances ſo little alterable as rock-cryſtal.

2*dly*, Heat entirely deſtroys the aggregation of moſt bodies, cauſing them to paſs from a ſolid to a fluid ſtate. This phænomenon is named *fuſion;* the bodies on which it is produced are called *fuſible.* There are various degrees of fuſibility, from that of platina, which is extremely difficult to melt, to that of mercury which remains

mains always in a fluid ſtate. When this fuſibility is carried to an exceſſive degree, it becomes volatilization. A body becomes volatile, or diffuſes itſelf through the atmoſphere, when it is cauſed to paſs, by a ſtrong rarefaction, from the liquid ſtate to that of an elaſtic fluid. It is then diſſipated by heat, and elevated in the atmoſphere, where it remains ſuſpended till cold reſtore to it part of its denſity and ſpecific gravity. Bodies which may be reduced to this ſtate are named *volatile;* thoſe incapable of it are, by way of oppoſition, called *fixed.* There are many degrees between fixity and volatility. It even ſeems impoſſible to ſuppoſe any body abſolutely fixed. Perhaps the only reaſon why any appear ſo, is, becauſe we cannot apply to them a degree of heat ſufficiently intenſe. We may make the ſame remark on infuſibility; it is never abſolute. The reaſon why rock cryſtal appears infuſible, is, becauſe we cannot apply to it the proper degree of heat. When we ſpeak, therefore, of the infuſibility or the fixity of certain ſubſtances, we are to be underſtood as ſpeaking only in reference to the heat to which it is in our power to ſubject them.

This eſſential volatility is to be carefully diſtinguiſhed from that which is merely apparent, and takes place only in conſequence of the communication of motion by a current of flame or vapours: Thus, for inſtance, zink, in a ſtate of calcination, is carried up by the flame that is raiſed during its combuſtion.

3*dly*, When heat acts on bodies conſiſting of two principles, one volatile, the other fixed, it generally ſeparates them by volatilizing the former. Such bodies are thus decompoſed, but without ſuffering any alteration; for by reuniting their principles, we can reproduce them with all their original properties. This ſeparation of principles is a true or ſimple analyſis. Fire, applied to bodies conſiſting of two ſubſtances, between which there is a wide difference in reſpect of volatility, reduces the volatile principle to vapours, but leaves the fixed uninjured. But in order that this true analyſis may take place, it is requiſite that both the volatile and the fixed principle of the compound be unalterable by the degree of heat applied to them; or that they be expoſed only to ſuch a degree of heat as they can bear without loſing any of their properties. The volatilized ſubſtance having then undergone no greater alteration than the fixed, they may be reunited ſo as to form the ſame compound which they conſtituted before their ſeparation. When this may be effected, the analyſis is true or ſimple. As bodies do not generally conſiſt of two principles, one of which is volatile the other fixed, and as it is often extremely difficult, and ſometimes even impoſſible, to apply to compounds of this kind preciſely that degree of heat which will volatilize the one without alteration, and leave the other uninjured; it may be naturally inferred, that the number of the bodies on which heat acts in this manner muſt be very inconſiderable. For this reaſon, chemiſts have now much leſs frequently recourſe to the operation of fire than formerly. The ſubſtances on which heat produces this effect are *decompoſable without alteration.* Some mineral ſubſtances, ſuch as cryſtallized ſalts and ſolutions of neutral ſalts, come under this claſs.

4thly, When the body expoſed to the action of fire conſiſts of ſeveral volatile and ſeveral fixed principles, the volatilized principles enter into mutual union; the fixed are alſo combined with one another: and ſuch is the reſult of this decompoſition, that though the pro-

ducts

ducts be reunited with the reſidues, the original compound will not be produced. This is therefore a falſe or complicated analyſis. The bodies on which heat acts in this manner are *decompoſable with alteration.*

Moſt natural ſubſtances belong to this claſs. They are too complex in their compoſition, and conſiſt of too many principles, to be decompoſed without ſuffering alteration. As the force of the affinity of compoſition acts upon all bodies, and is even promoted by heat, when any of the principles of a compound are volatilized by the action of fire, they react upon one another, unite, and form a new order of combination different from that in which they before ſubſiſted: the ſame thing takes place on the fixed principles of the body. Thus, when a piece of wood, bark, or any other vegetable ſubſtance, is expoſed to the action of fire, the water, the ſalts, and the oil, unite together, and conſtitute an acid, elaſtic fluids, and a brown oil, &c. which did not exiſt in the wood in that form. The action of heat, therefore, produces a total alteration on ſuch ſubſtances: the phænomena which attend it indicate a falſe or complicated analyſis, the reſults of which might lead chemiſts into miſtakes were they not aware of the uncertainty with which it is attended. It is certain that art can never reproduce wood or bark, by mixing together the phlegm, oil, acid, and charcoal obtained in this analyſis, and that the principles which it affords have ſuffered great alterations. Unluckily the bodies ſuſceptible of theſe alterations are the more numerous claſs. Under it all animal and vegetable, and moſt mineral, ſubſtances are to be ranked. But the modern diſcoveries will enable us to determine the true nature of the principles of ſuch ſubſtances, by examining ſuch of them as are diſengaged.

Hitherto we have ſpoken only of the effects of ſuch a ſtrong heat as is uſually employed in the operations of art: But a gentle and continued heat, ſuch as that which is exerted in the operations of nature, gives riſe to a number of important phænomena, which are highly worthy of the chemiſt's attention. The vibration and oſcillation of the particles of ſolid bodies which its impulſe occaſions, and the agitation and rarefaction of fluids ariſing from the ſame cauſe, produce a continued internal motion which gradually changes the form, the dimenſions, and the contexture, of the former; and produces a ſenſible alteration on the conſiſtency, the colour, the taſte, and, in a word, on the intimate nature, of the latter. Such is the general idea which we have reaſon to form concerning the exiſtence and power of all the chemical phænomena of natural bodies; concerning the ſpontaneous decompoſition and recompoſition of minerals; concerning the cryſtallization, the ſolution, the formation of ſalts, the vitrification, the metallization, the vitriolization, and the mineralization, which are carried on in the bowels of the earth. To this powerful agent we muſt likewiſe have recourſe, when we attempt to form an idea of the alterations to which animal and vegetable ſubſtances are liable; of the motion of the ſap in plants, and the mild fermentation which conducts them to maturity; of the formation of oils, the ſpiritus rector, mucilages, and the colouring principle; or of the compoſition, the decompoſition, the reciprocal changes, and the putrefaction of animal humours. All theſe important phænomena depend, more or leſs, on chemical operations; and that heat which is diffuſed over the globe is the great principle by which they are produced. It is at preſent enough for us to have taken a general view of this great

great cauſe of motion, life, and death. We have here ſketched the outlines of the picture; in what follows we ſhall endeavour to fill them up with a nice and faithful hand.

As the various effects of heat depend all on its power of ſeparating the particles of bodies, let us farther conſider this firſt effect, and attempt to eſtimate its influence.

Water in the ſtate of ice is ſoftened by a certain degree of heat, melted, and reduced to fluidity by a greater, and by a ſtill greater degree reduced to vapour, or an elaſtic fluid: ſo that water in a ſtate of vapour may be ſaid to contain three ſums of heat;—that which conſtitutes ice of a certain denſity; that which reduces ice to the ſtate of a liquid, rarefied to a certain degree; and, laſtly, that which rarefies the liquid to an elaſtic fluid.

When we attempt to apply this theory to all natural bodies, they appear to be all capable of paſſing through theſe ſeveral ſtates if expoſed to a ſufficient heat. The only difference among them, in point of this property, is, that ſome may be reduced by a leſs degree of heat while others require a greater. It is only for want of a ſufficient heat that we cannot reduce rock-cryſtal to a liquid or a vaporous ſtate: nor is it more difficult to conceive the poſſibility of this event, than to conceive an habitually elaſtic fluid, ſuch as air, acquiring an extreme ſolidity, as happens to this very ſubſtance in various combinations.

From theſe principles, it is eaſy to explain the formation of the elaſtic fluids which are diſengaged in many of the operations of nature and art. It uniformly happens, whenever a body receives and abſorbs a ſufficient quantity of heat to cauſe it to paſs into that ſtate of fluidity which conſtitutes an aeriform fluid; and therefore all fluids that poſſeſs this property owe it to heat. But it is alſo requiſite, that the preſſure of ſurrounding bodies, eſpecially the preſſure of air, do not oppoſe this extreme dilatation; or that the dilatation be ſo great as to overcome the reſiſtance which it meets with in the gravity of the air. Hence a body, whether nearer to or more diſtant from the ſtate of elaſtic fluidity, may be eaſily reduced to that ſtate by relieving it of the preſſure of the atmoſphere, as elaſtic fluidity always takes place *in vacuo.* Hence evaporation is moſt quick and copious on the tops of lofty mountains. And hence too it becomes neceſſary to mention preciſely, in a detail of experiments, with what degree of preſſure any body was reduced to an elaſtic fluid, or at leaſt what preſſure it can bear in that ſtate: for it is alſo to be obſerved, that all the bodies which can, with more or leſs eaſe, be reduced to the ſtate of vaporous or elaſtic fluidity, do not maintain themſelves in that ſtate with equal conſtancy; nay, ſuch are the differences among them in this reſpect, that they have been divided into *permanent and non-permanent.* The former remain long in the ſtate of elaſtic fluidity; nor do they paſs from it, till by ſome new combination they are deprived of the ſubſtantial heat by which they were maintained in that ſtate. The latter, which may be denominated vapours, loſe their elaſtic fluidity by degrees of preſſure or cold which may be eaſily eſtimated, and readily communicate to ſurrounding bodies that portion of heat which conſtitutes them aeriform fluids. Of this kind are water, alcohol or ſpirit of wine, and æther; theſe three fluids are reduced into vapours, and remain in that ſtate when the barometer ſtands at 28 inches,—water at 185° Fahrenheit,

renheit, ſpirit of wine at 167°, and æther at 92°, &c. It appears then, *1ſt*, That the ſtate of elaſtic fluidity is a mode of the exiſtence of bodies occaſioned by the combination of heat with their other principles: *2dly*, That every elaſtic fluid is a compound, conſiſting of a baſe of more or leſs ſolidity and the matter of heat: *3dly*, That the baſe of every elaſtic fluid requires a certain degree of heat to reduce it to vapour or elaſtic fluidity; and that it is doubtleſs in conſequence of their poſſeſſing theſe properties, that elaſtic fluids differ in gravity, elaſticity, &c.

M. Lavoiſier has explained this theory with great perſpicuity, in a memoir printed among the Memoirs of the Academy of Sciences for 1777.

Although we have diſtinguiſhed elaſtic fluids into permanent and non-permanent, yet it is to be obſerved, that this diſtinction exiſts not in nature. It is relative to the moderate heat and preſſure of the atmoſphere to which we are expoſed in the climates in which we live, and over many parts of the globe; and if the cold and preſſure were more conſiderable, even the fluids which we at preſent conſider as the moſt permanent, would ſoon ceaſe to be ſo; and, on the contrary, æther and ſpirit of wine would become permanent elaſtic fluids at a certain height in the atmoſphere, or in the warm temperature of the equatorial climates.

As the ſubſtance of heat, which contributes to the formation of elaſtic fluids, exiſts in them in a combined or *latent* ſtate, and becomes not perceptible to our ſenſes till thoſe bodies loſe their fluidity by entering into combination with other ſubſtances; we have therefore ſought for an expreſſion proper to denote heat in this ſtate, and have adopted the word *caloric* for that purpoſe; becauſe in this ſtate heat may be actually conſidered as having loſt its original character, which it recovers not till it be reſtored to a ſtate of liberty. Beſides, by affixing to it this denomination, we avoid the circumlocutions of the ſubſtance or matter of heat, or latent heat, which have been hitherto applied to it. Cooling, or the paſſing of heat into the ſtate of caloric, and ignition, or the paſſing of caloric into the ſtate of heat, depend both on the general law above laid down, that when bodies become more denſe, part of their heat is exhaled. Thus, whenever a gas or aeriform fluid is combined ſo as to become a liquid or a ſolid, it loſes a great part of its ſubſtantial heat; and to make it paſs into that ſtate of denſity, it muſt be expoſed to the action of ſome body, with which its baſe has a greater affinity than with heat. This is the general cauſe of the fixation of elaſtic fluids; and in this manner do they loſe that form by becoming fixed in liquid or ſolid bodies. We may likewiſe obſerve that each of theſe fluids loſes more or leſs heat in proportion as it becomes more or leſs ſolid in the new combination, or in proportion as that compound body is capable of containing leſs or more ſpecific heat. This obſervation explains why bodies burn with different degrees of rapidity; why they give during combuſtion more or leſs flame or heat; and why the reſidues which they leave are more or leſs ſolid, &c.; which phænomena ſhall be more particularly mentioned in the following chapter.

Laſtly, Since cold and preſſure are the two means by which elaſtic fluids are condenſed, we may perhaps be at length able, by employing intenſe degrees of both, to reduce all theſe from their gaſeous ſtate, and to obtain their baſes pure and ſeparate, by expelling the ſubſtantial heat which maintains them in fluidity. Thus we may come to know the baſes of vital air, azotic or

me-

mephitic gas, hydrogenous gas, &c. This has been already performed on the ſulphureous acid gas, which M. Monge has reduced to a liquid by means of an intenſe cold.

§ VI. *Of Heat as a Chemical Agent, and the ſeveral Ways in which it may be applied to Bodies.*

Chemists employ heat, on account of the changes which it produces on bodies, both for decompoſition and combination. Their firſt object ſhould be to meaſure exactly the degrees of heat neceſſary to produce all poſſible alterations on any body expoſed to it. Theſe degrees of heat are generally ranked under two claſſes; the firſt comprehending all degrees of heat below that of boiling water; the ſecond, all above that temperature. The ſcale of the thermometer marks out the former; our only means of determining the latter is the known fuſibility of bodies.

Degrees of Heat below the point of boiling Water.

The firſt degree extends from 44° to 53° Fahrenheit's ſcale *. This temperature promotes putrefaction, vegetation, and gentle evaporation, &c. It is but ſeldom employed in chemical operations, as being too inconſiderable; in ſome macerations made during winter, however, it is neceſſary. It is likewiſe uſeful for the cryſtallization of ſaline ſolutions, which after a proper evaporation are put into caves, or other places of this temperature.

The

---

* Reaumur's ſcale is uſed in the original.

The ſecond of theſe degrees, extending from about 61° to 70°, continues to promote putrefaction, excites a ſpirituous fermentation in ſaccharine liquors, and is favourable to evaporation and ſlow cryſtallization. This is the uſual temperature of mild climates. It is employed for maceration, the ſolution of ſaline ſubſtances, and fermentation, &c.

The third diviſion or degree extends from about 79° to 88°. It excites the acid or acetous fermentation in vegetables; and is ſufficient for the exſiccation of plants. It is uſed to effect ſome ſolutions of ſalts, and to produce fermentation.

The fourth degree, which riſes to 114°, is called the mean degree of hot water: this is the heat uſed in the veſſels called *balnea mariæ*. It deſtroys the organization of animal ſubſtances, and volatilizes the ſubtler part of animal oils, more eſpecially of the ſpiritus rector. It is employed in the diſtillation of thoſe vegetable and animal ſubſtances, of which we wiſh to obtain the phlegm and the odoriferous part.

The temperature of boiling water 185°, is uſed in decoctions, and the extraction of eſſential oils.

Degrees of heat above the boiling point.

The firſt degree or diviſion makes glaſs red, burns organized ſubſtances, and melts ſulphur.

The ſecond melts the ſofter metals, tin, lead, biſmuth, and ſuch glaſſes as are moſt eaſily reduced to a ſtate of fuſion.

The third effects the fuſion of moderately hard metals, ſuch as zink, regulus of antimony, ſilver, and gold.

The fourth burns porcelain, and melts the more refractory metals, cobalt, iron, and copper, &c.

The

The laſt and moſt intenſe degree exiſts in the focus of a burning-glaſs. This temperature calcines, burns, and vitrifies in an inſtant, all bodies ſuſceptible of combuſtion, calcination, or vitrification. A ſimilar heat may be excited by pouring from a blow-pipe a ſtream of vital air or oxigenous gas upon a piece of coal. M. Monge is of opinion, that by preſenting to combuſtible bodies, when in a ſtate of inflammation in a furnace, a quantity of compreſſed atmoſpheric air, the ſame effect might be accompliſhed which is produced by vital air. This proceſs may be one day or other applied to very important purpoſes.

Though theſe degrees above the heat of boiling water be determined by phænomena which are well known to chemiſts, yet they have not hitherto been meaſured with all the preciſion that could be wiſhed. It is therefore an object of the utmoſt importance to obtain an inſtrument capable of pointing out the exact degrees of heat employed in theſe operations. Mr Wedgewood in England has conſtructed a thermometer for this purpoſe: it conſiſts of ſmall pieces of clay half an inch in diameter. Theſe pieces, when contracted by the heat, fall between two graduated rulers of copper inclining towards each other upon a plate of the ſame metal; and thus ſhow what contraction they have ſuffered, and of conſequence to what degrees of heat they have been expoſed (*Jour. de Phyſ. Ann.* 1787. *)

The heat neceſſary in chemical operations is produced by burning charcoal, or common mineral coal. We uſe on thoſe occaſions furnaces of different forms and names, according to the different purpoſes for which they are intended; ſuch are the furnaces for digeſtion and

---

* There is an accurate deſcription of this ingenious contrivance, by the inventor himſelf, in the Engliſh Philoſophical Tranſactions for 1782.

and fuſion, the reverberating furnace, the wind furnace, and the cupelling furnace. A ſingle furnace, properly made, is often ſufficient for the purpoſes of all all theſe; and it is then called a *Polychreſt furnace.* The reader may conſult on this head the Chemical Dictionary of Macquer, who has contrived a moſt excellent and uſeful furnace; Baumé's Chemiſtry, Pott's Lithogeognoſia, and Abbé Rozier's *Journal de Phyſique,* in which there are deſcriptions of various furnaces conſtructed by different chemiſts. The flame of oil, or ſpirit of wine, is alſo employed ſometimes in lamp-furnaces adapted to the purpoſe.

The manner in which fire is applied to bodies in chemical proceſſes, likewiſe deſerves ſome explanation. If the combuſtible body be applied immediately to the ſubſtance on which you wiſh the fire to act, the operation is then ſaid to be managed with *naked fire.* But ſome intermediate body is often put between the fire and the ſubſtance expoſed to its action; hence the names *balneum mariæ,* ſand-bath, cinder-bath, dung-bath, &c.

The form of the veſſels made uſe of in ſubjecting bodies to the action of fire, and the various phænomena exhibited by bodies under the influence of heat, have cauſed a great variety of operations to be diſtinguiſhed by peculiar names. Such are roaſting, calcination, fuſion, reduction, vitrification. cupellation, cementation, ſtratification, detonation, decrepitation, fulmination, ſublimation, evaporation, diſtillation, rectification, concentration, digeſtion, infuſion, decoction, lixiviation. All theſe operations are performed by the action of fire, and enter into the practice of chemiſtry; and we ſhall therefore give a ſhort explanation of each of them.

Roaſting is a preliminary operation, which prepares mi-

mineral ſubſtances for undergoing a ſeries of ſucceeding ones, dividing their conſtituent particles, volatilizing ſome of their principles, and producing a certain alteration on their nature. Mineral ores are expoſed to this proceſs on purpoſe to ſeparate the ſulphur and arſenic which they contain, and to diminiſh the coheſion of their particles. Capſules of earth or iron, crucibles, and roaſting pots, are the veſſels in which it is uſually performed; and it is generally expoſed to the acceſs of the external air. Sometimes, however, the operation is performed in cloſe veſſels; and two crucibles, luted mouth to mouth, are commonly employed on ſuch occaſions.

Calcination is, as it were, a more advanced ſtage of the proceſs of roaſting. By this proceſs minerals are deprived of their water and ſalts; it likewiſe reduces calcareous ſubſtances to the ſtate of quick-lime, and metals to metallic oxides. The ſame veſſels are uſed in this proceſs as in the former.

In fuſion, a body is cauſed to paſs by fire from a ſolid to a fluid ſtate. The chief ſubjects ſuſceptible of this operation are ſalts, ſulphur, and metals. Crucibles of baked clay of various kinds and figures, with metallic cones and ingot moulds, are the inſtruments for this operation. Theſe laſt are employed to give the melted matter a certain form; which they mould into bars, ingots, or buttons.

In reduction or revivification, the calces of metals are, by means of fire, with charcoal or oils, reſtored to the metallic ſtate which they loſt by calcination.

Vitrification is the fuſion of ſuch ſubſtances as are capable of aſſuming the brightneſs, tranſparency, and hardneſs of glaſs. Vitrifiable earths with alkalis, and the

the oxides of metals, are the chief of the ſubſtances ſubjected to it.

Cupellation is the purifying of perfect metals, by the extraction of ſuch imperfect metals as are intermixed with them. This is performed by the addition of a certain quantity of lead to the mixture, and the expoſing of it to a due heat; which vitrifies the lead, and together with it the imperfect metals of the original mixture, leaving the perfect in a pure and ſeparate ſtate. This operation derives its name from the veſſels uſed in it. Theſe are a kind of flat crucibles, pretty like the ſmall cups known under the name of *cupels;* and the ſubſtance of which they are compoſed, being the earth of bones, is ſufficiently porous to abſorb and retain the lead that is ſcorified by the heat.

The name of *cement* is given to powdered ſubſtances, with which other ſubſtances expoſed to their action are carefully covered over. Thus, iron is covered over with powder of charcoal, that it may be converted into ſteel; and glaſs with plaſter or ſilex, to change it into a kind of porcelain. The proceſs by which this is effected is cementation, and requires the action ſometimes of a very ſtrong fire.

Stratification is an operation nearly ſimilar to the preceding. It conſiſts in arranging ſeveral ſolid ſubſtances, uſually in horizontal layers, and intermixed with certain pulverized bodies, to alter their nature, either in a crucible or in ſome other ſuitable veſſel capable of bearing the action of fire. This has received the name of *ſtratification*, becauſe the ſubſtances are diſpoſed in ſtrata or layers, one riſing above another. Copper and ſilver are treated in this manner with ſulphur, in order to effect their combination. This peculiar arrangement of ſubſtances named *ſtratification*, is often

often employed preparatory to fuſion, calcination, vitrification, &c.

Detonation is peculiar to nitre, and the mixtures into which it enters. It is the exploſion of ſuch bodies when heated in open or cloſe veſſels. Decrepitation differs from detonation only as producing a fainter noiſe, which is merely a kind of crackling ſound: it is peculiar to certain ſalts; which from a ſtate of ſolution are cryſtallized ſo rapidly, that the cryſtals formed burſt into minute pieces. This has been obſerved chiefly of common ſalt, or muriate of ſoda. Fulmination is a more quick and lively detonation; ſuch as takes place on fulminating gold, fulminating powder, and in the combuſtion of inflammable gas and vital air, &c.

Sublimation is the volatilizing of dry, ſolid, and often cryſtallized ſubſtances by means of fire. The veſſels uſed in ſublimation are glazed earthen pots, earthen crucibles with glaſs heads, and pots of earth or porcelain, arranged one above another, and joined by the inſertion of their necks one into another, which are known by the name of *aludels*, &c. Sulphur, arſenic, cinnabar, many mercurial preparations, ſome vegetable ſubſtances, more eſpecially camphire and flowers of benzoin, are the ſubjects of ſublimation.

Evaporation is the action of heat on liquids, to diminiſh their fluidity and quantity, and to obtain the fixed bodies diſſolved in them in a ſeparate ſtate. Thus, we evaporate the water of the ſea and of ſalt ſprings, in order to obtain the ſalt which they contain. This operation is performed in capſules, jars, earthen or glaſs evaporatories, and ſilver pans, according to the nature of the liquid to be evaporated. The evaporating ſubſtance is expoſed to the contact of the air, in order that the

the water, the body to be carried off by volatilization, may diffuſe itſelf through the atmoſphere, and that the air by its ſolvent power may promote the evaporation.

Diſtillation is an operation nearly ſimilar, but performed in cloſe veſſels. It is uſed to ſeparate volatile from fixed principles by means of fire. The diſtillatory veſſels are alembics and retorts. The firſt conſiſt of a lower veſſel named a *cucurbite*, intended to contain the body to be diſtilled, and an upper part or capital exactly fitted to it; the purpoſe of which is to receive the volatilized ſubſtance, and condenſe it by the coldneſs of its temperature (which is maintained by the contact of the external air, or of water ſurrounding it); when water is uſed, the veſſel containing it, into which the upper part of the alembic is immerſed, is called a *cooler*, or *refrigeratory*. From the lower part of the capital there proceeds a kind of beak or ſpout, through which the vapours paſs into a pipe, where they are condenſed into a liquid: from this pipe the liquid thus obtained is conveyed into other veſſels, which are commonly of a ſpheric form, and are named *receivers*. Theſe receivers are of various forms and names, matraſſes, balloons, &c. A retort is a kind of glaſs, ſtone, or metal bottle, of a conical form, with its extremity bent, ſo as to make an acute angle with its body; and on this account has it received the name *retort*. Diſtillation has been rather improperly diſtinguiſhed into three kinds, namely, diſtillation aſcending, *per aſcenſum*; diſtillation deſcending, *per deſcenſum*; and lateral diſtillation, *per latus*. This diſtillation is warranted only by the exterior form of the veſſels made uſe of. The volatilized matter has always a tendency to aſcenſion: But diſtillation performed in glaſs or metal alembics

bics has received the peculiar denomination of *aſcending*, becauſe the capital is placed over the cucurbite, and the vapours are ſeen to aſcend. The diſtillation performed in retorts is called *lateral*, becauſe the beak or neck of that veſſel comes out at the ſide of the apparatus; but the cavity of the retort in which the vapours are condenſed is higher than its neck, and the diſtilled ſubſtance paſſes through that cavity before reaching the neck. As to diſtillation *deſcending*, it was an operation which ſcarce ſerved any purpoſe, and is now no longer uſed; its products were always in a very bad ſtate, and great part of them was loſt in the proceſs. It was performed by ſpreading a piece of cloth over the mouth of a glaſs, placing upon it ſome vegetable ſubſtance, and covering this with the ſcale of a balance, or with a capſule of metal containing ſome live coals. This mode of diſtillation was formerly uſed in pharmacy and perfumery, for obtaining the eſſential oils of ſome odoriferous ſubſtances. The product paſſing through the cloth dropped into the glaſs, which was always half full of water, to cool the oil; but moſt part of the eſſence was always loſt on the cloth and the metal plate above. A more uſeful diſtinction is that which regards the manner in which the ſubſtances to be diſtilled are warmed. This is performed either with the *balneum mariæ*, by dipping the cucurbite in boiling water, or with the vapour, the ſand, or the cinder-bath, or with naked fire. It is alſo effected by means of the flame of a lamp, and by that of ſpirit of wine.

Rectification is a ſecond proceſs of diſtillation, the object of which is to purify a liquid ſubſtance. In it, heat is employed to carry off the pureſt and moſt volatile part, leaving the more fixed matter, which debaſed it, in a ſeparate ſtate; as is done, for inſtance, with ſpirit of wine, æther, &c.

Concentration is the direct contrary of rectification; its object being to volatilize part of the water, and thus improve the ſtrength of the fluids concentrated. The matter to be concentrated muſt therefore be of ſuperior gravity to water. This operation is performed on ſome acids, particularly on the ſulphuric and the phoſphoric; it is alſo employed on ſolutions of alkalis and neutral ſalts.

Digeſtion is the expoſing of ſubſtances which we wiſh to act gently on one another to a gentle and long continued heat. It is chiefly uſed to extract thoſe parts of vegetable ſubſtances which are ſoluble in ſpirit of wine or other fluids. Chemiſts formerly put great confidence in this operation. Though that confidence ſeems to have been juſtly due, as it appears from many painful reſearches, that too active or too rapid a fire alters the nature of moſt vegetable and animal ſubſtances; yet modern chemiſts do not depend on this proceſs with the ſame enthuſiaſm as the alchemiſts of old. The patient induſtry of theſe people was often employed for a ſeries of years on one proceſs of digeſtion; for by ſuch proceſſes they expected to perform wonders. Digeſtion is now confined to dyeing ſtuffs, elixirs, and liquors for the table; it is always ſucceſsfully employed to extract the principles of vegetables and animal matters, without altering them. It is likewiſe uſeful in ſeveral operations on minerals.

Infuſion is a well-known proceſs: it conſiſts in pouring warm or boiling water on ſubſtances of which we wiſh to extract the moſt ſoluble parts, and of which the contexture is ſo ſlight as to be eaſily penetrable, ſuch as thin bark, wood in ſmall thin pieces, leaves, flowers, &c. It is of great uſe for ſeparating ſubſtances that

that are eaſily ſoluble, and is often employed in chemical operations.

Decoction, or the continued ebullition of water with ſuch ſubſtances as are liable to be affected by its impreſſion, is uſed to ſeparate thoſe parts of bodies which are not ſoluble by a more moderate degree of heat. It produces conſiderable alterations on vegetable and animal matters; often effecting an entire change of their properties. It coagulates the lymph, melts greaſe and roſin, and hardens the fibrous parts of a vegetable or animal. When the chemiſt is well acquainted with its effects, he may employ it with conſiderable advantage.

In the proceſs of lixiviation, we diſſolve, by means of warm water, the ſaline and ſoluble particles of cinders, the reſidues of diſtillation and combuſtion, coals, and ſuch natural earths as we wiſh to analiſe. This operation very naturally derives its name from the *lixivial* ſalts which are obtained by means of it. The word *leſſive* is at preſent uſed in France as ſynonymous with *lixiviation*, and is even more frequently uſed. This operation, then, is merely a ſolution effected by means of heat: it is likewiſe nearly ſimilar to infuſion; the only difference is, that the latter is applied to vegetable and animal matters; while lixiviation is only employed to obtain ſubſtances poſſeſſing ſome of the properties of minerals.

Theſe are all the operations in chemiſtry in which fire is called in to act a part. Formerly, indeed, no chemical operation was performed without the help of this agent; and the ſcience was on that account named *Pyrotechny*. But as methods of analiſing bodies have been ſince diſcovered which are much leſs liable to error and more certain in their reſults; the agency of fire is now much leſs uſed in chemiſtry than formerly. The action of ſolvents, or menſtrua, employed in a cold ſtate, or in the ordinary temperature of the atmoſphere, is often ſufficient to accompliſh the moſt ſurpriſing changes on natural bodies, and affords ground for the moſt accurate inductions. This method has been applied to the examination of ſalts, earths, and vegetable matters, &c. with the happieſt ſucceſs. Heat is no more than a ſecondary mean, a kind of auxiliary that affords ſome aſſiſtance on ſuch occaſions. As different degrees of heat are requiſite in different operations, it would be an happy circumſtance if ſome means were contrived, by which we might be enabled to apply always the ſame preciſe degrees of heat when the ſame effects were wanted. Chemiſts and philoſophers have long wiſhed for a furnace which might afford regular and uniform degrees of heat: Hitherto, however, the manipulations of artiſts have given the only means that can in any degree ſerve that purpoſe. But perhaps it is not impoſſible to obtain that preciſion which we deſire, and of which the utility is ſo obvious. Dr Black is ſaid to have invented a kind of furnace, by which he can command a regular and uniform heat by means of a damping-plate with holes, which may be opened or ſhut at pleaſure *. We have not received a ſufficiently accurate deſcription of it, to enable us to conſtruct any on the ſame model. But we hope that a diſcovery ſo beneficial to chemiſtry will not be long unknown in France.

C H A P.

---

* For a good drawing, and an accurate deſcription of the furnace here alluded to, ſee the Edinburgh New Diſpenſatory, p. 82. ſecond edition.

CHAP. VI.

Of Atmoſpheric Air.

COMMON air is an inviſible, inodorous, inſipid fluid, poſſeſſed of gravity and elaſticity, extremely ſuſceptible of motion, and capable alſo of rarefaction and condenſation, which encompaſſes our globe to a certain height, and compoſes the atmoſphere. It likewiſe inſinuates itſelf into, and occupies, the interſtices or pores between the integrant parts of bodies. The atmoſphere which encircles our globe is far from being pure air. As it receives all the vapours that ariſe from the ſurface of the earth, it may be conſidered as a kind of chaos, or heterogeneous mixture. We ſhall by and bye ſee, however, that its nature is at preſent pretty well known. Water, mineral exhalations, and elaſtic fluids diſengaged from minerals and metals, are inceſſantly carried up into the atmoſphere, and may be ſaid to conſtitute its elements. The objects of attention in a natural hiſtory of the atmoſphere are, its height, the preciſe degree of which is not yet accurately determined; the variations to which it is liable; its gravity; its different ſtrata; the effects of its rarefaction and dilatation; winds, and meteors. But theſe come under that part of phyſics which is known by the name of *meteorology*, and form no part of the province in which we are engaged. Yet as air has a powerful influence on chemical phænomena, and it is of conſiderable importance to know the nature and extent of that influence, we ſhall here examine both the phyſical and the chemical properties of air.

§ I. *Of the Phyſical Properties of Common Air.*

FLUIDITY, inviſibility, inſipidity, gravity, elaſticity, and negation of ſmell, may be conſidered as the phyſical properties of air. Each of them merits a particular examination.

Such is the rarity of this fluid, that it readily yields to the ſlighteſt impulſe, changing its ſituation on the leaſt motion of bodies immerſed in it. This kind of fluidity depends on the degree of its aggregative force; and as it is not confined to atmoſpheric air, but is found to characteriſe ſeveral other fluids, theſe are called *aeriform fluids*, or *gaſes*. What conſtitutes the peculiar nature of aerial aggregation, is incapacity to paſs into a fluid ſtate; contrary to what moſt liquid bodies are ſuſceptible of. By this, however, no more is to be underſtood, than that hitherto we have not been able to apply to it any degree of preſſure or cold ſufficient to accompliſh this effect. This is the diſtinguiſhing characteriſtic of permanent gaſes. The fluidity of the air expoſes it to thoſe frequent and rapid motions which conſtitute the winds. It is not, however, capable of pene-

trating

trating into all bodies. Tranſparent matters, through which light readily makes its way, are ſecure againſt the impulſe of air. Water, ſolutions of ſalts, oils, and ſpirit of wine, paſs through many bodies whoſe contexture is ſuch as not to admit air. Theſe liquid ſubſtances are endowed with the property of dilating ſuch bodies, enlarging their pores, and diminiſhing the cloſeneſs of their contexture; of which air is deſtitute.

Air, when confined in veſſels, is abſolutely inviſible, not to be diſtinguiſhed from the glaſs that contains it: even when entirely filled with this ſubſtance, phials preſent to the eye a ſeeming vacuum. It owes this property of inviſibility to its tenuity and the ready paſſage which it affords to the rays of light: theſe are refracted, without being reflected by it. And it is therefore deſtitute of colour; though ſome natural philoſophers have perſuaded themſelves that they diſcovered large columns of it to be blue.

Naturaliſts have uniformly conſidered air as an inſipid body. Yet, in attending to what happens, when the nerves of animals are expoſed to the contact of this fluid, as in the inſtance of wounds, and on other ſimilar occaſions, we cannot but obſerve that it has a kind of pungency; of which we are not generally ſenſible, only becauſe we are ſo conſtantly accuſtomed to it. Wounds, when uncovered and expoſed to the air, are affected with an acute pain. A new-born infant expreſſes by its cries the diſagreeable ſenſations which it feels from the firſt contact of the external air. This pungency of the air is to be conſidered as the reaſon why wounds that are expoſed to it, uncovered, remain ſo long open. Atmoſpheric air, in the ſame manner, impedes the growth of new bark on ſuch vegetables as have been ſtripped of their covering. In order that trees may regain their bark, they muſt be covered over with ſome body which may exclude the air.

Air is perfectly inodorous. If the atmoſphere ſometimes affects our organs with a kind of fetid ſmell, that is to be attributed to the extraneous bodies that are mixed with it; as may be obſerved in miſts and vapours.

The gravity of air is one of the fineſt diſcoveries of natural philoſophy: the fact was never certainly known till about the middle of the laſt century; tho' Ariſtotle indeed is ſaid to have known that a bladder was heavier when filled with air than when empty. The ancients had no diſtinct idea of the gravity of air, but aſcribed to a certain occult quality, which they called *abhorrence of a vacuum*, all thoſe phænomena which depend on the weight of this body. Certain workmen finding it impoſſible to raiſe water by a pump above the height of two and thirty feet, were induced to conſult the famous Galilæo on the occaſion. He was amazed at the phænomenon. Death prevented him from diſcovering the reaſon of it; but this was afterwards diſcovered by his diſciple Torricelli in the following manner. He reflected, that water could not riſe in a ſucking pump, without being impelled by ſome exterior cauſe, the preſſure of which forced it to follow the motion of the piſton. The influence of that cauſe muſt be limited, ſince it never raiſed the water above the height of two and thirty feet. Therefore, if it were to act upon a body of greater ſpecific gravity than water, it would raiſe that body only to a height proportioned to its gravity. He next took a glaſs tube ſix and thirty inches in length, and hermetically ſealed at one end: this he filled with mercury, holding the cloſe end down, and ſtopping the upper end with his

finger,

finger, after he had poured in the mercury: then, turning the cloſe end up, he immerſed the other into a veſſel full of mercury; and upon removing his finger, found that part of the mercury in the tube had fallen down into the veſſel, but that a conſiderable quantity ſtill remained; which after various oſcillatory motions, at length ſettled at 28 inches. By comparing this with the height of 32 feet, to which water roſe in the pumps, he perceived that the difference of the elevations to which theſe two fluids roſe was in exact proportion to the difference between their ſpecific gravities; for the proportion of the ſpecific weight of mercury to that of water is as 14 to 1, and the water roſe 14 times as high as the mercury. It was not, however, till after long reflection, that he began to conjecture the weight of the air to be the cauſe why fluids were thus ſuſpended in a pump. Nor was the exiſtence of this weight certainly determined, till after the ingenious experiment which Paſchal directed to be made in France.

That celebrated philoſopher imagined, that if it were actually the weight of the air which cauſed water to riſe to the height of 32 feet in a pump, and mercury to the height of 28 inches in Torricelli's tube, theſe fluids would riſe to different elevations on the ſummit of a mountain and in a vale; as in the former caſe the weight of the atmoſphere muſt be diminiſhed. In conſequence of this ſuggeſtion of Paſchal's, Perrier made the famous experiment which finally determined the opinions of philoſophers concerning this phænomenon, on the 19th September 1648, at the foot and on the ſummit of the mountain Puits de Dome, in Auvergne. The barometer, or Torricellian tube, being filled with mercury, and fixed to a ſcale of 34 inches, divided into inches and lines, the mercury roſe about

about four inches higher at the foot of the mountain than on its ſummit, which is 500 toiſes higher. From this it was determined that the mercury varied about an inch for every hundred fathoms: and the barometer has ſince that time been very ſucceſsfully applied to the meaſurement of the height of mountains.

The weight of the air has an influence on many phyſical and chemical phenomena. It compreſſes all bodies, and reſiſts their dilatation; it oppoſes the evaporation and volatilization of fluids: and to it the waters of the ſea owe their liquidity; for they would otherwiſe be reduced to vapour, as may be obſerved of fluids placed in the vacuum produced by the air-pump. Air, by its gravitation on our bodies, retains both the ſolids and fluids in their proper places: and the blood often burſts through the ſkin, or from the lungs, on the tops of mountains, occaſioning hemorrhagies; becauſe the gravity and preſſure of the air are there conſiderably diminiſhed.

Laſtly, air poſſeſſes great elaſticity. However ſtrongly compreſſed, it inſtantly returns to its former rarity aſſoon as the compreſſing cauſe ceaſes to act upon it. The truth of this aſſertion is proved by a great many experiments. We ſhall here mention only the moſt obvious and moſt concluſive of thoſe phyſical facts by which it is evinced. Take a tube of glaſs, bent into a form ſomewhat like the letter U, and cloſe at one end; fill it nearly up with air, and then pour in a quantity of mercury to prevent the air from eſcaping: you may thus compreſs the air ſo as to know what degree of compreſſion this elaſtic fluid is ſuſceptible of, by comparing the diminution of its bulk with the height of the column of mercury employed to compreſs it. A foot-ball, which being filled with air rebounds from any hard body, affords another proof of the elaſticity of this ſubſtance. The fountain by compreſſed air, gives an inſtance of the ſame fact: Air being compreſſed into the ſuperior part of this veſſel, is ſoon dilated by the heat of the atmoſphere, ſo as to force the water out by a tube to a conſiderable height. Laſtly, the wind-gun, the effects of which are generally known, is another inſtrument for ſhowing the elaſticity of air, and the compreſſion of which it is ſuſceptible. It is computed, that air may be compreſſed into $\frac{1}{128}$th of its ordinary bulk.

Heat, which rarefies it by counteracting any compreſſive force to which it is expoſed, ſhows that it is no leſs capable of enlarging its bulk by dilatation. If a bladder full of air be expoſed to the heat of a furnace, the air will be dilated ſo as to burſt the bladder with a violent exploſion. This is likewiſe often the cauſe of the burſting of the veſſels in chemical operations; againſt which, however, proper precautions are now adopted. The diminution or total abſtraction of the weight of the atmoſphere, which is effected by the air-pump, affects a bladder filled with air in the ſame manner as a violent heat.

The reader will naturally conclude from this account of the gravity and elaſticity of air, that many of the variations which we obſerve in the atmoſphere and on the barometer are owing to theſe properties. In fact, the inferior ſupport the ſuperior ſtrata of the atmoſphere; and the compreſſion of a ſtratum of air is always leſs or greater in proportion as it occupies an higher or lower ſituation. Heat alſo, which is conſtantly varying, has the power of modifying this gravity and elaſticity. Theſe are the reaſons why air is found to be lighter, keener, and more agitated, &c. on on the tops of mountains, than on plains and other leſs elevated ſituations. To underſtand thoſe aſtoniſhing phænomena which the barometer offers to our attention, we muſt ſtudy the gravity and elaſticity of the atmoſphere, as well as the changes to which it is liable, from the influence of heat. M. de Luc and M. Sauſſure, have for ſome years paid much attention to this claſs of the phænomena of nature.

§ II. *Of the Chemical Properties of Common Air.*

THE properties above deſcribed are all that were anciently conſidered by philoſophers as belonging to air. Several chemiſts, at the head of whom Van Helmont, Boyle, and Hales, deſerve to be ranked, obſerving that air, or at leaſt a fluid with all the apparent properties of air, was obtained in the analyſis of many natural bodies, inferred, that this element ſubſiſted in thoſe bodies in a combined and fixed ſtate. Hence aroſe the name *fixed air*, which was at firſt given indifferently to all the elaſtic fluids obtained in chemical operations. The above mentioned philoſophers ſuppoſed theſe ſubſtances to be of the ſame nature with atmoſpheric air: But Dr Prieſtley has diſcovered a number of elaſtic fluids, which, though apparently the ſame with common air, yet differ from it in many reſpects. We muſt then have recourſe to other qualities, if we wiſh to diſtinguiſh atmoſpheric air from the other aeriform fluids, which like it are inviſible and elaſtic. Its chemical properties afford the only

only criterion on which we can eſtabliſh this diſtinction.

In examining the diſtinctive properties of air, we find two which are peculiar to it, and may very well ſerve to mark its character: one, its being favourable to combuſtion or inflammation; the other, its ſerving to maintain animal life in reſpiration. Let us carefully examine theſe two great phænomena.

It is exceedingly difficult to give a good definition of combuſtion. It is not one, but a number of phænomena which combuſtible bodies offer to our obſervation, when they are heated and expoſed to the action of the air. The chief of them are heat, motion, flame, redneſs, and the change of the nature of the ſubſtance that is burnt. There are many varieties among combuſtible bodies. Some of them burn briſkly, and afford a brilliant flame, ſuch as oils, wood, reſinous and bituminous ſubſtances, &c.: others burn away without producing a diſcernible flame; as for inſtance many of the metals, and charcoal which has been properly prepared: others again are conſumed by a ſlow motion, ſcarce obſervable, almoſt without ſeeming to be on fire, but always with a degree of heat;—ſuch is the combuſtion of ſome metallic matters. Combuſtion, however, takes place equally in all theſe inſtances; and the body which has been once burnt in any of theſe ways is no longer ſuſceptible of inflammation. The reſidue is always heavier than the combuſtible body. This may be eaſily proved to be the caſe with fixed combuſtible bodies. But again, thoſe of which the inflammable matter is of a volatile nature, burn with more rapidity than the former, and their fixed reſidue wants much of the original weight. From this it may perhaps be thought, that theſe laſt loſe much of their weight in burning: but it is only a ſeeming loſs they ſuffer; and there are no combuſtible bodies of which the reſidues are not weightier than before combuſtion. For what remains fixed on ſuch occaſions is not the only reſidue of the combuſtible body; a conſiderable part of volatile combuſtible bodies is converted into elaſtic fluids, which aſcend and are diffuſed through the atmoſphere: and were we to ſuppoſe that theſe leave no other reſidue but what appears after their combuſtion on the ſpot, or in the veſſel where they were burnt, we muſt believe what is impoſſible, that they afford no reſidue. Æther and ſpirit of wine burn away without leaving the ſmalleſt particle; but the ſubſtance into which they are converted is volatilized and diffuſed through the atmoſphere. When means are employed to collect it, it is found to poſſeſs more gravity than the combuſtible body from which it was produced. Thus, by burning ſixteen ounces of highly rectified ſpirit of wine under a chimney adapted to the worm-pipe of a ſtill, M. Lavoiſier obtained eighteen ounces of water as the product of that combuſtion. Oils, reſins, &c. preſent the ſame phænomenon. Thus, the cinders of burnt wood are not the whole of the reſidue which it affords; the reſt aſcends in the air: one part, not being thoroughly burnt, becomes ſoot; and the other mixing with the atmoſphere, is condenſed into water, or depoſites in it ſome other elaſtic fluids. It is therefore an eſtabliſhed truth in chemiſtry, that all combuſtible bodies acquire additional weight by being burnt.

To underſtand how this addition of weight is acquired, we muſt attend to another of the phænomena of combuſtion, which it will be neceſſary to explain more at large. Combuſtion can never take place without the help of air, and is always in proportion to the purity and the quantity of that fluid. Ever ſince the diſcoveries of Boyle and Hales, philoſophers have been ſtruck with this fact, and have propoſed a variety of hypotheſes to explain it. Boerhaave thought that air contributed to combuſtion by operating on the ſurfaces of combuſtible bodies, ſo as to diſſect them, if the expreſſion may be allowed, into their component particles. This hypotheſis did not explain why the ſame air could not always promote combuſtion. M. Morveau ſuppoſed this laſt fact to depend on the extraordinary rarefaction of the air by heat; in conſequence of which, it acquired ſuch elaſticity as to prevent the combuſtion of inflamed bodies by forcible compreſſion. But he offered this ingenious hypotheſis at a time when it was impoſſible to diſtinguiſh the true cauſe of the phænomenon. M. Lavoiſier, by a ſeries of fine experiments on the calcination of metals with determinate quantities of air, has proved, that, as John Ray the naturaliſt had before obſerved, ſo much air is abſorbed during calcination, that the calcined metal acquires preciſely that quantity of weight which the air loſes during this proceſs; and that the portion of air abſorbed actually remains in the metallic calx, as the calces of mercury may be reduced merely by expelling that fluid. Other facts led him ſtill farther. He obſerved, with Prieſtley, that the air which remains after the proceſs of calcination or combuſtion, can no longer ſerve to promote new proceſſes of the ſame kind; that it extinguiſhes flame, ſuffocates animals, and, in a word, has acquired a different nature. He likewiſe found that its diminution is exactly proportioned to the quantity abſorbed by the combuſtible body. On the other hand, air extracted from metallic calces has been

been found three or four times purer than atmoſpheric air. It not only promotes combuſtion, but even renders it much more rapid. A given quantity of the former will ſerve for the inflammation and total combuſtion of three or four times that quantity of matter which may be conſumed by the help of the ſame portion of the latter. To this ſingular fluid obtained from the calces of mercury, Dr Prieſtley, who firſt diſcovered it, gave the name of *dephlogiſticated air;* becauſe he conſidered it as atmoſpheric air deprived of the phlogiſton, which, according to him, is diffuſed through the whole atmoſphere. Its phlogiſton he believed to be retained by the mercurial calces, which are gradually reduced as this elaſtic fluid is diſengaged by heat. But as that name may lead to a falſe idea of its nature, we will give it the name of *vital air;* for it alone is the great agent in reſpiration, as well as combuſtion; and to uſe the expreſſion of M. Lavoiſier, it has four times as much of the genuine nature of air as common air has.

From thus obſerving that air is abſolutely neceſſary to combuſtion, and that part of the air neceſſary to the calcination of metals remains in the calces, M. Lavoiſier was at firſt led to think, that combuſtion conſiſted in the abſorption of pure air by the combuſtible body. Abſtracting the water and vapours contained in atmoſpheric air, he conſidered the ſubſtance that remained as a compound of two very different elaſtic fluids. One of theſe, which is the only genuine air, and which promotes combuſtion by precipitating itſelf into the combuſtible body, and uniting with it, is vital air. It generally compoſes a fourth part of the atmoſphere, and ſometimes even a third part, when it is in its pureſt ſtate. The other fluid is deleterious to animals, and extinguiſhes

extinguiſhes flame; and it conſtitutes three-fourths or two-thirds of the atmoſphere: it was at firſt named mephitic air. When a combuſtible body is expoſed to the air and kindled, a portion of the vital air in the atmoſphere becomes fixed in that body, and its combuſtion continues till it abſorb all the vital air immediately around it. The reſidue of the air, after it has loſt this pure vital part, can no longer contribute to combuſtion. It regains this power on being again qualified with a due quantity of pure air extracted from nitre or a metallic calx. This elegant theory propoſed by M. Lavoiſier in the years 1776 and 1777, appeared to explain all the phænomena of combuſtion. It accounted for the additional weight acquired by metallic calces, and the extinction of flame by air that has been already employed in combuſtion. But M. Lavoiſier, after continuing his experiments on the ſubject, has thought proper to modify and enlarge it by new obſervations. The bright flame which is obſerved on immerſing a burning body in vital air, or on pouring that fluid on the ſurface of a flaming ſubſtance (which may be done by means of an ingenious machine of his invention) made him deſirous of knowing whence it proceeded, and whether, according to the theory of Stahl, it were owing to the diſengagement of phlogiſton. He inquired into this with the more attention, becauſe the eelebrated Macquer had ſtill perſiſted, notwithſtanding *his* diſcoveries, in maintaining Stahl's theory, but had laboured to reconcile *his* theory with that of the father of philoſophical chemiſtry. Macquer was of opinion, that pure air became fixed in combuſtible bodies in conſequence of their phlogiſton being diſengaged; and that pure air and phlogiſton were reciprocally precipitated; the one from the atmoſphere into the combuſtible body, the other from that body into the atmoſphere: in every proceſs of combuſtion pure air extricated phlogiſton into a ſtate of liberty, and aſſumed its place; and in the reduction of metals, phlogiſton diſengaged pure air and occupied the room which it had formerly poſſeſſed. M. Lavoiſier obſerving that the bright ſparkling flame before mentioned, which affords the ſtrongeſt indication of the preſence of light or the matter of fire in a ſtate of activity, ſeems rather to ſurround the exterior part of the body in combuſtion, than to proceed as if it were diſengaged from it,—has been led to think that light and heat are ſeparated from vital air, in proportion as it is abſorbed by the body in combuſtion. His preſent opinion is, that vital air, like all other aeriform fluids, is a compound, conſiſting of a certain principle ſuſceptible of ſolidity, and of fire or the matter of heat; that to its poſſeſſing the latter it owes its ſtate of elaſtic fluidity; and that, being decompoſed in combuſtion, its fixed, ſolid principle, by entering into combination with the combuſtible body, increaſes its weight and changes its nature,—while the matter of fire that it contains is diſengaged under the form of light and heat. Thus, the modern doctrine has beſtowed on vital air what Stahl attributed to phlogiſton. If combuſtion conſiſt in the diſengagement of fire, it is air, not the combuſtible body, which burns. As to the principle which, in combination with the matter of fire, conſtitutes pure or vital air, though M. Lavoiſier is not yet perfectly acquainted with its nature, yet as it is often known to form acids by entering into combination with combuſtible ſubſtances, he has conferred on it the name of the *oxigenous* principle *. With this baſe, the ſulphuric, arſenic, and phoſphoric acids, &c. are produced in the combuſtion of ſulphur, arſenic, and phoſphorus, &c. In all theſe bodies it is ſtill the ſame. It is to be obſerved, that according to this new theory, the vital air which is obtained from metallic calces did not exiſt in theſe calces under that form. It becomes ſuch, in conſequence of the combination that takes place between the heat and light communicated through the veſſels in which the calces are contained during this proceſs, and the oxigenous principle by which they are conſtituted calces.

Such is the preſent ſtate of chemical doctrine (May 1787) concerning the nature of atmoſpheric air, and its influence on combuſtion. The theory of which we have given an account is daily gaining new ſtrength. The objections urged againſt it have but little weight: they even ſhow, that if its oppoſers were better acquainted with it, they would ceaſe to raiſe their voice againſt it, and that when it becomes generally known, it will be unanimouſly received by the learned.

Reſpiration is a phænomenon nearly reſembling combuſtion. Common air is decompoſed in the one as well as in the other; that it may contribute to either, it muſt contain a certain quantity of vital air. When it is deprived of all its vital air, the mephitic reſidue is fatal to animal life. Reſpiration is in fact but a ſlower combuſtion, in which part of the heat of vital air enters the blood as it paſſes through the

---

* M. Lavoiſier gave it at firſt the name of *oxigyne*; but finding it neceſſary to apply an analogous name to ſome other ſubſtances, before known by improper denominations, we have changed the *gyne* into *gene*, as more expreſſive of its Greek derivation.

the lungs, and is by it conveyed through the whole body. In this manner animal bodies receive their ſupplies of heat, which are abſolutely neceſſary, as they are conſtantly giving out the heat which they contain to the atmoſphere and other ſurrounding bodies. To maintain the heat of the blood is, therefore, one of the chief purpoſes of reſpiration; and this beautiful theory explains why the blood of thoſe animals that reſpire either no air or but very little, is always cold.

Meſſrs Lavoiſier and de la Place have diſcovered another ſervice which the air performs in the act of reſpiration. It abſorbs a certain principle that exhales from the blood, and appears to be of the ſame nature with coal. That ſubſtance being reduced into vapour enters into combination with the oxigenous part of vital air, and forms the carbonic acid which is diſcharged from the lungs by expiration. This fact,—the formation of the carbonic acid in the atmoſpheric air reſpired by animals, at the ſame time when the *mephitic* air is ſeparated,—explains why ſuch dangerous effects enſue from the ſhutting up of a number of perſons together in cloſe places; ſuch as happens in theatres, hoſpitals, priſons, and the hold of a ſhip, &c. After this, we can no longer be ſurpriſed at the noxious effects of air altered by reſpiration, by which perſons of delicate conſtitutions and great ſenſibility of nerves are particularly liable to be affected.

The atmoſphere which encompaſſes our globe appears, therefore, to be ſuffering continual alterations from the two great phænomena of combuſtion and reſpiration. That fluid would be very inadequate to theſe two great purpoſes, were there not other means provided for renovating the atmoſpere, and maintaining it with conſtant ſupplies of vital air. In the following

lowing chapter, and in the third part, we ſhall ſee that the organs of vegetables are deſigned by nature to extract this vital air from water, as well as to pour it into the atmoſphere, when ſtruck by the rays of the ſun.

§ III. *Of the diſtinguiſhing Properties of that Mephitic Air, or Azotic Gas, which enters into the Compoſition of Atmoſpheric Air.*

FROM the preceding account of atmoſpheric air, it appears to be a compound body, conſiſting of two gaſes or elaſtic fluids; one of which maintains combuſtion or reſpiration, but the other is entirely unfit for either of theſe purpoſes. The firſt, which is named vital air, exiſts in the proportion of 0,27 or 0,28; while the latter amounts to 0,73 or 0,72. We have aſſerted the firſt to be a compound of the caloric and the oxigenous principles; the ſecond, like all other gaſeous bodies, is alſo a compound of the caloric principle with a baſe ſuſceptible of ſolidity. To this elaſtic fluid, which conſtitutes more than two thirds of the atmoſphere, M. Lavoiſier at firſt gave the name of *moſettic* air; becauſe it extinguiſhes combuſtion, and deſtroys animals. But ſince all gaſes, except vital and atmoſpheric air, are equally noxious, and are therefore all equally intitled to the name of *moſettes* or *mephites*, which has been always applied to elaſtic fluids unfit for reſpiration;—we have adopted the word *azotic gas* as the peculiar denomination of *this* aeriform fluid: and we may of conſequence apply the ſubſtantive *azote*, or or the term azotic principle, to the baſe of this gas; which, like the oxigenous principle, the baſe of vital air, becomes fixed by entering into combination with a number of ſubſtances. In order to give ſome idea of the nature of this azotic gas, we ſhall mention a few of its properties. It is ſomewhat lighter than common air, and therefore occupies the upper part of rooms in which the air hath been altered by combuſtion or reſpiration. Though ſo noxious to animals in the ſtate of elaſtic fluidity, yet the azotic principle, its baſe, is one of the component principles of animal bodies; from which it is extracted in great abundance. It is likewiſe one of the conſtituent parts of volatile alkali or ammoniac, and of the nitric acid. It appears to be abſorbed by vegetables, and perhaps alſo by animals. It is highly probable that the ſame principle enters into the compoſition of all alkaline bodies, and may be conſidered as a genuine *alkaligenous* principle, in oppoſition to the baſe of vital air, to which we have given the name of the *oxigenous* principle. Thus we are led to conſider the atmoſphere as a vaſt reſervoir of *acidifying and alkalifying* principles, though it be itſelf neither acid nor alkaline.

Here we can only mention theſe properties; in the ſucceeding part of the work they ſhall be more particularly explained. Here we have only endeavoured to point out the difference between the two fluids of which our atmoſphere conſiſts, and to fix the reader's attention on the nature of each as diſtinct from the other.

CHAP. VII.

Of Water.

WATER was long thought to perform an important part in almoſt all the phænomena of nature, and to be capable of aſſuming a vaſt variety of forms, and entering into many combinations, without ſuffering any alteration of nature, or becoming unable to reſume its original ſtate. But the late reſearches of Meſſrs Lavoiſier, Meunier, de la Place, and Monge, have diſcovered that water, like air, is compounded of more ſimple principles which may be obtained ſeparate. The period of this important diſcovery conſtitutes a glorious æra in the hiſtory of chemiſtry. We ſhall afterwards ſee by what means theſe philoſophers accompliſhed the analyſis of water. Let us firſt conſider the chemical properties of this body.

§ I. *Of the Phyſical Properties of Water.*

PHILOSOPHERS define water to be an inſipid, ponderous, and tranſparent fluid, without colour or elaſticity, extremely ſuſceptible of motion, and capable of paſſing through the various ſtates of aggregation, from the ſolidity of ice to the tenuity of vapour or elaſtic fluidity.

It is found in almoſt all natural bodies; but nature has united it with many ſubſtances with which art has not yet learned to make it enter into combination. It is obtained from wood, and from the moſt ſolid bones; it is known to exiſt in the hardeſt and moſt denſe calcareous ſtones; it conſtitutes the moſt conſiderable part of animal and vegetable fluids, and even enters into the compoſition of the ſolid parts of ſuch bodies. Theſe are the facts which gained it a place among the number of the elements.

The natural philoſopher views it as exiſting in maſſes over the globe, filling up its cavities, or channelling its ſurface. Its hiſtory comprehends that of the eternal ice which covers the ſummits of ſome lofty mountains and the polar ſeas, of lakes, rivers, rivulets, ſprings, clouds, rain, hail, and ſnow. It is diſtinguiſhed into terreſtrial and atmoſpheric water. It attracts the curious inquiry of the philoſopher, in its paſſing ſucceſſively from the ſurface of the earth into the atmoſphere, and from the atmoſphere upon the riſing heads of hills; and again, in its gathering into ſtreams, producing ſprings, fountains, and rivers; and in the laſt form, holding

holding its headlong courſe to its great reſervoir the ſea. Obſerving the phænomena of this immenſe maſs of water, we behold it agitated with the moſt tremendous motions; we ſee its fluctuations and currents ſometimes raiſing awful liquid mountains; we ſee it ſometimes encroaching on the limits of the earth, and ſometimes retiring within its ancient boundaries. Here new lands ſpring up from its depths; there the foundations of iſles of ancient name are ſapped, and they ſwallowed up in its bowels. If we trace its action in ſubterraneous cavities, we there find it engaged in humbler labours, producing ſalts and cryſtals, and depoſiting them in the clefts of the rocks. All theſe objects muſt come under our attention in purſuing the natural hiſtory of water. But we muſt firſt examine its phyſical and chemical properties.

The moſt remarkable of theſe is its being ſuſceptible of various forms, and becoming by turns a ſolid, a liquid, or a vaporous body. Let us conſider it under each of theſe three modifications.

I. *Of Water in the State of Ice.*

Ice ſeems to be the natural ſtate of water; for, in chemiſtry at leaſt, we conſider that as the natural ſtate of any body in which its aggregative force is ſtrongeſt: But as it appears much more frequently in a liquid ſtate, liquidity is ſtill conſidered as the natural ſtate of water.

Several phænomena highly worthy of obſervation occur in the formation of ice.

1. The change of a liquid into a ſolid body, which takes place on the freezing of water, occaſions a heat of

of ſome degrees. In a thermometer immerſed into freezing water, the mercury riſes ſome degrees above 32°; while in another, in the open atmoſphere of the ſame temperature, it either remains fixed at that point or ſinks below it. It appears, therefore, that part of the heat which is fixed in water in liquid ſtate, is diſengaged and eſcapes into the atmoſphere when it aſſumes a ſolid form; and the ſpecific heat of ice is actually leſs than that of water. A ſimilar diſengagement of heat is obſerved in the cryſtallization of ſalts.

2. The external air promotes the formation of ice. Water in a cloſe veſſel freezes but very ſlowly; but expoſe it to the open air, even in the ſame temperature and ice will almoſt inſtantly appear. A ſimilar phænomenon is obſerved in the cryſtallization of ſalts; many ſaline ſolutions, which in cloſe veſſels are maintained in that ſtate, will almoſt in an inſtant diſplay cryſtals, if you open the mouth of the veſſels and expoſe them to the contact of the atmoſphere.

3. Gentle motion is favourable to the production of ice. The ſame thing is obſervable of ſaline cryſtallizations. By ſhaking ſome ſolutions, which otherwiſe would not produce cryſtals, we ſometimes ſee theſe appear while the ſhaking is continued. I have often obſerved this in ſolutions of calcareous nitrate and muriate. Theſe analogies between the formation of ice and that of ſaline cryſtals prove, that the former is actually a ſpecies of cryſtallization.

4. The bulk of a piece of ice appears to be greater than that of the water of which it is formed; bottles and other glaſs veſſels are burſt in conſequence of the freezing of liquids with which they are filled. But this effect is to be aſcribed not to the water, but to

the

the air which is diſengaged from it during its congelation.

When ice is formed, it is diſtinguiſhed by the following properties.

1. It has been obſerved by M. Mairan, that when formed by a ſlow congelation, its cryſtals are in the form of needles croſſing each other at angles of — from 60° to 120°. Sometimes its cryſtallization takes a regular and determinate form. M. Pelletiers, a ſcholar of M. D'Arcet's, and member of the college of pharmacy, obſerved in a piece of fiſtulous ice cryſtals in the form of flat quadrangular priſms, terminating in two dihedral ſummits, but with great varieties. On the other hand, when ice is ſuddenly formed, and in large maſſes, it becomes one irregular ſolid, exactly like that produced when ſolutions of ſalts are preſſed cloſe together and ſuddenly cooled.

2. Its ſolidity is ſo great, that it may be reduced to powder, and carried about by the wind. In very cold climates, ice becomes ſo hard that it may be hewn into pieces like ſtone, and uſed in building. Nay, we are even confidently told, that maſſes of ice have been hollowed into cannons, and charged and diſcharged ſeveral times before melting.

3. Its elaſticity is very great, much greater than that of water in a fluid ſtate. Throw a piece of ice on a ſolid plane, it rebounds from it like any other hard body.

4. It has a keen, ſharp taſte, nearly approaching to cauſticity. Every perſon knows what kind of ſenſation ice gives when applied to the ſkin. Phyſicians employ it in external applications as a tonic or diſcuſſive, &c.

5. Its gravity is leſs than that of the fluid on which it

it ſwims; which ſeems to be occaſioned by its containing a greater quantity of air in proportion to its bulk. The ſame phænomenon takes place on moſt of thoſe bodies that admit of concretion by cold, and fuſion by heat, ſuch as butter, fats, wax, &c. and ſtill ariſes from the ſame cauſe; for every ſubſtance is by itſelf more denſe and weighty in its ſolid than in a fluid ſtate.

6. Its tranſparency, at leaſt in irregular maſſes, is obſcured by air-bubbles. You may be convinced of this by examining a piece of ice attentively; and if the cavities be opened under water, the air which they contain will be ſeen to iſſue in bubbles from its ſurface.

7. It melts at ſome degrees above 32°; the liquefaction proceeding gradually from the ſurface to the centre.

8. Paſſing from a ſolid to a liquid ſtate, it produces cold in the ſurrounding atmoſphere. Modern chemiſts think that it abſorbs heat when it melts; and that the quantity of the caloric principle which becomes fixed in it on that occaſion, is equal to the quantity of heat diſengaged when it paſſes from fluidity into the ſtate of ice. The ſame phænomenon is common to all fluid bodies that can be condenſed into ſolids, and again reduced to fluidity by the variation of their temperature.

II. *Of Water in a Fluid State.*

The properties of water in a fluid ſtate are very different from thoſe of ice.

1. Its taſte is much fainter, for it is generally conſidered

dered as inſipid. And yet people that drink much of it, can diſtinguiſh differences in its taſte at different times, &c.; which ſhows that it is not abſolutely inſipid.

2. Its elaſticity is leſs than that of ice. Some experiments of the Academy *del Cimento,* have even cauſed this property to be entirely denied to it. But the Abbé Mongez has proved the elaſticity of water by a ſeries of ingenious reſearches; and has even ſhown, that the experiments of the Academy admit of an inference directly oppoſite to that which has been deduced from them. For the metal ſpheres, which had been filled with water for thoſe experiments, continued to exſude liquid drops after being taken out of the preſs; which could not have happened if the water had ſuffered no compreſſion.

3. In the ſtate of a liquid aggregate, water is more under the influence of the affinity of compoſition. From this circumſtance it has obtained the name of the great ſolvent of nature. It does indeed enter into union with a great many bodies, and even contributes highly to the mutual combination of bodies.

4. It ſeems incapable of combination with light, which paſſes through it without producing or ſuffering any alteration. Light is known to change its courſe in paſſing through water, ſo as to aſſume a more perpendicular direction.

5. Heat dilates it to a gaſeous ſtate. Its paſſing from a liquid ſtate to that of aeriform fluidity conſtitutes ebullition. The cauſe of this phænomenon is, that, part of the maſs of water under examination having aſſumed the form of an elaſtic fluid, the heat no longer ſuffers it to remain in union with that which is ſtill liquid: each bubble riſes from the bottom of the veſſel,

veſſel, and aſcends into the atmoſphere, in obedience to the action of heat. I have explained the cauſe of ebullition at large in my *Memoires de Chimie*, publiſhed in 1784, page 334.

The weight of the air has a remarkable influence on the ebullition of water. It oppoſes its dilatation and evaporation: And in proportion as the gravity of the air is leſs or more, the reſiſtance which it oppoſes to the volatilization of water muſt be weaker or more powerful. Thus, Fahrenheit obſerved, that the temperature of water in a ſtate of ebullition is not always the ſame. In order then, to know with greater certainty the preciſe degree of heat at which water boils, we muſt conſult the barometer as well as the thermometer, and we ſhall find the requiſite heat always proportioned to the weight of the air.

The influence of the weight of the air on the rarefaction and ebullition of water becomes more remarkable when we make our obſervations at various heights in the atmoſphere. Thus, *cæteris paribus*, water boils eaſier on the ſummit of a mountain than in a valley or on a plain; the heat requiſite to produce ebullition being leſs in the former ſituation than in either of the two latter. All fluids are eaſily rarefied at very elevated heights; for this reaſon, liquids that are highly volatile, ſuch as ſpirit of wine, æther, and alkaline or ammoniac gas loſe much of their ſtrength on the tops of mountains; a fact which has been generally obſerved by natural philoſophers, and fully determined by an obſervation made by M. de Lamanon, at the height of more than 1800 toiſes above the level of the ſea. Abſtract the weight of the atmoſphere with the pneumatic engine, and you may heat water to ebullition, and reduce it to vapour, without raiſing it to the temperature of 40°.

Laſtly, A third circumſtance, beſides the heat and the gravity of the atmoſphere, which affects the ebullition of water, is the dryneſs or humidity of the atmoſphere; but as the influence of this circumſtance is entirely chemical, we ſhall reſerve the conſideration of it to the next ſection.

6. Boil water in a cloſe veſſel, and with a ſuitable apparatus for collecting the vapours; let theſe be condenſed by cold, and conducted into a receiver; what is thus obtained is diſtilled water. By this means water is obtained pure, and ſeparated from thoſe earthy and ſaline matters which almoſt always alter it, but are now left in the bottom of the veſſel. Chemiſts, who always need pure water for their experiments, provide themſelves with it in this way. They pour river or fountain water into a cucurbite of copper tinned over within: this they cover with a capital inſerted into a refrigeratory filled with very cold water, for the purpoſe of condenſing the vapours; which are thus cauſed to paſs in drops into glaſs-veſſels prepared for their reception. But in order to obtain diſtilled water in the greateſt purity, an alembic peculiarly adapted for this purpoſe muſt be employed. To abridge the proceſs of diſtillation, this veſſel ſhould be prepared on particular principle; the cucurbite ſhould be broad and flat, and the capitl of the ſame form. Water thus diſtilled is perfectly pure. Chemiſts formerly made uſe of ſnow or rain water; but theſe are now known to contain ſolutions of ſome extraneous ſubſtances.

Diſtilled water has an inſipid taſte, and when drunk oppreſſes the ſtomach with a kind of weight; but after being expoſed to the open air, and briſkly ſhaken, it re-

recovers its taſte, and may be drunk with ſafety. Diſtillation does not alter water, it only deprives it of the air which is always united with it in its ordinary ſtate, and communicates to it that lively freſh taſte which renders it potable. Boerhaave diſtilled a quantity of water 500 times ſucceſſively, without being able to diſcover any alteration upon it. Some philoſophers have at different times aſſerted, that water is changed into earth; becauſe, at each new diſtillation, it leaves a certain quantity of an earthy reſidue in the bottom of the veſſel. M. Lavoiſier has made a ſeries of moſt accurate experiments, with a view to determine this. By weighing the glaſs veſſels employed in the proceſs of diſtillation, and doing the ſame with the water diſtilled and its reſidue, he has diſcovered that this earth is nothing but a part of the matter of the veſſels ground down by the action of the water.

III. *Of Water as an Elaſtic Fluid.*

When water is reduced by the action of fire into the ſtate of vapour or elaſtic fluidity, it acquires new properties which diſtinguiſh it from what it was under the two former modifications.

1. If the air into which it is received be above the temperature of 65°, and not overcharged with humidity, it becomes perfectly inviſible.

2. If the temperature of the atmoſphere be below 53°, and, if it be already loaded with moiſture, the watery vapour forms a white or grey cloud which is very plainly diſtinguiſhable: The reaſon of this is, that it is not diſſolved in humid air, as ſhal be afterwards

wards ſhown; but a true precipitation actually takes place.

3. Its dilatation is ſo conſiderable, that, as M. Wath aſſures us from the moſt accurate computation, it occupies, in this form, 800 times the ſpace which it fills when liquid.

4. Such is its elaſticity, that when compreſſed, it produces dreadful exploſions; and is happily employed in mechanics to move enormous maſſes. Its utility in that valuable machine the ſteam-engine is well known both to philoſophers and artiſans.

5. Agreeably to one of the moſt uniform laws of the affinity of compoſition, it has a greater tendency to combination in this ſtate, in which its aggregative force is weakeſt, than in the two former. Chemiſts have frequently occaſion to obſerve with what rapidity water in the ſtate of vapour diſſolves ſalts, ſoftens mucous ſubſtances, corrodes and calcines metals, &c.

6. It is entirely diſſolved in air; when precipitated from the atmoſphere, it conſtitutes dew. This ſolution obeys the ſame laws with ſaline ſolutions; as has been ſhown by M. Le Roy of Montpelier, in an excellent memoir on the elevation and ſuſpenſion of water in the atmoſphere, (*Melanges de Phyſique et de Medicine, Paris,* 1771.)

7. One of the moſt remarkable phænomena of water in a vaporous ſtate, is its power of quickening the combuſtion of oil; as in the experiment of the æolipile applied to the enameller's lamp, in common fires of mineral coal or charcoal, and in the burning of greaſe; inſtead of extinguiſhing, water rather increaſes the ſtrength and fury of the flame in all theſe inſtances. Theſe phænomena led Boerhaave to think that flame was in a great meaſure compoſed of water. We will ſee how much this

this ingenious conjecture of Boerhaave's is confirmed, or at leaſt juſtified by the modern diſcoveries concerning water, when we come to ſhow that this fluid, in a vaporous ſtate, increaſes the violence of flame, in conſequence of being itſelf decompoſed by the bodies in combuſtion.

8. Water in vapour, and diſſolved in the air, is condenſed, and part of it precipitated, when expoſed to a temperature a few degrees above the freezing point; it then reſumes its liquidity; and in this manner is dew produced. Sometimes, when expoſed to a ſudden cold ſeveral degrees below the freezing point, it is congealed into icicles, and ſeems to ſuffer a kind of cryſtallization: hence thoſe hoar, icy incruſtations that are formed in winter on the windows of apartments expoſed to the north: hence too thoſe ſmall icy flakes into which the aqueous vapours iſſuing from the lungs are formed in Siberia and other countries expoſed to an extreme cold.

§ II. *Of the Chemical Properties of Water.*

NO other natural body is ſuſceptible of more combinations than water; and it has, on this account, long held the name of the *great ſolvent of nature.* The waters of the ſea, of lakes, of rivers, ſprings, and fountains, are far from being pure, and are impregnated with almoſt every other ſubſtance, eſpecially with ſaline matters.

It combines with air in two ways: 1. It abſorbs that elaſtic fluid and retains it without paſſing from its liquid

quid ſtate. It even appears that water owes its pleaſant freſh taſte to the air thus combined with it. The pneumatic engine proves the reality of this combination; when the air above the water is exhauſted, that which is mixed with it is gradually diſengaged in the form of bubbles. The air contained in water may be obtained by diſtilling the water in a pneumato-chemical apparatus. When water is boiled, the firſt bubbles that ariſe conſiſt of air, and the water, after loſing them, has no longer the ſame lightneſs or reliſh. It recovers theſe properties by being expoſed for ſome time to the open atmoſphere, or by being briſkly ſhaken. 2. Air, with a certain degree of heat, diſſolves water, and renders it elaſtic and inviſible like itſelf. The greater its heat, the greater alſo is its power of maintaining water in a ſtate of ſolution. Le Roy of Montpelier has examined with minute attention the ſtate of water in the atmoſphere. His ingenious experiments ſhow, that the drieſt hot air, if incloſed in a flaſk, and cooled to a certain temperature, affords a precipitate of water; that more or leſs aqueous vapour is neceſſary to ſaturate the ſame quantity of air according to its heat; and that this water is precipitated from the atmoſphere through the night, and forms a particular kind of dew. He has even been led to think, from theſe facts, that the weight of the atmoſphere depends upon the quantity it contains of this water, which is always in proportion to its temperature.

Though it is not conſiſtent with the method which we propoſe to follow, to enter upon the examination of ſaline matters in this place; yet we muſt obſerve, that water, as it poſſeſſes in an high degree the property of diſſolving them, always contains a certain

quan-

quantity of ſome ſaline ſubſtance. Calcareous ſalts are moſt frequently mixed with water, and communicate ſome diſagreeable, and ſometimes even noxious, qualities to well and river waters. Theſe are ſometimes alſo found to contain a portion of the carbonic acid, of clay, of iron, and of the extracts of vegetables altered by putrefaction. All ſuch waters are unwholeſome; thoſe vitiated with the former mixture are called crude, hard waters: they have an inſipid taſte, are heavy upon the ſtomach, and unfavourable to digeſtion; and being likewiſe often purgative, the uſe of them is not without danger. It is, therefore, an object of conſiderable importance to diſtinguiſh the quality of water; to diſcover whether it be impregnated with any bodies which may communicate to it noxious properties; and to adopt means for purifying it from ſuch a mixture.

Good wholeſome water is generally diſtinguiſhed by the following characteriſtics. It is very clear and limpid; no extraneous body alters its tranſparency; it has no kind of ſmell; it has a lively, freſh, and almoſt pungent taſte; it boils readily, and without loſing its tranſparency; it entirely diſſolves ſoap, in ſuch a manner as to produce an homogeneous fluid, without clouds or lumps; it boils leguminous vegetables without hardening them: if tried by an addition of thoſe liquors that are named *re-agents*, ſuch as alkalis, and ſolutions of mercury and ſilver with nitre, it loſes neither its purity nor tranſparency; or at leaſt if it ſuffers any change of that kind, it is almoſt imperceptible. Laſtly, it paſſes eaſily through the ſtomach and the inteſtines, and is favourable to digeſtion. Spring or river water, which filtrates or flows through ſand, is in continual motion, and is not polluted with the putrefaction of animal or vegetable ſubſtances,—is found to poſſeſs

poſſeſs all theſe properties: but filth muſt not be conveyed into it by ſewers; the channel muſt not be filled up ſo as to divert or ſlacken its courſe; nor muſt hemp be ſteeped, or foul linens waſhed in it, &c. On the contrary, water which ſtagnates in ſubterraneous cavities, which iſſues from a calcareous or gypſeous ſoil, which has no current, which is overgrown with plants or crawls with inſects, which is very ſhallow, with a ſoft muddy bottom, conſiſting of putrid vegetables; all ſuch water exhibits quite different qualities. Its taſte is inſipid or even nauſeous; it has the ſmell of a mouldy or putrid ſubſtance; it is often green or yellowiſh; green or brown flakes of matter, the remains of putrefied vegetable ſubſtances, are ſeen ſwimming in it; it turns vegetable blues to green; it becomes dark and muddy when boiled; forms clouds with ſoap, and hardens all kinds of pulſe; the re-agents cauſe it to give precipitates in greater or leſs abundance; it oppreſſes the ſtomach, remains long upon it, and retards digeſtion.

Several means are uſed to correct theſe bad qualities, which have been adopted entirely from the conſideration of its phyſical and chemical properties.

1. Stagnant waters are put in motion by cutting out for them a ſloping channel, expoſing them to the action of mills, cauſing them to riſe in ſpouts through the air, or to tumble down in caſcades. By theſe means the putrid gas and ſpiritus rector are cauſed to evaporate, extraneous matters are collected and depoſited in the bottom, and a conſiderable quantity of air is attracted into combination with the water.

2. Marſhes and pools are cleanſed of all putrefying animal and vegetable ſubſtances: and this cannot be

done without agitating their waters at the ſame time, which is alſo ſerviceable.

3. Water is filtrated thro' jars or fountains, the bottoms of which are covered with fine ſand and ſponges: theſe need to be renewed from time to time. The bottoms of ſmall rivulets naturally covered with a bed of mud, are alſo laid with ſand and pebbles.

4. The above are means for purifying water by ſeparating from it ſuch heterogeneous matter as may happen to float in it; but they cannot deprive it of any ſaline ſubſtances that exiſt in it in a ſtate of ſolution. To ſeparate theſe from water, it muſt be boiled, left to ſettle and cool till it become clear, then filtrated thro' paper or pure ſand, and expoſed to the air in broad ſtone veſſels. After undergoing this proceſs, it may be drunk with ſafety. Ebullition frees hard water of the principle which occaſions its diſagreeable ſmell, and cauſes it to precipitate part of its calcareous ſalts: but to produce the laſt effect, the water muſt be boiled for half an hour, or for ſo long time as may be neceſſary to make it diſſolve ſoap, and to deprive it of the property of hardening pulſe.

5. If boiling be found inſufficient for purifying water of its calcareous ſalts, as ſometimes happens when it is ſtrongly impregnated with them; theſe muſt then be precipitated by boiling it with a ſmall quantity of potaſhes, or for want of potaſhes with common aſhes; the ſalts then fall to the bottom; and the water being ſuffered to ſettle, and expoſed to the air, acquires all the qualities which we wiſh it to poſſeſs.

6. We may alſo make uſe of ſome ſubſtances to correct the diſagreeable and noxious qualities of water, ſuch as ſugar, meal, barley, corn, honey, pot herbs, and

ſome labiated aromatic plants. But theſe cannot, like the former means, communicate to it the qualities of pure water; they only ſubſtitute one taſte in the place of another.

This account of the chemical properties of water repreſents it only as a powerful agent in combination, capable of entering into union with many natural bodies. But in many of its combinations it ſuffers a remarkable alteration, which was not taken notice of till within theſe few years (in the month of April 1784); and which is highly worthy of the attention of chemiſts. Water has long been known to favour combuſtion in ſome inſtances, as in the enameller's lamp, in the inflammation of oils, in ſtrong conflagrations, &c. Some philoſophers had thought themſelves authorized by theſe facts to conclude, that water was ſometimes changed into air: but we are indebted to a few French academicians for a more accurate account of theſe phænomena, and of the nature of water. M. Lavoiſier having obſerved, with M. de la Place, that when inflammable gas is burnt in a cloſe veſſel, by the help of vital air, a product of pure water is obtained (a fact which was obſerved almoſt at the ſame time by M. Monge, with the moſt accurate attention, in the laboratory of the ſchool of Meziere), concluded, that this product muſt be compoſed by the combination of vital air with inflammable gas; and that theſe were the conſtituent principles of water. This theory, by which M. Lavoiſier preſumed to deprive water all at once of the character of a ſimple elementary body, which it had ſo long maintained, met with keen oppoſition; and its author found himſelf under a neceſſity of eſtabliſhing it by analytical as well as by ſynthetic facts. He therefore

fore attempted to decompoſe this fluid, by exhibiting to it bodies, the affinity of which with one of its principles was ſo ſtrong, that they might be expected to ſeparate it from the other. Obtaining the aſſiſtance of M. Meuſnier, in his reſearches on this head, thoſe two philoſophers read, in the academy, on the 21ſt of April 1784, a Memoir, proving that water is not a ſimple ſubſtance, but a genuine compound of the baſe of inflammable gas with that of vital air or the oxigenous principle; and that the two principles may be eaſily ſeparated from each other. To obtain theſe two matters ſeparate, M. Lavoiſier at firſt employed the following proceſs. In a ſmall bell-glaſs, above ſo much mercury, he put a certain quantity of very pure diſtilled water mixed with iron-filings: Theſe filings were gradually calcined; an inflammable elaſtic fluid was diſengaged, and collected immediately above the mercury; and in proportion as theſe two phænomena appeared, the quantity of the water was diminiſhed. By proſecuting this experiment farther, the iron may be entirely calcined and totally decompoſed; for the water, in M. Lavoiſier's opinion, both occaſions the calcination of the iron and gives out the inflammable gas. As the fluid is compoſed of the oxigenous principle and the baſe of inflammable gas, the iron gradually depriving it of the former, combines with that principle to form a metallic oxide, and leaves the inflammable gas diſengaged. Such was the firſt experiment in which this enlightened chemiſt accompliſhed the decompoſition of water. But in thoſe reſearches which he proſecuted in conjunction with M. Meuſnier, he followed a much ſhorter and more concluſive proceſs. Placing the barrel of a gun in a furnace, and heating it red-hot, he dropped a certain quantity of water through it. In this proceſs, the water being reduced to vapour is decompoſed as ſoon as it comes into contact with the red iron, and the oxigene which it contains becomes fixed in the metal; as appears from the increaſe of its weight and the alteration of its ſubſtance. The baſe of inflammable gas being ſet at liberty, paſſes quickly through the gun-barrel, and is received into bell-glaſſes placed for that purpoſe at the oppoſite end. On a repetition of their experiments, with all the preciſion poſſible, thoſe philoſophers diſcovered, that water contains about ſix parts of the oxigenous principle with one of the baſe of inflammable gas; that of conſequence this laſt principle conſtitutes but a ſeventh part of the compound; that it is thirteen times lighter than common air; and that it occupies, when at liberty, fifteen hundred times the ſpace which it filled in its aqueous combination.

Water appears to act in the ſame manner on many other combuſtible bodies, which it reduces with more or leſs facility to a burnt ſtate, and to afford uniformly a quantity of inflammable gas. It may be decompoſed with zinc, charcoal, or oils; with the laſt of theſe, by dropping the water into boiling oil in a retort, the neck of which is immerſed under the glaſſes of a common pneumato-chemical machine. But great caution is neceſſary to prevent the exploſion that takes place when the water riſes in the vacuum produced in the neck of the retort by the ebullition of the oil. To determine certainly whether a combuſtible body, ſuch as a metal, a coal, &c. be capable of decompoſing water, immerſe a piece of it red hot in-

to

to a veſſel of water, under a bell-glaſs filled with the ſame fluid, and the inflammable gas, which is always diſengaged whenever water is decompoſed, will be received into the glaſs. This, namely, the decompoſition of water, and the production of inflammable gas, is the reaſon why bubbles ariſe when red iron is plunged into water, as has been obſerved by Meſſrs Haſſenfraſt, Stouttz, and D'Hellancourt, of the royal mineralogical ſchool of France. A ſimilar diſengagement of inflammable gas, the conſequence of the decompoſition of water, takes place when a piece of flaming charcoal is thrown into a quantity of that fluid.

Theſe are the newly diſcovered facts concerning the nature and compoſition of water. Meſſrs Lavoiſier and Meuſnier think, therefore, that this fluid is a compound of about ſix parts of the oxigenous principle and one of the baſe of inflammable gas, or, more accurately, of 0.86 of the former body, and 0.14 of the latter; that iron, charcoal, and oils, having a ſtronger affinity with the oxigenous principle than it has with the baſe of inflammable gas, enter into combination with it, leave the combuſtible elaſtic fluid diſengaged, and thus decompoſe water; that this liquid may be again formed by burning inflammable gas with vital air; that when this proceſs of combuſtion is carefully performed, a quantity of water is obtained, which anſwers preciſely in weight to the quantity of the two gaſes, by the combination of which it was produced; that in many chemical operations, water is produced by this combination; and that, therefore, if ſpirit of wine and oils be burnt under a chimney, proper for condenſing their vapours, and fitted to the worm-pipe of a ſtill, the other end of which is joined to a receiver, a quantity

tity

tity of water is obtained almoſt always greater than that of the combuſtible liquid which affords it; becauſe the inflammable gas, diſengaged from the liquid, combines with the pure part of the atmoſpheric air which is decompoſed during the combuſtion *.

Theſe diſcoveries, and the theory founded upon them, cannot but form one of the moſt illuſtrious æras in the hiſtory of natural philoſophy. As it is of the utmoſt importance to conſider all the conſequences of which it admits with all poſſible care, we ſhall here add a few obſervations, in order to convey more diſtinct and accurate ideas of it.

We have mentioned, that all aeriform fluids owe their gaſeous ſtate to the matter of fire or heat combined with them. Inflammable gas depends on the ſame principle: For as the decompoſition of water and its change into inflammable gas always requires an high temperature, and as the more violent the heat applied the more rapid is the change; this gas, therefore, appears to acquire its amazing levity, and to aſſume the aeriform ſtate, in conſequence of a conſiderable quantity of heat being abſorbed by its aqueous baſe; which is the reaſon why it can never be obtained

---

* However ingenious and concluſive theſe experiments may appear, philoſophers are not yet unanimous in conſidering water as a compound body. Dr Prieſtley, in the 11th article of the 1ſt part of the 78th vol of the Philoſoph. Tranſ. R. S. Lond. gives an account of ſome experiments concerning the compoſition of water; from which he is led to conclude, that water is a ſimple body, which enters into the compoſition of all elaſtic fluids; that in the combuſtion of inflammable gas with vital air, water is only depoſited, not produced; and that the calcination of iron by ſteam, and its reduction by inflammable air, &c. may be explained by the tranſitions of water and phlogiſton.

ed but in a ſtate of extreme fuſion. It becomes, therefore, neceſſary to beſtow a particular name on this baſe of inflammable gas, which when combined with the oxigenous principle, the baſe of vital air, is ſuſceptible of a ſolid form, as in the inſtance of ice. This baſe being conſidered as one of the eſſential principles of water, muſt be diſtinguiſhed by a name expreſſive of that property. We have adopted the word *hydrogene*, or *hydrogenous* principle, as anſwering the purpoſe. And we call water a compound of the oxigenous principle, or the baſe of vital air, and the hydrogenous principle, or the baſe of inflammable gas. And as there are many inflammable elaſtic fluids, ſuch as alcohol, æther, volatile oils, &c. when reduced to elaſtic fluidity; we diſtinguiſh this principle of water in its aeriform ſtate by the name of *hydrogenous gas*.

In a future chapter we ſhall have occaſion to review this important ſubject; in this place it is ſufficient to have ſhown, that water is not a ſimple, but a decompoſable body. Nature in her grand operations effects the ſeparation of principles with much greater facility than art, and by many more ways than art can ever diſcover or adopt. It is in conſequence of its decompoſition that water purifies the atmoſphere, by pouring into it ſtreams of vital air; that it contributes to the formation of ſaline matters, of the principles of which pure air is always one; and that ſuch a quantity of inflammable gas is often diſengaged from ſtagnant waters, as ſometimes to overload the atmoſphere, and to produce igneous meteors, in conſequence of being kindled by the electric fluid in its ſtruggles to maintain its equilibrium. Laſtly, This

fine

fine diſcovery of the component principles of water, its decompoſition and recompoſition illuſtrates and explains many of the phænomena of nature, particularly the renovation of the atmoſphere, the ſolution of metals, vegetation, fermentation, and putrefaction; as ſhall be ſhown more at large in ſeveral ſucceeding chapters of this work.

CHAP. VIII.

Of Earth in general.

THE philoſophers of antiquity believed in the exiſtence of a ſimple ſubſtance, the principle of hardneſs, gravity, dryneſs, and fixity, and the baſe of all ſolid bodies, to which they gave the name of *earth*. This opinion, founded ſolely on abſtract reaſoning and hypotheſis, has long been taught in the ſchools, and is ſtill maintained by a number of philoſophers. Paracelſus gave the name of earth to all reſidues obtained by analyſis. But ſucceeding chemiſts following the advice of Glauber, to examine reſidues with as much attention as products, were ſoon convinced that thoſe were far from being pure earth; and the opinion of Paracelſus was of conſequence exploded. Boerhaave having adopted the notion of Paracelſus under ſome reſtrictions, obſerved, that after every analyſis, there remained a dry, inſipid, heavy, colourleſs matter; poſſeſſing in ſhort all the properties of earth. But theſe matters, when chemically examined, are found to differ ſo conſiderably from one another, that they cannot, with

with any propriety, be comprehended under one general denomination.

Beccher, as has been already mentioned in our account of Principles, admitted three different kinds of earth; vitrifiable, inflammable, and mercurial. Stahl conſidered the firſt of theſe as the only genuine earth; and Macquer follows Stahl in thinking vitrifiable earth the pureſt and the moſt elementary.

In order to determine what judgment we ought to form on this matter, let us firſt examine attentively the properties which chemiſts agree in aſcribing to elementary earth. We find ſix which have been conſidered as its diſtinguiſhing characteriſtics; namely, gravity, hardneſs, inſipidity, fixity, infuſibility, and inalterability. But all of theſe properties are found as well in the earth which forms the baſe of rock-cryſtal, quartz, and vitrifiable ſtones in general, as in clays. If then a number of ſubſtances, conſiderably different from one another in many reſpects, be found to poſſeſs in common all the diſtinctive properties attributed to elementary earth, are we to conſider them as ſo many ſimple primary earths? Or, ſhall we rather adopt the opinion of Stahl and Macquer, who, finding vitrifiable earth to poſſeſs in a more eminent degree all the properties of elementary earth, conſider it as the only genuine primary earth, and the others merely as bodies formed by it in combination with different principles?

However plauſible this opinion, however reſpectable its authors, we cannot agree to conſider vitrifiable earth as primary and elementary: 1. Becauſe this earth is not found in equal purity, even in all the ſtones in which Stahl and Macquer have themſelves admitted its exiſtence; for inſtance, let quartz, rock-

cryſtal,

cryſtal, and flints, be examined and compared. 2. Becauſe all the diſcriminating properties of earth are found to belong to many ſubſtances which differ from vitrifiable earths only in poſſeſſing thoſe characteriſtics in a leſs eminent degree. 3. Becauſe vitrifiable earth has not been hitherto ſhown to be, as ſome chemiſts think, the baſe of all ſolid matters, and of all the various kinds of earth.

We ought to adopt the following ſentiments with regard to this matter. We obſerve many ſubſtances in nature poſſeſſing the properties of earths; among which it is impoſſible to diſtinguiſh which is the moſt ſimple, as chemiſts find them all to poſſeſs nearly the ſame degree of ſimplicity: Beſides, though one of theſe ſhould be demonſtrated to be more ſimple than the reſt, it would be farther neceſſary to ſhow that it enters into their compoſition, and conſtitutes the principle of their coherence and ſolidity. Wherefore, without preſuming to determine what is properly elementary earth, we ought to admit the exiſtence of various kinds of earth, and to ſtudy their properties, in order that we may recogniſe and diſtinguiſh them whenever chemical analyſis offers any of them to our attention, combined or ſeparate.

Chemiſts have long allowed the exiſtence of ſeveral kinds of earthy matters: but the earlier claſſifications of theſe matters are faulty, becauſe the properties aſſumed as characteriſtics were neither ſufficiently numerous nor ſuch as they were certainly known to poſſeſs. Such, for inſtance, is the diviſion of earths into mineral, vegetable, and animal: for though the fixed reſidues obtained by a laſt analyſis of organized matters, after lixiviating their aſhes, be generally deſtitute of taſte or ſmell, dry and indiſſoluble, yet theſe properties are not

ſufficient

ſufficient to intitle them to a place among the earths, as they poſſeſs neither inalterability, infuſibility, nor ſimplicity. That ſubſtance which compoſes the dry, ſolid baſe of animal bones, and which, from its dryneſs, inſipidity, and inſolubility, had obtained the name of earth, has been, within theſe few years, diſcovered to be a true ſaline matter; as we ſhall ſhow at large in the chemical hiſtory of the animal kingdom. And we may with great probability conjecture, that the inſipid, inſoluble parts, which remain after the laſt analyſis of other animal matters, are of the ſame nature. The name metallic earths, given to the calces of metals from their dryneſs, and becauſe ſome of them are deſtitute of ſmell and incapable of ſolution, does not properly belong to them; for they are extremely fuſible, and are, every one of them, compounds, as ſhall be afterwards ſhown.

The mineralogiſts who have treated of the hiſtory of earths, have formed a more regular and accurate arrangement of them than chemiſts, who have conſidered this ſubject only in general, and ſo far as it is connected with the theory of chemiſtry. Moſt of the modern philoſophers who have attempted a claſſification of theſe matters, have characterized them by their chemical properties, and have by that means thrown much new light on the natural hiſtory of the mineral kingdom. Wallerius, Cronſtedt, and Monnet, have given complete ſyſtems of mineralogy on this plan. No chemiſt has made more numerous experiments on earths and ſtones than Pott, who has given a methodical arrangement of thoſe bodies according to his own obſervations. The continued labours of M. D'Arcet, and the many analyſes of ſtones made by Bergman and Bayen, likewiſe merit the higheſt praiſe. We ſhall not attempt to exhibit and compare the ſeveral claſſifications of theſe philoſophers: our preſent object is not to give the natural hiſtory of earthy matters, but merely to give the reſults of the various reſearches which have been directed to this purpoſe, with a view to ſhow how many kinds there are of earth conſidered chemically, and what are the characteriſtic properties of each kind.

Before proceeding farther, we muſt obſerve, that in our opinion no diſtinction ſhould be made between earths and ſtones as to claſſification; becauſe, when we conſider them chemically, their ſubſtance is the ſame, and only their aggregation different. Grit-ſtone, for inſtance, is but ſand agglomerated by the force of aggregation; and ſand is nothing but grit-ſtone, the integrant parts of which are divided, and their aggregation broken: the ſame chemical properties are common to both.

Pott has divided earths and ſtones into four claſſes; the vitrifiable, the argillaceous, the calcareous, and the gypſeous. From later diſcoveries it appears, that the ſubſtances hitherto known by the name of calcareous earths, are true neutral ſalts: gypſeous ſtones have been likewiſe diſcovered to be a kind of ſaline ſubſtance. Only two, therefore, of Pott's four claſſes of ſtones actually belong to that diviſion of natural bodies. Dr Black, whoſe name will long mark one of the moſt illuſtrious æras in the annals of modern chemiſtry, by examining the baſe of Epſom ſalt, has diſcovered it to conſiſt of a peculiar ſubſtance, to which he has given the name of magneſia, and claſſed it among the earths. And his opinion has been unanimouſly adopted by chemiſts. Bergman, in analyſing ponderous ſpar, has diſcovered a peculiar earth, to which he has given the

the name of *terra ponderoſa*, and which we call *barytes*.

We think theſe two laſt ſubſtances ought to be diſtinguiſhed from earths properly ſo called, for reaſons to be mentioned in the following chapters.

Thus we acknowledge as true earths none but ſuch matters as are abſolutely inſipid, inſoluble and infuſible; and we diſtinguiſh, by a chemical examination, what ſubſtances poſſeſs theſe properties. We admit only two kinds of pure earth, equally ſimple and equally elementary.

The firſt is that which conſtitutes the baſe of rock-cryſtal, quartz, grit-ſtone, flints, and of almoſt all hard ſcintillating ſtones. Its chemical character is to ſuffer no alteration even from the moſt violent action of fire, but to retain its hardneſs, tranſparency, and all its other properties, to whatever degree of heat it be expoſed *. It has been called *vitrifiable earth*, becauſe it is the only ſpecies of earth capable of forming, in combination with alkalis, tranſparent glaſs. But the name which we prefer is *ſilice*, derived from that of ſiliceous earth, which has been likewiſe given it becauſe it is conſtantly found in ſilices.

The ſecond kind of earth which we conſider as ſimple and pure, is pure argillaceous or *aluminous* earth. The following properties conſiderably different from thoſe of the former ſpecies, form its peculiar character. However pure, it is almoſt always opaque; or if it enter into any tranſparent ſtones, thoſe are much inferior in tranſparency to ſiliceous ſtones. It is always diſpoſed in thin layers or laminæ, one above another.

This

---

* Some chemiſts, however, talk of the fuſion of rock-cryſtal as poſſible by the help of oxigenous gas.

This diſpoſition correſponds to the cryſtalline form which the former ſpecies conſtantly affects. Though it have no ſtronger taſte than ſiliceous earth, yet it appears to act in ſome manner on our organs; for it adheres to the tongue: which property naturaliſts expreſs by ſaying, that it ſticks to *the tongue.* Its force of aggregation is never ſo ſtrong as that of the former earth; for which reaſon argillaceous ſtones are never very hard, but may be broke by a blow with a hammer, without being cut or ſtruck till they give fire, like ſcintillating ſtones. The aggregative force of aluminous earth being ſo weak, renders it much more ſuſceptible of combination than the other kinds; and accordingly clays are much ſeldomer found pure than either quartz or rock-cryſtal. From this it may be eaſily inferred, why clays are almoſt always coloured, and why few of them poſſeſs all the properties of the aluminous character in any eminent degree. Aluminous earth ſuffers an alteration from the action of heat, to which ſiliceous earth is not liable. Inſtead of remaining, like the latter, unchanged when expoſed to an ardent heat, it acquires an addition of aggregative force. It even aſſumes, in ſuch circumſtances, ſome of the properties of the ſiliceous, its hardneſs and averſion to combination. Water acts on aluminous earth, penetrates into its ſubſtance, adheres to it, and renders it ſoft and ductile. The exiſtence of this combination appears from the difficulty with which the adheſion between theſe two ſubſtances is overcome, a ſtrong and long continued heat being neceſſary to effect a ſeparation between them. The properties which this ſpecies of earth poſſeſſes of compoſing a paſte with water, and becoming hard by the action of fire, render it a very valuable material in the arts. Laſtly, another proper-

ty

ty of aluminous earth, which diſtinguiſhes it from the ſiliceous ſtill more than any of the former, is its capacity of entering into combination with a vaſt number of other bodies. So ſubject is aluminous earth to the affinity of compoſition, that we find it a principle in many compounds: and for this reaſon we have enumerated and deſcribed its properties the more at large, in order that it may be readily recogniſed when obtained in analyſes.

Theſe are the two kinds of earthy matter which appear worthy of being conſidered as diſtinct claſſes, and likewiſe as elementary ſubſtances, ſince they have not hitherto been decompoſed. We are not ſufficiently acquainted with their origin, their formation, and their chemical properties, to pronounce, as ſome chemiſts have ventured to do, that one of them is ſimpler than the other, and that the other is nothing but a modification of it. We cannot think ourſelves as yet authoriſed to advance, that the earth of rock-cryſtal, or ſiliceous earth, is the baſe of the aluminous, to conſtitute which it only needs to be attenuated, divided, and wrought up in a particular manner; becauſe no chemiſt has hitherto accompliſhed ſuch a tranſmutation.

The two earthy matters, of the properties of which we have here taken a general view, are ſeldom found pure. Rock-cryſtal is the only body which affords ſiliceous earth in this ſtate; doubtleſs becauſe it is exceſſively hard, and poſſeſſes the force of aggregation in an high degree. Even there, it is often coloured by the addition of ſome extraneous ſubſtance. In quartz it is ſtill oftener altered by combination with ſome colouring matters. But aluminous earth is ſtill ſeldomer found pure. In ſhort, almoſt all the earths and ſtones which naturaliſts have diſtinguiſhed by different names, are compounds of one or two ſimple earths, or of ſaline earthy ſubſtances, particularly of chalk and magneſia, and ſometimes of metallic matters, of which iron occurs the moſt frequently. To be convinced of this, the reader needs only to caſt his eyes on M. Monnet's work, in which he has arranged ſtones according to their conſtituent parts. That chemiſt's plan of arrangement certainly merits no ſmall praiſe ; but while it exhibits to view all the advantages which lithology can derive from chemiſtry, it at the ſame time ſhows how far we are from an accurate and certain claſſification of ſtones according to their chemical properties. This ſubject falls under our diſcuſſion in the following chapters.

PART

PART SECOND.

The MINERAL KINGDOM: MINERALOGY.

SECTION I.

EARTHS *and* STONES.

CHAP. I.

General View of Mineralogy: General Diviſion of Minerals, and particular Diviſion of Earths and Stones; their various Characteriſtics.

ALL the bodies of the globe which we inhabit are the objects of natural hiſtory. So grand and ſublime is this ſcience, when conſidered with a view to its general ſcope! ſo extenſive, when traced through all the minute details into which it enters! Its obſervation ranges from the meteorous phænomena of the atmoſphere to the changes which the matters depoſited in the ſtrata of our earth undergo. All the bodies ſcattered over its ſurface, ſeas, lakes, rivers, brooks, mountains, hills, valleys, plains, and caverns, engage the attention of him who cultivates natural hiſtory. The inanimate matter of the globe, and the animals inhabiting it, are equally the ſubjects of his curious inquiry. The eye of genius may indeed comprehend the whole under one grand and extenſive view: but humble ſcrupulous obſervation confines itſelf to minute detail; detaches the ſeveral parts of this great whole; examines them apart from one another; and thus divides the ſcience into a number of ſeparate branches. Many a man of invincible perſeverance, has ſpent his life in obſerving and deſcribing the manners and operations of inſects; and yet the ſubject is not exhauſted.

The ſtudent might therefore be deterred from the ſtudy of natural hiſtory as too arduous and diſguſting a taſk; but thoſe who have ſucceſsfully proſecuted the ſcience, have endeavoured to ſmooth the difficulties of the road to its attainment, by adopting means for rendering it eaſier of comprehenſion, and for aſſiſting the memory. Theſe are called *methods.* They conſiſt in arrangements of natural bodies, according to their properties. The characteriſtics on which ſuch a claſſification is founded ought to be ſtriking and invariable.

One of the moſt diſtinct and important is a diviſion of all natural bodies into three great orders, which are named *kingdoms;* the mineral, the vegetable, and the animal. Though the two laſt of theſe ſeem to poſſeſs ſome leading properties in common, yet the difference between them in point of form and exterior organization is ſufficient to make us conſider them as ſeparate orders.

Minerals compoſe the ſolid maſs of the globe, or at leaſt its exterior cruſt through which the efforts of men have penetrated. Their bulk and dimenſions are in-

increaſed only by the juxta-poſition of their parts and by their attractive force. They are liable to no change or variation, but ſuch as are occaſioned by the mutual chemical action of bodies. And for theſe reaſons they are named *rude*, *inorganized*, *inanimate bodies*.

Vegetables, again, increaſe by the operation of an interior power: they have organs to refine and convert into nouriſhment, the juices which they derive from the earth and the atmoſphere. They ſpring up, live, and die; by a real generation, they propagate other bodies like themſelves.

Laſtly, Animals have organs more complex than thoſe of vegetables; undergo more rapid changes; and are, from their ſuperior ſenſibility and loco-motive powers, much more ſubject to the influence of ſurrounding bodies.

The branch of natural hiſtory which comprehends the deſcription of minerals, is named *mineralogy*. The firſt naturaliſts who attempted claſſification, arranged minerals into a great many claſſes. They admitted into their arrangements, as ſo many diſtinct orders of minerals, water, earth, ſand, ſoft ſtones, hard ſtones, precious ſtones, figured ſtones, ſalts, ſulphur, pyrites, minerals properly ſo called, and metals, &c. Concerning the progreſs that mineralogy has made ſince the days of Henckel, one of the firſt who wrote in a methodical manner on this department of natural hiſtory, till the appearance of M. Daubenton, whoſe claſſification is a maſterpiece of accuracy and preciſion, the reader may conſult the ſyſtems publiſhed during that period; of which a collection has been made by M. Mongez junior *. He traces the ſucceſſive improvements which the

---

* Manuel du Mineralogiſte.—Paris, 1784.

the ſcience has received from the labours of Bromel, Cramer, Henckel, Woltersdorff, Gellert, Cartheuſer, Juſti, Lehman, Wallerius, Linnæus, Vogel, Scopoli, Romé de Liſle, Cronſtedt, De Borne, Monnet, Bergman, Sage; concluding with thoſe of M. Daubenton, who has accompliſhed all that could be wiſhed.

To make ourſelves acquainted with minerals, the firſt thing to be done is, to diſtinguiſh them into ſo many claſſes marked, each by ſome leading and diſtinct properties. We ſhall accordingly divide them into three. Under the firſt, we ſhall arrange thoſe ſtones and earths which are inſipid, inſoluble, and incombuſtible: under the ſecond, ſaline matters, having a ſtronger or fainter taſte, ſoluble in water, but incombuſtible: and, under the third, combuſtible ſubſtances, inſoluble in water, and affording either a weaker or ſtronger flame when expoſed to the contact of fire, and at the ſame time not excluded from the acceſs of air.

Moſt of that part of the maſs of our globe with which we are acquainted conſiſts of earths and ſtones, which by their inſipidity, inſolubility, and incombuſtibility, are diſtinguiſhed from ſalts and inflammable bodies. Being regularly arranged in ſtrata or layers, they form mountains, hills, and plains; in mountains, they are diſpoſed either in huge ſhapeleſs maſſes, or in inclined horizontal layers; in plains, they are ranged in horizontal ſtrata, and covered with a bed of vegetative earth, produced by the accumulation of the remains of organized bodies. Often, however, ſuch large maſſes appear under a regular cryſtalline form in ſubterraneous cavities or clefts. Moſt of them appear to have been formed by the action of water; and it is continually dividing, attenuating, and tranſporting them from

from one place to another, and cauſing them to undergo many other changes. The natural hiſtory of theſe bodies conſtitutes *geology* and *lithology*; the firſt treating of earths, the ſecond of ſtones: But the two ſhould be united under one claſs; for all earths, excepting mould formed of the reſidues of putrefied organized ſubſtances, are nothing but ſtones, the aggregation of which is deſtroyed; and ſtones again are formed by the union of earthy matters.

As there are a vaſt number of different kinds of earths and ſtones, and a knowledge of them is highly important in ſcience as well as of great uſe in the arts of life; philoſophers have ſought to diſtinguiſh them from one another, and to give certain directions for recogniſing them wherever they occur. Ancient naturaliſts did not think of dividing them into diſtinct claſſes by their peculiar properties; they were content with deſcribing their general qualities, and followed the order of their real utility or fancied value. Few of the ſtones, therefore, mentioned by Pliny in his natural hiſtory, can now be found. Modern naturaliſts, obſerving the inconveniences which attend this way of deſcribing ſtones, have adopted a different method, in order to eſtabliſh more obvious and laſting diſtinctions. By obſerving their exterior and ſenſible properties, they have arranged them into orders, genera, and ſpecies; and have thus rendered the ſtudy more eaſy and advantageous.

Form, hardneſs, interior ſtructure, colour, and the appearance they exhibit when broken, are the properties which have been aſſumed as characteriſtics of earths and ſtones. To theſe ſome naturaliſts have added ſome of their chemical properties, eſpecially the manner in which they are affected by fire, and the alterations

terations which they ſuffer from acids. Let us here examine each of theſe properties, in order to underſtand the application of the general principles of lithology to the particular hiſtory of each of the genera of ſtones.

§ I. *Form conſidered as a Characteriſtic of Stones.*

BY the form of ſtones, we underſtand the order and relative arrangement of their ſurfaces. The eye, at the very firſt glance on a collection of ſtones in a cabinet, perceives ſome of them to be of a regular geometrical figure, and others irregular maſſes; and obſerves, that regularity of form is in ſome inſtances accompanied with tranſparency, in ſome with opacity. Uniform obſervation has eſtabliſhed it as a certain fact, that ſome ſpecies of ſtones always follow a particular mode of cryſtallization; while others never appear but in irregular fragments. Several naturaliſts are of opinion, that all ſtony matters poſſeſs the property of aſſuming a cryſtalline form; that ſome indeed poſſeſs it in an higher degree, and diſplay it more invariably than others, but that all have ſome peculiar cryſtalline form, which appears in their minuteſt particles. Such is the opinion of M. Romé de Lille, who has given a very copious and accurate hiſtory of the various cryſtallizations of mineral ſubſtances *. That philoſopher arranges the forms in which ſtones and all other mineral bodies appear, under the three denominations of

---

* Voyez ſa Criſtallographie, 2d edit. Paris 1783.

of determinate, indeterminate, and confuſed cryſtallization; and ſhows, that there is no mineral ſubſtance but appears in one or other of theſe ſtates. But the truth is, ſo many of them affect the ſecond mode of cryſtallization, and the third, which is irregular and difficult to be diſtinguiſhed, that we cannot gain a ſufficient knowledge of the cryſtalline form of ſtones, to authorize us to aſſume this as one of their determinate characteriſtics. Yet a number of mineralogiſts have formed general ſyſtems of lithology and mineralogy on the principle of the regularity of the form of ſtones and minerals. Linnæus was the firſt that adopted this plan of claſſification; and though he has not entirely accompliſhed what he propoſed in introducing it, he at leaſt directed the attention of ſucceeding naturaliſts to this property of ſtones, and opened the way which has led to all the diſcoveries which have ſince been made on this ſubject.

Such is the ſtate of the preſent opinions concerning the connection between cryſtallography and the ſtudy of ſtones and minerals. It explains the formation, and ſometimes the nature of theſe ſubſtances; and often helps us to recognize and diſtinguiſh them from one another: but it is not adequate to form the baſis of a complete ſyſtem of mineralogy; it is only one of the means to be employed in a claſſification of minerals. That eminent philoſopher M. Romé de Lille, to whoſe labours we are indebted for ſo much of our knowledge concerning the peculiar forms of minerals, has not founded his diviſions of theſe bodies on their cryſtallization alone: inſtead of making them form the great principle of his claſſification, he has only examined and deſcribed the forms of mineral ſubſtances, claſſed according as their nature is ſaline, ſtony, or metallic, and

ac-

according to the various combinations into which they enter.

§ II. *Hardneſs conſidered as a Characteriſtic of Stones.*

THERE are a great many varieties of the aggregation of the component particles of ſtones, of which lithologiſts have happily availed themſelves to diſtinguiſh them from one another. Some have ſuch ſtrength of aggregation, and ſuch a degree of hardneſs, that they yield not even to the beſt tempered ſteel, ſuch as gems or precious ſtones. Others yield, and may be cut with inſtruments, but not without difficulty, ſuch as quartz, flints, hard grit-ſtone, porphyry, and granite. All of theſe ſtones when ſtruck ſmartly againſt a ſteel blade produce a great many ſparks; which property has gained them the name of *ſcintillating* or *igneſcent ſtones*. Thoſe ſparks are minute pieces broke off from the ſteel by its colliſion with the ſtones, and kindled by the heat which that colliſion produces: that heat is even ſo intenſe, that the particles ſtruck off from the ſteel are melted; and if they be collected on a piece of white paper and viewed through a magnifier, they will appear a parcel of half-calcined, half-vitrified ſcoriæ, like the droſs of forges. As the ſtones which act in this manner on ſteel are not all of the ſame denſity, but vary from the hardneſs of gems and rock-cryſtal to the ſoftneſs of ſand-ſtones and vitrifiable breccias recently formed, they muſt afford a greater or

a

a leſs quantity of ſparks, according to their reſpective degrees of hardneſs.

There are a great many other ſtones, the aggregative force of which is much leſs conſiderable, and which are ſo ſoft that they may be eaſily cut with ſteel inſtruments. Some of them, ſuch as marble and alabaſter, are ſuſceptible of a fine uniform poliſh. The reſt, and among theſe almoſt all argillaceous ſtones, admit only of an imperfect poliſh, and always retain a dull, greaſy appearance. We can at any time judge of the hardneſs of thoſe which poſſeſs this property in ſo moderate a degree, and of the poliſh of which they are ſuſceptible, by wetting their ſurface. This ſimple proceſs communicates to them a momentary poliſh, which diſappears in proportion as the moiſture evaporates.

It is to be obſerved, that many other ſtones beſides the claſs of igneſcents produce a real ſcintillation when ſtruck againſt ſteel; the reaſon of which is, that ſuch ſtones are mixtures, containing ſome igneſcent parts. Thus, ſome kinds of marble, and many calcareous breccias, ſcintillate when ſtruck againſt ſteel; becauſe they contain quartzoſe or flinty particles, intermixed with the calcareous matter of which they are moſtly compoſed.

The gravity of ſtones is neceſſarily proportioned to their denſity. Some naturaliſts have conſidered this property as of great importance in a claſſification of ſtony matters. M. de Buffon conſiders ſpecific gravity as one of the beſt means to enable us to diſtinguiſh their particular character. But ſuch nice and accurate experiments are neceſſary to determine the relative gravities of ſtones, that this property cannot very well be aſſumed as the baſis of a lithologic method; as plainneſs

neſs and ſimplicity are highly requiſite in the elements of this branch of natural hiſtory.

§ III. *Of the Fracture, Conſidered as a Characteriſtic of Stones.*

ALL ſtones when broken diſplay a certain arrangement of their integrant parts, an interior contexture and diſpoſition of their particles: but this, ſo far from being uniformly the ſame, is infinitely diverſified through the various claſſes of ſtony ſubſtances. To this appearance which ſtones preſent when broken, lithologiſts have given the name of *fracture.* By obſerving it, we may learn ſome particulars which will be of uſe to help us to diſtinguiſh their peculiar characters. From a compariſon of ſuch obſervations as have been made on the interior ſtructure of ſtones, it appears that the ſeveral ſorts of fracture which they afford may be reduced under certain heads. Some, like glaſs, give ſmooth poliſhed ſurfaces of a curved figure. This is denominated the *vitreous fracture;* it appears very diſtinctly in rock-cryſtal, quartz, &c.

Others again diſplay ſurfaces, which are uniformly ſmooth, but in their figure alternately convex and concave. The pieces may be neatly re-united. This is called the *conchoidal fracture.* The correſponding convexity and concavity are of various forms and ſizes, wide, narrow, round, oblong, deep, ſhallow, &c.;

as in ſeveral kinds of flint, jaſper, agate, and petroſilex.

There is another kind of ſtones, which when broken exhibit on their new ſurfaces an aſſemblage of round projecting points, ſimilar to grains of ſand worn by water: this is called the *granulated fracture*, and is very obſervable in ſand-ſtone. The ſize and other varieties of the granulation conſtitute a number of diſtinctions among the ſtones of this ſpecies, ſerving to diverſifiy their characters. It is of this ſpecies we ſpeak when we ſay *fine* or *coarſe grained* ſtones.

Laſtly, There are many ſtones, the fracture of which ſhows them to conſiſt of ſmooth equal laminæ, diſpoſed one over another. Moſt of thoſe are ſtones which bear the name of *ſpars*; and this is therefore denominated *the ſparry fracture.* Theſe laminæ differ from one another in extent, magnitude, thickneſs, tranſparency, and poſition with regard to the axis of the cryſtallized ſtone; for all the brilliant ſtones of this fracture exhibit a real cryſtallization. Such as are dark and without luſtre, are only ſaid to be *lamellated*, not ſparry. The diſpoſition of the laminæ, ſo much diverſified in gems, and calcareous, vitreous, and ponderous ſpars, is what occaſions the brilliancy of talc, and the ſeveral kinds of feldt-ſpar, ſuch as cat's eye, the avanturine, the labradore ſtone, &c.

Some writers on this ſubject have arranged ſtones according to their fracture, conſidered in conjunction with their general form. In the year 1755, Cartheuſer publiſhed a ſyſtem of mineralogy, in which he diſtinguiſhed ſtones into lamellated, fibrous, ſolid, and granulated. But fracture alone is inſufficient for the principle of a claſſification of ſtones; it muſt be taken together with the other characteriſtics which are examined in this chapter *.

§ IV. *Colour conſidered as a Characteriſtic of Stones.*

THAT diverſity of colours which we obſerve in ſtones, is occaſioned by the various combuſtible or metallic ſubſtances which enter into their compoſition. Sometimes the whole ſtone is of the ſame colour, and ſometimes variegated. The colouring part of ſtones is generally an accidental property of their nature; the preſence of which is not abſolutely neceſſary, and which is liable to great varieties. There are indeed ſome kinds of ſtones which are pretty uniformly coloured, ſuch as cryſtallized gems, ſchorls, and tourmalines; and in theſe the colour may be aſſumed as a characteriſtic. But as there are other ſpecies, and more eſpecially varieties, of which it cannot be conſidered as a diſtinguiſhing property, lithologiſts therefore do not refer to it as a principle of claſſification.

Where colour *may* be conſidered as a characteriſtic property, we muſt diſtinguiſh between ſuch ſtones as are all of one colour, and uniformly opaque, or uniformly tranſparent, and ſuch as are variegated with ſpecks or veins; we muſt likewiſe take notice of the number of the colours which appear in any maſs of ſtone; as in marble, for inſtance, there are ſometimes no fewer than ſix or ſeven. According to the number and

---

* *Voyez L'Introduction a la Sciagraphie de Bergman, par M. Mongez le Jeune,* page 21.

and the diſpoſition of the colours in thoſe bodies, they are diſtinguiſhed into ſtones of one, two, three, or four colours, variegated, ſpotted, veined, punctuated, clouded, flowered, figured, herboriſed, &c.

§ V. *Alteration produced by Fire, conſidered as a Characteriſtic of Stones.*

SEVERAL mineralogiſts, not content with obſerving the exterior and more obſervable qualities of ſtones, have extended their inquiries to their chemical properties, with a view to aſſume theſe as grounds of diſtinction. The particular alteration which any ſtone ſuffers from the action of fire, is conſidered by many lithologiſts as an excellent mean for enabling us to aſcertain its peculiar nature. They have obſerved, that fire deprives ſome ſtones, ſuch as quartz, of their tranſparency and hardneſs, without changing their nature or altering their eſſential properties: others again, ſuch as rock-cryſtal, have been found to loſe not even their denſity and tranſparency when expoſed to the action of heat: and others have been found fuſible and tranſmutable into glaſs of various colours; of which kind are ſchorls, zeolites, aſbeſtos, amianthus, and granites: laſtly, there are ſtill many others, ſuch as calcareous ſtones, which fire deprives of part of their weight, deſtroying their conſiſtency, and rendering them ſoluble in water, without melting them. Other experiments, managed with more careful attention, have ſhown, that ſome ſtones loſe their colour by fire, and that to ſome it communicates a deeper ſhade. Such in general is the re-

reſult of the experiments of Meſſrs Pott, D'Arcet, and many other chemiſts.

To complete the natural hiſtory of ſtones, it is neceſſary to take notice of theſe alterations, and to mark their differences. It appears in general, that ſimple ſtones are liable to the leaſt alteration of their properties by fire; and that in proportion as a ſtone is more or leſs compound, it is more or leſs ſubject to ſuch an alteration. But ſtill the obſervation of theſe alterations cannot be of much benefit to lithologiſts, as the experiments neceſſary to diſcover it are tedious and difficult; whereas the properties aſſumed as characteriſtics in a claſſification of ſtones, ſhould be ſuch as are obvious to the eye, or at leaſt may be diſcovered by a ſimple expeditious proceſs.

Sometimes, indeed, when we cannot determine the nature of a ſtone by obſerving its external properties, we may have recourſe to the alteration which it ſuffers from the action of fire, by means of the blow-pipe, an ingenious contrivance of Bergman's. Yet notwithſtanding the ingenious ſimplicity of this invention, the neceſſary apparatus is ſo incommodious, that it can ſcarce be rendered portable, ſo as to be uſed in a lithologic excurſion, but muſt remain confined to the laboratory *.

§ VI.

---

* See Bergman on the blow-pipe, at the end of his Chemical Eſſays, tranſlated into Engliſh by Dr E. Cullen. London, 1784.

All the apparatus neceſſary is a blow-pipe, a piece of charcoal, a ſmall ſilver ſpoon, and three ſmall phials containing ſoda, fuſible ſalt, and borax; and the proceſs may be performed in any place where a candle can be ſheltered from the wind. Complete apparatus for the purpoſe, in a box no larger than a book in twelves, are ſold at a Mr Brown's, bookſeller, near the Strand, London.

§ VI. *The Action of Acids conſidered as a Characteriſtic of Stones.*

ACIDS are the ſolvents ofteneſt uſed in chemiſtry. Though we have not yet treated of theſe ſalts, yet we muſt here ſay a few words of the phænomena which ſtones exhibit when brought into contact with them. The greater part ſuffer no alteration from acid ſalts; but ſome diſplay a very obſervable motion, and an agitation ſomewhat like a ſlight ebullition, if a drop of the nitric acid be cauſed to fall through a glaſs-tube on their ſurface. This phænomena bears the name of *effervefcence.* It is owing to an aeriform ſubſtance, which being diſengaged from the ſtone by the action of the acid, riſes thro' the acid in a number of ſmall bubbles. That elaſtic fluid is itſelf a peculiar acid, diſengaged by the more active acid poured on the ſtone, and is the product of an actual decompoſition. All calcareous ſtones exhibit this effervefcence when brought into contact with acids: the nitric acid produces the moſt powerful effects, and is moſt commonly employed on ſuch occaſions. The diſengagement of an aeriform acid is a proof that the matter from which it iſſues is a ſaline combination: But as this combination is inſoluble, and without any diſcernible taſte, and as it compoſes moſt of the exterior layers of the globe of the earth, naturaliſts always conſider it as a ſtony ſubſtance.

Stones may therefore be divided into effervefcent and non-effervefcent. And a ſmall phial full of nitric acid becomes of conſequence a neceſſary article in excurſions to examine and collect ſtones. This, together with the magnifier and the ſteel, are all the inſtruments which the lithologiſt needs to carry with him on ſuch an expedition.

Since Bergman recommended the examination of ſtones by fire with the blow-pipe, they are alſo aſſayed with ſoda, borax, and fuſible ſalt, which act variouſly upon them according to the differences of their nature, but generally produce fuſion in ſome degree, together with other phænomena. We ſhall explain this method of analyſing ſtones more particularly in the chapter in which we treat of all the methods of effecting that analyſis.

CHAP. II.

The Lithologic Method of M. Daubenton, extracted from his Tableau de Mineralogie.

NONE of all the mineralogiſts who have attempted a methodical arrangement of ſtones, has given a more accurate or perſpicuous claſſification than M. Daubenton. The ingenuity with which this naturaliſt, ſo deſervedly celebrated, has contraſted the characteriſtics of thoſe ſubſtances, renders his method more accurate and uſeful than any before propoſed. The properties which he has aſſumed as characteriſtics are all invariable and obvious. They are chiefly regularity or irregularity of form; the various degrees of tranſparency and opacity; conſiſtency or hardneſs; the poliſh of which ſtones are ſuſceptible; the form or reſpective arrangement of the integrant parts, which occaſions the vitreous, conchoidal, granulated, lamellated, and ſpathoſe fractures; colours, in thoſe inſtances in which they are not accidental; a duſky, brilliant, or mildly lucid ſurface. As it would be impoſſible to improve upon the perſpicuity and accuracy of M. Daubenton's ſyſtem, all that we ſhall here do, is, to lay before our readers his diviſion of earths and ſtones, as he has exhibited it in his *Tableau Methodique de Mineraux* *.

---

* *Tableau Methodique des Mineraux, ſuivant leurs differentes natures, et avec des caracteres diſtinctifs, apparens ou faciles à reconnoitre; par M. Daubenton, &c. Paris, chez Demonville, Pierres, Debure, Didot l'ainé, &c. in-8. de 36 pages.*

FIRST ORDER OF MINERALS.

SANDS, EARTHS, AND STONES *.

Theſe Subſtances melt not in Water, like Salts, burn not like Combuſtible Bodies, nor diſplay the luſtre of Metallic Matters.

CLASS FIRST.

Stones which give Fire with Steel.

Genus I. Quartz.

Cryſtalline Subſtance, Fracture vitreous, not lamellated.

Species I. Opaque, or ſemi-tranſparent Quartz.

Varieties.
1. greaſy
2. grained
3. lacteous
4. foliated
5. cryſtallized

Species II.

---

* Here we give only part of M. Daubenton's table; but in the hiſtory of ſalts and combuſtible bodies, his diviſion of thoſe matters ſhall be introduced. As we follow that table ſo faithfully as to copy even the

Species II. Tranſparent Quartz, ROCK CRYSTAL,

Two pyramids of ſix ſides, with or without a ſix-ſided priſm between them.

Varieties.

1. cryſtallized
2. rough
3. white
4. red. *BOHEMIAN RUBY.*
5. yellow. *OCCIDENTAL TOPAZ.*
6. ruddy, or blackiſh. *SMOKY TOPAZ.*
7. green
8. blue. *WATER SAPPHIRE.*
9. violet. *AMETHYST*
10. irideſcent.

Species III.

---

the characters in which the ſeveral parts of it are printed, we ſhall here ſubjoin the beginning of the author's prefatory account of it.

" Since the year 1779, this table has been exhibited in manuſcript, " in the Hall of the College Royal, during the courſe of my lectures, " and many copies of it have been taken. I have made repeated al- " terations, according as I received from others, or acquired by my " own obſervation, new information reſpecting mineralogy. I have " even given up for a time my deſign of exhibiting on my table the " reſults of a chemical analyſis of the different minerals it contains, as " I had begun to do, becauſe there has not yet been a ſufficient num- " ber analyſed. My chief object in drawing out this table was to fa- " cilitate the ſtudy of mineralogy. The beſt means for diffuſing the " knowledge of the ſciences is to ſimplify their elements: Methodical " arrangements contribute to that end. For though it be impoſſible " to include all the properties of natural bodies, in any claſſification of " them, yet ſuch a claſſification is uſeful, convenient, nay, even ne- " ceſſary.

Species III. Quartz in agglutinated fragments, Grit-ſtone, or Siliceous Grit,

granulated fracture.

Varieties.

1. hard grit-ſtone
2. friable
3. Levant grit-ſtone. *Very fine grain*
4. filtering ſtone. *Porous*
5. glittering
6. veined
7. diſplaying figures of plants
8. coarſe grained.

Species IV. Quartz in ſeparate grains, Sand,

vitreous ſurface.

Varieties.

1. angular
2. round
3. moving
4. fluid.

Species

“ ceſſary. In the firſt volume of my Lectures on Natural Hiſtory, now in the preſs, I ſhall give a particular explanation of my table, in which both the advantages and defects of my arrangement of minerals will be pointed out. Here I ſhall only obſerve, that minerals are in this table diſtributed into orders, claſſes, ſpecies, and varieties. The diſtinctive characteriſtics of each article are printed in Italic characters.

“ The names in Roman capitals are thoſe which I think moſt ſuitable to the things which they are uſed to denote: Thoſe in Italic capitals are ſynonymes; the uſe of which is attended with inconveniences, and which are inſerted only that the knowledge of the matters which they denote may be the eaſier acquired.

Species V. Quartz in concrete Maſſes.

Sandy and quartzoſe Breccias, or Pudding Stones.

Genus II. Semi-tranſparent Stones,

vitreous fracture, ſometimes conchoidal.

Species I. Agates,

of all colours, except milk white, fine red, orange, and green.

Varieties.

1. clouded
2. punctuated
3. ſpotted
4. veined
5. onyx
6. iriſed
7. preſenting the figures of herbs
8. exhibiting the appearance of moſs

Species II. Chalcedonies,

lacteous tranſparency.

Varieties.

1. reddiſh
2. blueiſh
3. veined
4. onyx
5. irideſcent. OPALS
6. round and ſolid. GIRASOLS
7. round and hollow. ENHEDRALS
8. in ſtalactites
9. in ſediment
10. hydrophanes

Species

Species III. Carnelians,

beautiful red.

Varieties.
1. pale
2. punctuated
3. onyx
4. exhibing figures of herbs
5. in ſtalactites

Species IV. Sardonyx,

orange colour.

Varieties.
1. pale
2. veined
3. onyx
4. preſenting figures of herbs
5. blackiſh

Species V. Flints,

gray, white, reddiſh, blackiſh.

Varieties.
1. with tubercles
2. in layers

Species VI. The Praſeum,

green.

Varieties.
1. green
2. clouded
3. ſpotted

Species VII. Jade,

greaſy poliſh.

Varieties.
1. whitiſh
2. olive coloured
3. green

Species VIII. Petroſilex,

tranſparency of wax, conchoidal fracture.

Varieties.
1. white
2. reddiſh
3. veined.

Genus III. Opaque Stones,

vitreous fracture, ſometimes conchoidal or duſky.

Species I. Miln Stone,

more or leſs porous.

Varieties.
1. porous
2. denſe, or full

Species II. Pebbles,

concentric layers,

Varieties.
1. ſpotted
2. veined
3. onyx
4. oculiform
5. exhibiting figures of herbs
6. concreted into breccias. PUDDING STONES.

Species III. Jaſper,

vitreous fracture, often duſky, without concentric layers.

Varieties.
1. green.
2. red
3. yellow

4. brown

Varieties.

- 4. brown
- 5. violet
- 6. black
- 7. grey
- 8. white
- 9. clouded
- 10. ſpotted
- 11. veined
- 12. onyx
- 13. flowered
- 14. univerſal
- 15. fragments united in breccias

Genus IV. Scintillating Spar. FELD-SPATH.

Species I. Feld-Spath, regularly cryſtallized.

Varieties.

- 1. in oblique (angled) priſms, of four ſides
- 2. in ſix-ſided priſms, with ſummits of two planes
- 3. in ten-ſided priſms, with ſummits of four facets

Species II. Feld-Spath in confuſed cryſtals.

Varieties.

- 1. white
- 2. pearl-grey. FISH'S EYE
- 3. red.
- 4. red, with brilliant ſpangles. NATURAL AVANTURINE
- 5. green
- 6. blue
- 7. violet
- 8. with green and blue ſtripes. *LABRADORE STONE*
- 9. with ſtripes of various colours. CAT'S EYE

Genus V. Cryſtal Gems,

tranſparent and lamellated, not electrifiable by heat alone without friction.

Species I. Red,

Varieties.

1. Garnets
   cryſtallized with 12, 24, or 36 facets. There are alſo yellow, and brown, &c. garnets
2. The balaſs-ruby,
   roſe-colour, octahedral cryſtals

Species II. Red and orange,

Varieties.

3. Spinell ruby,
   fire-coloured, cryſtallized like the balaſs-ruby
4. Vermilion,
   cryſtallized like the garnet
5. Hyacinthe-la-belle,
   cryſtallized under 4 hexagonal ſides with ſummits, having 4 rhomboidal facets

Species III. Orange-coloured,

Variety.

6. Hyacinths,
   cryſtallized like the hyacinthe-la-belle

Species IV. Yellow,

Varieties.

7. Oriental topaz,
   cryſtallized in 2 pyramids of 6 facets
8. Saxon topaz,
   cryſtallized in priſms of 8 ſides, with ſummits of 13 facets

Species V. Yellow and green.

Variety. 9. Peridots, *CHRYSOLITES, cryſtallized in priſms of 6 ſides, with pyramids of 6 faces*

Species VI. Green.

Variety. 10. Peruvian emerald, *cryſtallized in 6 ſided priſms*

Species VII. Green and blue.

Variety. 11. Aqua-marine, *cryſtallized like the Saxon topaz.*

Species VIII. Blue.

Variety. 12. Oriental ſapphire, *cryſtallized like the oriental topaz*

Species IX. Indigo.

Variety. 13. Indigo ſapphire, *cryſtallized like the oriental topaz and ſapphire*

Species X. Red and violet *.

Varieties.
- 14. Syrian garnet, *cryſtallized like the garnet*
- 15. Oriental ruby, *cryſtallized like the oriental topaz and ſapphire*

---

* Gems formed without colouring matter are white. *Note of M. Daubenton.*

Genus VI. Tourmalins, Cryſtal Gems,

compoſed of laminæ perpendicular to the axis of the cryſtal, and electrifiable by heat alone without friction.

Varieties.

1. Braſilian ruby,
   red in four-ſided priſms, with pyramids of 4 facets
2. Braſilian topaz,
   yellow, cryſtallized like the Braſilian ruby

Genus VII. Tourmalins,

electrifiable by heat alone without friction, laminæ not perpendicular to the axis of the cryſtal.

Varieties.

1. Tourmalins of Ceylon,
   tranſparent, orange-coloured, very little channelled on the ſurface
2. Spaniſh tourmalins,
   tranſparent in a ſtrong light, orange-coloured, very much channelled
3. Tourmalins of Tyrol,
   fiſſures traverſing the priſm
4. Tourmalins of Madagaſcar,
   SHORLS OF MADAGASCAR,
   opaque, black
5. Lenticular tourmalins
6. Peridots of Ceylon,
   yellow and green, very much channelled
7. Peridots of Brazil,
   yellow and green, very much channelled

Varieties.
8. Braſilian emerald, *green*
9. Braſilian ſapphire, *blue* *

Genus VIII. Shorls,

not electrifiable by heat without friction, opaque cryſtals, or long green ſemi-tranſparent needles.

Species I. Cryſtallized Shorls.

Varieties.
1. in oblique priſms, with four ſides
2. in ſix-ſided priſms
   PIERRE DE CROIX
3. in ſix-ſided priſms, with ſummits of 2 facets, or pyramids of 3 or 4 facets
4. in priſms of 8 ſides, with ſummits of 2 facets

Species II. In articulated fragments.

Varieties.
1. ſpathoſe ſchorl, *ſtriated with ſparry ſtripes*
2. in maſſes. SCHORL PASTE *brilliant points in the fracture*

Genus IX. Azure Stone,

opaque and blue.

Varieties.
1. purpliſh blue
2. blue

---

* All theſe tourmalins, excepting the lenticular, are cryſtallized in nine-ſided priſms, with ſummits of three or ſix facets. *Note of M. Daubenton.*

CLASS SECOND.

Earths and Stones which neither give Fire with Steel, nor effervesce with Acids.

Genus I. Clays,

when moiſt they are ductile; when dry they are poliſhed by a ſlight rubbing with the finger.

Species I. Clays abſolutely infuſible.

Varieties.
1. uſed to make pots for the glaſs-houſe
2. for tobacco pipes

Species II. Clays partly fuſible.

Varieties.
1. for porcelain
2. for Engliſh pottery.
3. for ſtone-ware

Species III. Clays entirely fuſible.

Varieties.
1. for common pottery
2. for delf-ware
3. for Dutch tiles
4. for tiles
5. for bricks

Genus II. Shiſtus,

argillaceous and foliated fracture.

Varieties.
1. black ſtone
2. common ſhiſtus
3. writing ſlate
4. poliſhing ſtones
5. green ſtone
6. hone
7. fragments united in breccias

Genus III. Talc,

poliſhed gliſtering laminæ, without ſpathoſe fracture.

Species I. Talc in large leaves.

Variety Muſcovy talc

Species II. In ſmall leaves.

Variety. Mica

Genus IV. Steatites,

feel greaſy, like tallow.

Species I. Steatites in layers.

Varieties,
1. fine French chalk (de Briançon)
2. coarſe French chalk (de Briançon)

Species II. Compact Steatites.

Varieties.
1. ſoap rock (Pierre de lard)
2. Spaniſh chalk

Species III. Lapis Ollaris.

Varieties.
1. Como ſtone
2. foliated lapis ollaris

Genus V. Serpentines,

the poliſh and colours of marble.

Species I. Opaque ſerpentines.

Varieties.
- 1. ſpotted
- 2. veined

Species II. Semi-trànſparent Serpentines.

Varieties.
- 1. granulated
- 2. fibrous.

Genus VI. Amianthus,

filaments not calcinable, leaves or flakes lighter than water.

Species I. Amianthus with ſoft fibres.

Varieties.
- 1. with long fibres
- 2. with ſhort fibres

Species II. Amianthus with hard (brittle) fibres.

Varieties.
- 1. Aſbeſtos, eaſily diviſible into parts (mur)
- 2. Aſbeſtos, not eaſily diviſible into parts (non mur)

Species III. Amianthus in flakes or leaves;

Varieties.
- 1. foſſil leather
- 2. foſſil cork

Genus VII. Zeolite,

cryſtallized in divergent radii, or tranſmutable into a gelly by ſolution in acids.

Species I. Cryſtallized Zeolite.

Species

Species II. Compact Zeolite.

Varieties.
- 1. white
- 2. blue
- 3. red

Genus VIII. Fluor Spar,

fragments with triangular faces, all inclined to each other.

Species I. Fluor Spar in cryſtals.

Varieties.
- 1. octahædrons
- 2. cuneiform octahædrons
- 3. with 14 faces
- 4. cubical

Species II. Fluor Spar in irregular Maſſes.

Genus IX. Ponderous Spar,

in rhomboidal fragments, the lateral faces perpendicular to the baſes.

Species I. Cryſtallized Ponderous Spar.

Varieties.
- 1. in rhomboidal plates
- 2. in octahædrons with acute ſummits
- 3. in octahædrons with obtuſe ſummits
- 4. in hexagonal plates with acute ſummits
- 5. in hexagonal plates with obtuſe ſummits
- 6. in tables
- 7. in cock's combs (or lenticular)

Species II. Ponderous Spar cryſtallized confuſedly

BOLOGNA STONE.

Genus X. Ponderous Stone. *TUNGSTEN,*

reſembling Fluor Spar in the form of its fragments, but much heavier; it becomes yellow in acids.

CLASS THIRD.

Earths and Stones which effervеſce with Acids *.

Genus I. Calcareous Earths.

Effervеſcence with Acids.

Species I. Compact.

Variety. Chalk.

Species

---

* Though modern chemiſts conſider theſe ſubſtances as neutral ſalts; formed by the union of chalk with the carbonic acid, we ſubjoin them here after the earthy matters, in order to give a connected view of M. Daubenton's method. Naturaliſts, who employ in their arrangements none but exterior and ſtriking characteriſtics, muſt conſider theſe ſubſtances as genuine earths: but in the hiſtory of ſaline matters, they will be viewed in a different light.

Species II. Spongy.

Variety. Stone-marrow.

Species III. In powder.

Variety. Foſſil Flour.

Species IV. Conſiſtency of cream.

Variety. Lac lunæ.

Species V. Figured.

Variety. Congealed.

Genus II. Calcareous ſtones,

indifferent colour and poliſh.

Species I. Coarſe grained.

SPECIMEN.

Limeſtone from Arcueil.

Species II. Fine grained.

SPECIMEN.

The Thunderſtone.

Genus III. Marbles.

Granulated fracture, fine colours and poliſh.

Species I. Marbles of ſix colours.

Varieties.
White, grey, green, yellow, red, and black.
Specimen.
Marble from Wirtemberg.

Species II. Marbles of two colours.

Varieties.
15 in number, formed by the combination of 6 colours, 2 together.
Specimen.
white and grey.
Marble of Carrara.

Species III. Marbles of three colours.

Varieties.
20 in number, formed by the combination of 6 colours, 3 together.
Specimen.
grey, yellow, and black.
Lumachello.

Species IV. Marbles of four colours.

Varieties.
15 in number, formed by the combination of 6 colours, 4 together.
Specimen.
white, grey, yellow, and red.
Brocatello from Spain.

Species V. Marbles of five colours.

Varieties.
6 in number, formed by the combinations of 6 colours, 5 together.
Specimen.
white, grey, yellow, red, and black.
Breccias of Old Caſtile.

Genus

Genus IV. Calcareous Spar.

Regular form, ſpathoſe fracture.

Species I. Cryſtallized calcareous ſpar.

Varieties.
1. obtuſe rhomboidal figure.
   Iceland Spar.
2. lenticular rhomboidal figure
3. lenticular rhomboidal figure, with 6 triangular faces
4. acute rhomboidal figure
5. with 12 pentagonal faces
6. with 3 triangular faces.
7. ſix-ſided priſm
8 ſix rhomboidal ſides, with 6 faces lozenge-wiſe
9 with 12 ſcalene triangular faces
10 with 12 faces of 4 or 5 ſides, and 6 quadrilateral facets
11 with 6 hexagonal faces, and 12 facets of four ſides.

Species II. Striated calcareous ſpar.

Varieties.
1. with parallel ſtriæ
2. with divergent ſtriæ

Genus V. Concretions.

Succeſſive coats.

Species I. Stalactite Concretions.

Varieties.
1. in columns,
2. tabular
3. reſembling alabaſter

Species II. Concretions by incruſtation.

Species III. Concretions by ſediment.

Varieties.
- 1. by horizontal ſediments
- 2. by rounded ſediments

CLASS FOURTH.

Mixed Earths and Stones.

Mixed earths.

Genus I. Sand and clay.

Species. Sand for founders.

Variety. Sand from Fontenai-aux-roſes.

Genus II. Sand and calcareous earth.

Genus III. Clay and calcareous earth.

Species. Marle.

Varieties.
- 1. marle, Armenian bole
- 2. marle, terra ſigillata
- 3. ſtone for taking ſpots out of cloth (pierre a detacher)
- 4. fuller's earth
- 5. porcelain earth
- 6. pipe clay
- 7. potter's clay (terre a faïance)
- 8. white marle
- 9. foliated marle
- 10. marle for manure

Mixed

Mixed ſtones,

OF TWO GENERA.

Quartz and ſcintillating ſpar	Granitin.
Quartz and ſchorl	Granitello.
Quartz and ſteatites	Quartzoſe ſteatites.
Quartz and mica	Micaceous quartz.
Tranſparent quartz and mica	Micaceous cryſtal.
Quartz in grit and gem ſtone	1. Garnet on grit-ſtone. 2. Garnet in grit-ſtone.
Quarts in grit and mica	Micaceous grit.
Quartz in grit and calcareous matter	1 cryſtallized grit. 2 grit in ſtalactites.
Quartz in ſand and opaque ſtone	ſandy and ſiliceous breccias.
Quartz in ſand and ſchiſtus	ſcintillating ſchiſtus, *HORNSTONE. TRAP.*
Quartz in ſand and zeolite	ſcintillating zeolite.
Scintillating ſpar and ſchorl paſte	ophites.
Semi-tranſparent ſtone, with opaque ſtone	jaſperated agate, or agatized jaſper.

Schorl

Schorl and mica - - - - - - - - -	micaceous ſpathoſe ſchorl.
Schiſtus and mica - - - - - - - - -	micaceous ſchiſtus
Schiſtus and marble - - - - - - -	Florence ſtone.
Serpentine and marble	1. green Egyptian marble. 2. ſea green marble. 3. green antique marble. 4. green marble of Suza. 5 green marble of Varalta.
Ponderous ſpar and calcareous matter	alkaline ponderous ſpar.

OF THREE GENERA.

Quartz in ſand, ſchiſtus and mica	rough wheat-ſtone.
Quartz, gem, and mica - - - -	garnet rock.
Quartzoſe paſte, ſcintillating ſpar in ſmall fragments, and ſchorl	porphyry.
Quartzoſe paſte, ſcintillating ſpar in large fragments, and ſchorl	ſerpentine. *hard ſerpentine.*
Quartz, ſchorl, and ſteatites - - -	tuberculous rock.
Quartz, ſcintillating ſpar, and ſchorl	granite.

OF FOUR GENERA.

Quartz, ſcintillating ſpar, ſchorl, and mica	granite.

CONSISTING OF MORE OR FEWER GENERA, UNITED IN BRECCIAS } univerſal breccias.

DOUBLE BRECCIAS.

Varieties.
1. Fragments of porphyry, and paſte of porphyry.
2. Fragments of granite, and ſchorl paſte.

VOLCANIC PRODUCTS*.

Genus I. Lavas, or Matters formed by Volcanoes; volcanic Matters.

Species I. Porous Scoriæ.

Varieties.
1. in irregular maſſes
2. in ſtriped maſſes
3. in the form of ſtalactites
4. in fragments. LAPILLO
5. in ſmall fragments. POUZZOLANA.
6. in duſt. VOLCANIC CINDERS.

Species

---

* M. Daubenton places volcanic products at the end of minerals, without ranking them under any of the four orders of which his method conſiſts. As their hiſtory is uſually ſtudied along with that of ſtones, I have annexed them here.

Species II. Baſaltes,

compact and ſcintillating, blackiſh cinerous fracture, &c. with brilliant points, without ſmall plates, like thoſe of the ſcintillating ſchiſtus.

Varieties.
- 1. in irregular maſſes
- 2. in balls
- 3. in tables
- 4. in priſms of 3, 4, 5, 6, 7, 8, or 9 ſides
- 5. in articulated priſms

Species III. Glaſs.

Varieties.
- 1. in ſeparate fibres.
  GLASS GALL.
- 2. in agglutinated fibres.
  PUMICE STONE.
- 3. in compact maſſes.
  VOLCANIC SCORIA.
  LAPIS OBSIDIANUS.

Genus II. Volcanized Matters; that is to ſay, matters altered by the heat of volcanoes, *appearing to have been baked, calcined, melted, or vitrified.*

Species I. Granite.
II. Garnet.
III. Hyacinth.
IV. Mica.
V. Peridot.
VI. Quartz.
VII. Schorl.
VIII. Scintillating ſpar.
IX. Calcareous Subſtances.
X. Baked Earths, Tripoli.

STONES, with the Nature of which we are not yet ſufficiently acquainted to reduce them under certain Claſſes.

Jargon of Ceylon,

cryſtals in rectangular priſms, with pyramids of 4 *triangular faces.*

The name of Jargon appears to be given to many ſtones, the particular ſtructure of which is hitherto unknown.

Macles,

in ſquare or cylindrical priſms, the tranſverſe ſection of which exhibits a blue croſs.

The macle has been conſidered as a ſchorl; but the opinion has not been proved.

White Cryſtals,

in flattened priſms with 10 *ſides, with two ſummits of four faces, one of which forms a concave, the other a convex angle.*

Violet or green Cryſtals,

rhomboidal, with two facets inſtead of two oppoſite angles.

Theſe white, violet, and green cryſtals, have obtained the name of Schorls, although they do not appear to be of the ſame nature with ſchorls.

CHAP. III.

Of the Claſſification of Earths and Stones according to their chemical Properties.

THOSE chemiſts who have engaged in the ſtudy of minerals, have endeavoured to eſtabliſh diſtinctions among them founded on their chemical properties. And though a ſufficient number of earths and ſtones has not yet been examined, to enable us to form very accurate or complete arrangements of them on theſe principles; yet it is certainly an object of importance to the ſtudent of mineralogy to know the preſent ſtate of chemical ſcience reſpecting theſe ſubſtances, and what advantage the mineralogiſt can derive from it in arranging them.

Of all the philoſophers who, ſince Cronſtedt, have attempted to arrange earths and ſtones by their chemical properties, Bucquet, Bergman, and Kirwan, have been the moſt ſucceſsful, and have given the moſt complete ſyſtems. As each of theſe gentlemen has followed a peculiar mode of arrangement, and as each of their methods poſſeſſes ſome undeniable advantages, we we ſhall here lay before our readers ſucceſſive views of the three ſyſtems, and ſhall at the ſame time point out their ſeveral defects.

§ I. *Of the Chemical Diviſion of Earths and Stones propoſed by* BUCQUET.

BUCQUET, after many laborious reſearches with a view to this object, at length formed, a little before his death, a ſyſtem of earths and ſtones, on the compound principle of their chemical properties and their exterior characteriſtics, as obſerved by naturaliſts, which he had reſolved to follow in his future courſes of lectures. In repeated converſations with him during the lingering illneſs which ended in his death, I obtained a full account of that method; which was communicated to the public in the firſt edition of this work. I ſhall now again give it as it then appeared, only adding a few notes, to take notice of the improvements which this branch of the ſcience has received ſince the year 1779.

According to Bucquet, earths and ſtones ſhould be arranged under three diviſions: the firſt comprehending ſimple earths and ſtones; the ſecond, compound earths and ſtones; and the third, mixtures of earth and ſtone.

Simple earths and ſtones, in a ſtate of purity, are inſipid, dry, hard, inſoluble, and infuſible. Whenever any of them appear to poſſeſs theſe properties in a leſs

perfect

perfect degree, more eſpecially when any of them appear ſuſceptible of fuſion, they are to be conſidered as not pure, but alloyed by the mixture of ſome extraneous matter. Such as are pure, admit not of decompoſition by chemical analyſis ; but the number of pure ſtones is much more ſcanty than Bucquet thought it.

Compound earths and ſtones are to be regarded as combinations of the ſimple earths with ſaline or metallic ſubſtances. Theſe combinations have been effected by the operation of fire or water in the great laboratory of nature. Their chemical characteriſtics are, to melt eaſily, to ſuffer vitrification from the action of fire, and to be ſeparable into ſeveral ſimple ſubſtances by the action of ſolvents, more eſpecially by the action of acids.

Mixed earths and ſtones are eaſily diſtinguiſhed by inſpection. They ſeem to be formed by the irregular aggregation of ſeveral earths and ſtones, both ſimple and compound. To analyſe them, the ſeveral different matters of the irregular aggregate muſt be divided and examined each by itſelf. Their peculiar natures may be then certainly determined by chemical experiments.

DIVISION I.

Simple Earths and Stones.

THESE are divided into four orders.

ORDER I. VITREOUS STONES.

THESE are extremely hard, and perfectly tranſparent ; of a vitreous fracture ; give fire with ſteel ; and

and ſuffer no alteration in tranſparency or hardneſs from the action of heat.

This firſt order contains two genera; rock cryſtal and vitreous precious ſtones.

Genus I. *Rock-Cryſtal.*

Rock-crystal exhibits all the properties of vitreous ſtones in the moſt eminent degree. Its fracture, which is ſimilar to that of glaſs, diſtinguiſhes it from the following genus.

It may be ſubdivided into ſpecies.

1. *By the Property of Form.*

Species.

1. Inſulated hexahædral cryſtals, with two hexahædral pyramids. The Abbé Rochon has obſerved, that theſe produce a double refraction.
2. Hexahædral cryſtals, united in groups, with one or two points.
3. Tetrahædral, duodecahædral, flattened, &c. cryſtals. Thoſe of which the facets are varied and irregular are always hexahædral.
4. Rock-cryſtal in maſſes, from Madagaſcar. It produces only a ſingle refraction.

2. *By the Property of Colour.*

5. Reddiſh rock-cryſtal.
6. Smoky cryſtals.
7. Black cryſtals.
8. Yellow cryſtals.
9. Blue cryſtals.
10. Green cryſtals.

3. *By accidental Circumſtances.*

Species.

11. Hollow rock-cryſtal.
12. Containing water.
13. One cryſtal incloſed within another (emboités).
14. Rounded; pebbles from the Rhine.
15. Incruſted with metallic calces.
16. In gæodes.
17. Containing amianthus.
18. Containing ſchorl.
19. Incruſted with pyrites.

Their formation by water is proved,

1. By their tranſparency.
2. By the form of ſmall cryſtals.
3. By the incloſure of one cryſtal in another.
4. By their incloſing ſubſtances alterable by fire.

They are cut and poliſhed into vaſes and toys.

Genus II. *Vitreous Precious Stones.*

THE precious ſtones which we rank under this genus, have all the properties which characterize rock-cryſtal, and more eſpecially its inalterability by fire. Though this may ſeem an inverſion of the natural order, and Bergman informs us, that he found theſe ſtones to be compoſitions of ſeveral different matters; yet in their hardneſs, their tranſparency, and the manner in which they are affected by fire, they differ but little from rock-cryſtal; but they are inferior in hardneſs, their colour is not ſo clear and lively, and their fracture is lamellated. The differences among precious ſtones, particularly with regard to the manner in which

which they are affected by fire, induced Bucquet to ſeparate them, and to arrange them among thoſe of the orders of ſtones to which they have the neareſt reſemblance.

The four precious ſtones which we diſtinguiſh by the denomination of vitreous, are,

Species.
1. The oriental topaz.
2. The hyacinth.
3. The oriental ſapphire.
4. The amethyſt.

M. Daubenton has always conſidered this laſt as a quartz cryſtal.

ORDER II. QUARTZOSE STONES.

THESE are not ſo hard or tranſparent as the former; their fracture is vitreous; and they give fire with ſteel. Heat deprives them of hardneſs and tranſparency, and reduces them to a white opaque earth *. Under this order we arrange four genera.

Genus I. *Quartz.*

It poſſeſſes all the above characteriſtics.

---

* It was on account of their being liable to alteration by fire, that Bucquet diſtinguiſhed quartz from rock-cryſtal, and arranged them under a particular genus. He likewiſe obſerved, that this ſtone dipped in water, after being for ſeveral times ſucceſſively heated red hot, communicated to that fluid a degree of acidity. Future experiments will determine the certainty of this fact. A.

Species.

1. Tranſparent quartz, cryſtallized in hexagonal pyramids; its priſms either not obſervable, or at leaſt very ſhort.
2. Tranſparent quartz in maſſes.
3. Opaque or lacteous quartz.
4. Greaſy quartz.
5. Carious quartz.
6. Green, blue, or violet quartz; priſm of amethyſt.
7. Yellow quartz, of a lamellated fracture.

Topaz { Saxon.
Braſilian.

Theſe topazes poſſeſs all the characteriſtics of quartz.

Genus II. *Flint, Agate.*

Flints and agates are ſmall round maſſes, generally opaque, ſometimes ſemi-tranſparent, either hollow or ſolid, of various colours, and diſpoſed in ſtrata;—in chalk, as is the caſe with flints; or in clay, as agates. Their fracture is ſometimes ſcaly.

Species.

1. Grey flint.
2. Yellow flint.
3. Red flint.
4. Corneous flint; gun-flint.
5. Brown Egyptian flint.
6. Tranſparent clouded flint; German agate.
7. Red agate; male cornelian.
8. Pale red agate; female cornelian.
9. Brown or yellow agate; ſardonyx.

10. Agate

Species.

10. Agate-onyx, in concentric laminæ.
11. Laminated agate, in horizontal layers; but the appearance of the laminæ, and their diſpoſition with regard to the figure of the ſtone, depends in a great meaſure on the manner in which it is cut.
12. Figured agates.
    - Dendrites; herborized agates *.
    - Anthropomorphites.
    - Zoomorphites.
    - Uranomorphites.
13. Agate, apparently mouldy; marked with ſmall green points, generally owing to moſſes.
14. Agate of four colours; elementary.
15. Grey agate; grey chalcedony.
16. White, lacteous, or chalcedony agate.
    - in layers.
    - in ſtalactites.
    - round, cacholong.
17. White agate, with a mild reflection of the light.
    - Lapidaries agate, mild luſtre.
    - Cat's eye.
    - Oculus mundi, or hydrophanes.
    - Opal.
    - Giraſol.
18. Brown agate, with brilliant gold-coloured points. Avanturine.
19. Oriental agate.
20. Agate containing water (Enhydre).

The formation of quartz, agates, and flints, is owing to water, as is proved,

1. By

---

* M. Daubenton has ſhown, in a memoir read to the Academy, that herborized ſtones contain very fine moſſes, or ſmall grains of black iron ore. A.

1. By their form.
2. By their layers.
3. By their moſſes.
4. By their containing water.
5. By the organized matters mixed with them, as in the moſſy or mouldy agates.

This alſo appears from the circumſtances and properties of the gæodes. Theſe are ſtone boxes, filled with cryſtals: they contain ſilex and quartz arranged in concentric layers.

Genus III. *Organic Matters converted into Silex, or Agate.*

These are diſtinguiſhed from the other genera of this order, by poſſeſſing the characteriſtic properties of quartzoſe ſtones under an organic form *.

Species.

1. Wood petrified, but ſtill fibrous, and ſuſceptible of poliſh.
2. Wood, the texture of which indicates its particular kind. Fir.
3. Sea-urchens and madrepores converted into ſilex.
4. Shells converted into agate.
5. Carpolites: theſe have been miſtaken for petrified

---

* It would perhaps be a much more natural mode of diviſion, to arrange under a diſtinct claſs, all ſuch animal and vegetable ſubſtances as have ſuffered alteration from lying under ground. The name of that claſs might be foſſils, and it might be placed at the end of the organic kingdoms.

Species.

trified fruits: they are properly ſmall *ludus helmontii* ſcilicified.

6. Entrochites.
7. Lapis frumentarius ſiliceus.

This laſt ſtone gives fire with ſteel, but does not effervesce with acids. It ſeems to be formed by an aſſemblage of cornua ammonis divided perpendicularly to their volutes.

There are two opinions concerning petrifaction. Some think that organized bodies are entirely tranſmuted into ſtone: others are of opinion, that the void ſpaces formed by animal ſubſtances in ſoft earths, and the interſtices in the fibrous texture of vegetables, are gradually filled up by an accumulation of earthy matter. But we can pretend to no certain knowledge of the cauſe of this phenomenon. Vegetable matters are obſerved to become almoſt always quartzoſe, and ſcarce ever calcareous; while animal ſubſtances, on the contrary, become generally calcareous, and ſeldom quartzoſe *. From this fact we may almoſt conclude, that no real petrifaction takes place, and that organized bodies are not converted into ſtone: For, 1. Shell-fiſh and madrepores only loſe their mucilage or animal gluten, by putrefaction, and are reduced to calcareous ſkeletons, which exiſted during the life of the animals: 2. What is ſaid to be petrified wood, is nothing more than an accumulation of vitrifiable earth in moulds formed

---

* Since the diſcovery of the fluoric acid gas, which poſſeſſes the property of depoſiting quartzoſe earth, ſome naturaliſts have conjectured, that petrifaction may be produced in a ſimilar manner. But this is to be regarded as mere conjecture, till ſuch time as it be ſhown that there exiſts in the interior parts of the earth an acid which maintains quartzoſe earth in a ſtate of ſolution.

formed by putrefied vegetables. As the fibres of the vegetable body are gradually deſtroyed by putrefaction, a quantity of quartzoſe earth is depoſited by the water in the ſpace which they occupied: a quartzoſe ſtone is thus formed of the very figure and texture of the vegetable body, but not a particle of that ſubſtance enters into its compoſition.

Genus IV. *Jaſper.*

Jasper poſſeſſes all the characteriſtics of quartzoſe ſtones. It is infuſible, but loſes its aggregation by fire: it is extremely hard, opaque, and variegated with divers colours; its fracture is duſky and vitreous. It is not often found arranged in beds; it generally compoſes conſiderable maſſes or veins in rocks: It is alſo found in ſmall round lumps. Moſt ſpecimens of jaſper that we have ſeen are mixtures of quartz and chalcedony. It ſometimes contains calcareous ſpar.

Naturaliſts have divided jaſper into a great many ſpecies. Theſe may be reduced to the following.

Species.

1. White jaſper.
2. Grey.
3. Yellow.
4. Red.
5. Brown.
6. Green.
7. Veined.
8. Spotted.
9. Green, with red points: bloody jaſper.
10. Flowered.

Jaſper is uſed for making toys, particularly cups and ſeals. There are many antique engravings on ſtones of this kind.

Genus V. *Grit, or Free-ſtone.*

Grit-stone is opaque, of a granulated fracture, much ſofter than quartz or flint; it is found in large maſſes, of various degrees of hardneſs, and ſometimes finer, ſometimes coarſer, grained.

Species.

1. Grit cryſtallized in rhombi. M. de Laſſone has ſhown that theſe owe their form to the chalk incorporated with them *.
2. Grit in the form of cauliflowers,
3. In ſtalagmites.
4. White.
5. Grey.
6. Red.
7. Black, or brown.
8. Veined.
9. Figured, or herboriſed.
10. Grit, of which the aggregation is deſtroyed; ſand.

Sand appears under the following varieties:

Varieties.

1. Quick-ſand.
2. Angular ſand.
3. Sand rounded by the action of water.

4. Pure

---

* Memoirs of the Academy of Sciences for the year 1777.

Varieties.

4. Pure white ſand.
5. Micaceous ſand; glarea.
6. Yellowiſh, argillaceous; founder's ſand.
7. Ferruginous ſand; yellow.
8. ——————— black.
9. Blue ſand; from copper.
10. Violet ſand; from tin.
11. Auriferous ſand.

ORDER III. ARGILLACEOUS EARTHS *and* STONES.

THESE are greaſy; clammy, or pliant; ſtick to the tongue; foliated; frequently coloured; and diſpoſed in large maſſes, and in layers.

Their force of aggregation is leſs than that of quartzoſe ſtones; but they have a greater tendency to combination, and are therefore often altered. Heat contracts and hardens them, ſo as to give them the appearance of quartzoſe ſtones, and cauſe them to give fire with ſteel as well as thoſe. Water reduces them to a paſte, divides, and purifies them; they abſorb water, and retain it with ſuch force of combination, that they cannot be again totally deprived of it.

Part of the ſubſtance of theſe ſtones combines with acids. Some chemiſts have taken clay to be nothing but ſiliceous earth altered by the vitriolic acid; but that opinion has not yet been fully proved.

Many naturaliſts have entertained an opinion, that vitrifiable earths, after being long expoſed to the agency of water, air, and heat, are ſeparated and reduced into fine ſoft particles, capable of combination with water, and thus paſs into the ſtate of clay. This theory being founded on ſome accurate obſervations, merits

more

more reſpect than the former: But the evidence of neither amounts to demonſtration.

Theſe two properties of mixing with water ſo as to compoſe a ductile paſte, and again becoming hard by the action of fire, render clay fit for being wrought into tiles, bricks, pottery, delft-ware, and porcelain: and an account of theſe makes a part of the hiſtory of this kind of earths.

Naturaliſts have deſcribed a great many kinds of ſtones as belonging to this order; but they have confounded among them many falſe clays and compound ſtones; ſuch are, of the laſt, ſerpentine, zeolite, trapp, &c.

The name of *clay* properly belongs to none but ſuch earths as are hardened by fire, are diluted in water, and combine with the ſulphuric acid to form alum.

Macquer having examined a great many of them, found none abſolutely pure *. Many of them owe their colour and fuſibility to their being mixtures of various combuſtible and metallic ſubſtances.

Bucquet divided them into four genera.

Genus I. *Soft Ductile Clays.*

THESE, when dug from the bed or quarry, may be kneaded; but they become dry in the open air.

Species.

1. White clay; pipe clay.
2. Sandy clay,
3. Clammy blackiſh clay; for white pottery.
4. Clay, with a mixture of mica, kaolin; partly fuſible; for porcelain.

5. Me-

---

* Academy of Sciences, 1758.

Species.

5. Metallic clay, fuſible; terra ſigillata; Armenian bole.
6. Pyritous clay; fuſible; blue, green, marbled; uſed in common pottery.

Genus II. *Dry, Friable Clays; Clay of Tripoli.*

All thoſe clays which Bucquet ranked among the tripolis, are dry in the interior parts of the earth. They are all found in beds or layers, often very thin, and arranged one above another. All of them crumble down into duſt under the finger, and abſorb water readily; they likewiſe ſtick to the tongue.

Species.

1. Dry, grey, foliated clay; fullers earth.
2. Red tripoli. Some people take this to be a volcanic product.
3. Grey tripoli.
4. Black tripoli.
5. Rotten ſtones of an olive grey colour.

Genus III. *Schiſtus.*

Schisti are foliated ſtones which ſplit readily into plates: they are a mixed fuſible ſubſtance; they are placed in huge maſſes in the bowels of the earth, and always in an oblique direction. Almoſt all quarries of ſchiſti exhibit on their exterior ſurface and in the uppermoſt layers impreſſions of plants of the ruſh and fern kinds, &c. of ſhells, fiſhes, or inſects, &c.

Species.

1. Black ſchiſtus, tender; ampelite.
2. Fiſſile ſchiſtus; ſlate.
3. Black, hard ſchiſtus; writing ſlate.
4. Red, brown ſchiſtus, &c.
5. Schiſtus marked with impreſſions of vegetable or animal bodies.
6. Very hard ſchiſtus, uſed for whetting razors.

Genus IV. *Feldt-Spar.*

It exiſts in the form of rhomboidal plates; its fracture is ſpathoſe, and it gives fire with ſteel: It is for this reaſon called *ſcintillating ſpar.* Though harder than the ſchiſti, it is fuſible. Bucquet thought it to be an argillaceous ſtone, coloured by a mixture of iron. M. Monnet conſiders it as a compound of quartz, clay, magneſia, and a ſmall portion of calcareous earth. Its being but little known is the cauſe of this diverſity of opinions concerning its nature. A more accurate examination muſt determine its true character *.

---

* Father Pini, an Italian naturaliſt, was the firſt who deſcribed cryſtallized feldt-ſpar. Since his diſcovery, it has been found in many places in France. Very regular feldt-ſpar cryſtals are found at Roanne en Forez. I have given a minute deſcription of that which is found in the Alençon granites, and is one of the moſt regular and beautiful with which I am acquainted, in my *Memoires de Chimie.* A.

Species.

1. Priſmatic feldt-ſpar *.
2. White feldt-ſpar.
3. Red feldt-ſpar.
4. Green feldt-ſpar.
5. Blue feldt-ſpar.

ORDER IV. FALSE CLAYS.

THESE reſemble clays only by having a foliated texture, and greaſy appearance; ſome of them indeed harden by fire.

They differ from clay, as not being fit for compoſing a paſte with water, and as being moſt of them fuſible in fire. They combine with the vitriolic acid to compoſe a ſalt in the form of needles, which ſuffers no alteration from air, but is ſoluble in four or five parts of water, and does not ſwell in fire; in a word, is not alum. Bucquet, who had examined a great many of thoſe ſtones, gave theſe as their characteriſtics: but as they are very little known, they may ſtill be ranked near the clays †.

Genus

---

† M. Daubenton ranks this among the ſcintillating ſtones. It is diſtinguiſhed by three charaſteriſtics from every other ſpecies of ſtones; its texture is ſpathoſe; it yields a mild or *chatoyant* luſtre; and it gives fire with ſteel. With theſe characteriſtics, this genus muſt contain more ſpecies than Bucquet aſcribed to it. M. Daubenton included under it the fiſhe's eye, the avanturine, and the labradore ſtone. A.

* The Abbé Mongez, in his Introduction to Bergman's Sciagraphy, obſerves, that theſe ſtones might be with more propriety named *magneſian ſtones*. I ſhould willingly agree to uſe that name; but I believe a number of experiments are neceſſary before we can receive it as expreſſive of their nature. A.

Genus I. *Lapides Ollares, hard.*

Their texture can ſcarce be called foliated; their appearance is greaſy; and they are ſuſceptible but of an indifferent poliſh.

Species.

1. Grey, Swediſh lapis ollaris.
2. Greeniſh lapis ollaris; Swediſh colubrine.
3. Yellowiſh lapis ollaris; Chineſe ſoap-ſtone.
4. Bright green lapis ollaris; jade. Bucquet thought the nephritic and Otaheitean ſtones to be varieties of the jade. The jade is very hard, and gives fire with ſteel. Bucquet appears to have followed Pott in placing it among the lapides ollares.
5. Dirty green lapis ollaris; colubrine.
6. Serpentine. A ſtone of a deep green, or rather blackiſh colour, with black ſpots or veins, like a ſerpent's ſkin. On account of its appearance, we have placed it at the end of the lapides ollares; it ſeems to be a compound.

Genus II. *Soft Lapides Ollares; Steatites,* or *Smectites.*

These are more of the nature of ſoap than the foregoing genus. They may be eaſily cut; they frothe with water, and ſome of them have externally a ſtriking reſemblance to ſoap.

Species.

1. White, compact ſteatites; Brianҫon chalk.
2. Bright Brianҫon chalk; the druggiſts Venice-talc.
3. White, Norwegian ſteatites.
4. Red marbled Norwegian ſteatites.
5. Reddiſh Norwegian ſteatites.
6. Green compact ſteatites from Norway.
7. Green and red ſteatites from Norway.
8. Green, foliated; ſoft colubrine of Norway.
9. Black ſteatites; uſed by ſtone-cutters.
10. Sparkling grey ſteatites; plumbago, molybdena, and very improperly black lead. Plumbago being reduced to powder, and wrought into a paſte with a mixture of iſinglaſs, is incloſed in ſmall cylinders, which are cut to a point at one end, and uſed as pencils or crayons *.

Genus

---

* Since the death of Bucquet and the firſt edition of this work, Meſſrs Scheele, Grahn, and Hielm, have very ſucceſsfully inveſtigated the nature of plumbago: they have found it to be a kind of ſulphur, formed by the combination of the carbonic acid with phlogiſton. We ſhall give its hiſtory after that of ſulphur. The ſame chemiſts, more eſpecially M. Scheele, have a very proper diſtinction between plumbago and molybdena, which former naturaliſts had always confounded together. M. Scheele conſiders molybdena as a compound of ſulphur with a certain acid, to which he gives the name of the *molybdenic*. *(See the hiſtory of ſulphur.)* It is plumbago which is uſed for pencils. F.

In England, the plumbago uſed for pencils is not ground to powder and mixed with iſinglaſs; but cut into long ſlender pieces and incloſed in wood. Thoſe deſcribed by the author are an inferior kind.

Genus III. *Talc.*

It conſiſts of poliſhed glittering plates, diſpoſed one over another, and of a gelatinous tranſparency. Theſe laminæ or plates are ſometimes cryſtallized in an hexagonal form, or in ſections of ſix-ſided priſms. A ſtrong fire melts it into coloured glaſs.

Species.

1. Talc in large tranſparent plates; Muſcovy glaſs.
2. Talc in very ſmall ſilvered ſpangles.
3. Talc in very ſmall golden ſpangles. Theſe two kinds are uſed to dry writing, under the name of *gold* or *ſilver powder.*
4. Talc worn into the form of pebbles.
5. Talc in black ſpangles.
6. Talc in mixed brilliant ſpangles.

Genus IV. *Amianthus, Aſbeſtos.*

The ſtones of this genus conſiſt of fibres or threads diſpoſed parallel to one another, or interwoven like the texture of a web. Thoſe threads are ſometimes ſtiff, ſometimes flexible; and they differ from one another in colour, length, and thickneſs. The ancients ſpun them, and made of them a kind of cloth, to which they gave the name of *incombuſtible linen,* in which they burnt the bodies of the dead, in order to preſerve their aſhes, &c.

Amianthus melts, in a ſtrong fire, into an opaque coloured glaſs.

Species.

Species.

1. Hard grey aſbeſtos, with parallel threads; ligneous aſbeſtos.
2. Hard green aſbeſtos, with parallel threads.
3. Hard green aſbeſtos; its threads in bundles.
4. Aſbeſtos, with diverging fibres.
5. Hard aſbeſtos, with ſoft fibres.
6. Hard amianthus, with parallel greeniſh fibres.
7. Hard amianthus, with parallel white fibres.
8. Amianthus in bright white bundles.
9. Amianthus in hard yellowiſh bundles.
10. White flexible amianthus.
11. Grey amianthus.
12. Mountain fleſh.
13. Mountain leather.
14. Mountain cork.

DIVISION II.

Compound Earths and Stones.

THESE cannot be diſtinguiſhed by ocular obſervation from thoſe of the former diviſion. As to the nature of their compoſition, they are formed of an homogeneous matter, almoſt always coloured, generally opaque, but ſometimes tranſparent; moſt of them are regularly cryſtallized. They are diſtinguiſhed into genera by form and colour. They are all very fuſible, and afford glaſs of various kinds. Their fracture is ſometimes vitreous, ſometimes ſcaly. In theſe ſubſtances nature has combined together earths, ſalts, and metals.

Bucquet divided theſe ſtones into two orders: Under the firſt he comprehended earths and ſtones compounded with water, which he characteriſed as products of that element. This order again he divided into two genera, namely, ochres and zeolite. Under the ſecond order he reckoned ſchorl, macles, trap, azure ſtone, fuſible precious ſtones, volcanic cryſtals, volcanic glaſs, and pumice ſtones: theſe eight kinds of ſtone he conſidered as formed by the action of fire. We have undertaken to give an account of the ideas of that celebrated chemiſt concerning the nature and claſſification of ſtones; but as the diſtinction between theſe two orders is not eſtabliſhed by a ſufficient number of concluſive facts, and as M. Bucquet himſelf offered them only as hints, we ſhall here give the hiſtory of theſe genera ſucceſſively, without dividing them into orders.

Genus I. *Ochres.*

OCHRES are leſs eaſily diluted in water than clays; they are friable and ſoil the fingers; they are coloured by metallic matters, generally by iron. When expoſed to a ſtrong fire, they aſſume a deeper colour: violent heat melts them. They are uſed in painting.

Species.

1. Yellow ochre.
2. Red ochre, blood coloured.
3. Green ochre; Verona earth.
4. Brown ochre; Umber earth.

Genus II. *Zeolite.*

The zeolite, firſt deſcribed by Cronſtedt, is a ſtone compoſed of needles diverging from a common centre. It neither gives fire with ſteel nor efferveſces with acids: When expoſed to fire it ſwells and produces a white opaque glaſs reſembling enamel. By diſtilling it in a retort, a conſiderable quantity of water is obtained. The reſidue, according to Bergman, conſiſts of ſiliceous, aluminous, and calcareous earth. Bucquet, who analyſed it, mentioned his having found in it very little ſiliceous earth, and a particular kind, neither aluminous nor calcareous; which with the ſulphuric acid afforded a ſalt cryſtallized in ſmall ſhining plates, reſembling the boracic acid, and to which he thought proper to give the name of *zeolitous earth*. Theſe two earths are cryſtallized together by the help of water, which forms more than an eighth part of the compoſition: for, from an ounce of white zeolite, from the iſland of Ferro, M. Bucquet obtained a dram and an half of water *. The property of compoſing a jelly with various acids is not peculiar to it; azure ſtone, tin, and ſeveral iron ores, &c. are capable of a ſimilar compoſition †. Its origin and formation are unknown; abundance of it is found among the products of volcanoes.

---

* Voyez *les Memoires de Savans etrangers, Tome IX. p. 576.*

† M. Pelletier, apothecary, a ſcholar of M. d'Arcet, has given in the *Journal de Phyſique* (1782, vol. XX. page 420.) a memoir on the analyſis of the zeolite of Ferro. He has found, by the moſt accurate experiments, that 100 grains of this ſtone contain 20 grains of aluminous, 8 grains of calcareous, and 50 of ſiliceous earth, and 22 grains of water. Conſult that memoir. F.

noes. There is great plenty of it in the iſle of Ferro. We are acquainted with five kinds of it.

Species.

1. White zeolite, in tranſparent faſces.
2. White zeolite, in compact faſces.
3. Red zeolite.
4. Green zeolite.
5. Blue zeolite.

Neither the red, the green, nor the blue, has yet been examined.

Genus III. *Schorls.*

Schorl is a dark-coloured ſtone, generally violet, black, or green, very ſeldom white, ſufficiently brittle, and capable of giving fire with ſteel. It melts eaſily into a black opaque glaſs: it is, according to Bucquet, a combination of iron and aluminous earth. Bubbles have been found in the interior part of ſchorls, ſimilar to thoſe in the ſlags of glaſs-houſes.

Its origin is not very well known. Some people think it a volcanic product, becauſe it is often found in places which have felt the ravages of fire; but it is likewiſe found among matters which have been long expoſed to the action of water.

Species.

1. Violet ſchorl, in cryſtals.
2. Violet ſchorl, in fibrous maſſes.
3. Black ſchorl, in priſms of 4, 6, 8, or 9 ſides, with pyramids of 2, 3, or 4 faces, like the violet ſchorl.

Species.

4. Black ſchorl, in maſſes.
5. Green ſchorl, in lamellated maſſes.
6. White ſchorl, ſomewhat blueiſh.
7. Electric ſchorl, of a yellowiſh red, tourmaline.

Genus IV. *Macles.*

Under this name we comprehend a genus of ſtones, of a priſmatic form, opaque, dirty-coloured, and generally of a regular figure. By analyzing them M. Bucquet found them to be of a nature nearly reſembling that of ſchorls, namely, a compound of iron and aluminous earth.

Species.

1. Tetrahædral macle, the ſection of which exhibits the figure of the croſs. It is found in a kind of hard deep blue ſchiſtus of Brittany, to which it adheres ſtrongly: it is very brittle, and when broken, exhibits on its tranſverſe ſection two blueiſh lines, cutting each other in the form of a croſs. Sometimes the middle of the priſm appears to be full of a matter reſembling that of the gangue.
2. Stones of the croſs; hexahædral priſms, articulated and croſſed in the middle like the arms of a croſs; theſe are found in the leaves of yellow mica; the two arms never croſs each other at right angles.

Genus V. *Trap.*

Trap is an hard ſtone, fine grained, of a foliated fracture, and angular, like the ſteps of a ladder. Its colour is a deep green, approaching to black, often inclining to the colour of ochre; it is very ponderous, and gives fire with ſteel. It melts into a blackiſh glaſs, and is always covered with a kind of cruſt ſofter than itſelf. It is a compound of aluminous earth and iron: According to Bucquet, iron exiſts in it, in the proportion of twenty-five pounds to the quintal, ſo that it might be conſidered as an iron ore. M. Daubenton thinks it a ſchiſtus containing quartz in ſand. There is only one kind of trap known,—that which we have deſcribed.

Genus VI. *Azure Stone; Lapis Lazuli.*

This ſtone is claſſed along with the preceding genera, on account of its colour, the fineneſs of its grain, and the quantity of iron which, from an analyſis, it appears to contain.

Species.

1. Oriental azure ſtone.
2. Azure ſtone, of a pale blue, and often purpliſh.
3. Armenian ſtone, clouded with white and pale blue.

The azure blue uſed in painting, which is one of the moſt fixed and permanent colours known, is a preparation of this ſtone.

Genus VII. *Fuſible Cryſtal Gems.*

M. Bucquet, in conſequence of obſerving the differences of the various kinds of gems, or precious ſtones, as to chemical properties, was induced to arrange them ſeparately under thoſe diviſions and orders to which they ſeemed moſt properly to belong. Thoſe which we are going to introduce in this place are evidently compounds. Bergman found them to conſiſt of various ſubſtances, ſuch as ſiliceous and aluminous earth, lime, and iron; all of them are fuſible and compoſed of laminæ. Their fracture is lamellated.

Species.

1. Aqua-marina.
2. Emerald.
3. Chryſolite.
4. Ruby.
5. Vermilion, or Bohemian garnet.
6. Garnet.

Genus VIII. *Volcanic Cryſtals.*

Under this genus Bucquet comprehended all ſuch ſtones as are of a regular form, tranſparent, coloured, and ſimilar to cryſtal gems, but poſſeſs not the hardneſs or brilliancy of theſe laſt. They are found in cavities lined with ſmall ſparkling particles of the ſame nature, agglutinated together. They are met with in the neighbourhood of volcanoes. We admit three ſpecies of them.

Species.

Species.

1. Volcanic chryſolite; polyhædral cryſtals of a golden green.
2. Volcanic hyacinth, polyhædral cryſtals of an orange yellow.
3. Volcanic garnets. Theſe ſtrongly reſemble ſingle garnets; but they are irregular, and, as well as the two foregoing ſpecies, ſcattered among brilliant lavas.

Genus IX. *Pumice-Stones.*

Most pumice-ſtones appear to be a collection of vitreous threads wound up together, nearly like yarn on a clue. The pumice-ſtone is really a combination of various ſubſtances which have been reduced to fuſion by the volcanic heat.

Pumice-ſtones may be divided into four ſpecies; each of which has many varieties.

Species.

1. White fibrous pumice-ſtone.
2. Coloured fibrous pumice-ſtone.
3. Light cellular pumice-ſtone.
4. Compact cellular pumice-ſtone.

Genus X. *Volcanic Glaſs.*

The glaſs melted and diſcharged by volcanoes is a mixture of earthy and ſaline matters, coloured with iron

iron or ſome other metallic ſubſtance. It is actually a natural chemical combination effected in the dry way:

Species.

1. Greeniſh cellular glaſs.
2. Blackiſh cellular glaſs, or in agglutinated threads.
3. Black glaſs, very fine and tranſparent; Iceland agate; lapis obſidianus of the ancients.

DIVISION III.

Mixed Earths and Stones.

The characteriſtics of the ſtones of this diviſion are eaſily diſtinguiſhed. We can diſcover, merely by inſpection, of what different matters they conſiſt; and the more readily if we compare them with the ſtones of the two foregoing diviſions. We formerly obſerved, that, in order to analize them, it is firſt neceſſary to divide the various ſubſtances with an hammer; after this operation is performed, they are found to conſiſt of ſimple united with compound ſtones. If theſe mixed ſtones be expoſed unbroken to the action of fire, they will melt with more or leſs facility into a party-coloured glaſs, the nature and colours of which will be according to thoſe of the matters of which it is compoſed.

Theſe ſtones appear to have been formed by the union of the ſeveral ſubſtances of which they conſiſt, effected either by fire or water. On account of this circumſtance, Bucquet ſubdivided this third diviſion into two orders, as well as the foregoing. His firſt order comprehends mixed ſtones formed by water: the ſecond, ſuch as owe their compoſition to fire. As this ſubdiviſion is authoriſed by many more facts than that of the ſecond diviſion, we ſhall follow it with more confidence.

ORDER I. EARTHS *and* STONES *Mixed by* WATER.

Genus I. *Petro-ſilex*, or *Rock-Stone*.

BY this name naturaliſts denote a ſtone of an intermediate hardneſs between ſoft ſtones and ſilex. M. Daubenton ranks it among the vitreous ſtones, becauſe it ſcintillates with ſteel, and its fracture is vitreous, though ſometimes rather ſcaly. Petro-ſilex has a kind of faint or half tranſparency like wax. It is duſky and deſtitute of brilliancy, and has even ſomewhat of the appearance of tallow; it is fine grained and very compact; it is found in large maſſes: it ſometimes diſplays layers variouſly ſhaded, diſpoſed one over another. The chemical characteriſtic by which M. Bucquet diſtinguiſhed it, was its diſpoſition to melt by fire into an opaque glaſs. It is far from being ſo eaſily diſcoverable to be a mixture as the following genera; it ſeems to poſſeſs the characteriſtics of compound ſtones *; and for

---

* I muſt here obſerve, that theſe characteriſtics of ſtones, derived from the manner in which they are affected by fire, are founded on experiments made by M. Bucquet, in conjunction with the Duke de Rochefoucault, in an excellent furnace for fuſion, conſtructed on purpoſe in the laboratory in which that illuſtrious cultivator of chemiſtry

for this reaſon we rank it at the head of the third diviſion: it forms a kind of intermediate ſtep between this and the foregoing.

The form of its layers, the matters which they often contain, and ſtill more the maſſes in which it is accumulated in the bowels of the earth, ſhow plainly that it owes its origin to water.

Species.

1. Grey petro-ſilex.
2. Reddiſh.
3. Greeniſh.
4. Brown.
5. Black.
6. Spotted.
7. Veined.

Genus II. *Pudding-Stone.*

Pudding-stone is a mixture of flints united by a cement of a different nature. That cement is either gritty or argillaceous, or ochreous; ſometimes it is hard, and reſembles ſilex.

Its formation is by no means equivocal; it is owing to water. Theſe ſtones are always found either on the ſea-ſhore, or in places which have been once covered with water, and afterwards left dry.

Species.

---

miſtry proſecutes ſo many reſearches for the improvement of the ſcience. I have re-examined moſt of the reſults of thoſe experiments, which it is to be hoped will be one day communicated to the public: they will confirm the fine ſeries of experiments made by M. D'Arcet; and will add to them a number of facts, ſerving to ſupport Bucquet's arrangement of ſtones.

Species.

1. Sandy pudding-ſtone.
2. Ochreous.
3. Argillaceous.
4. Siliceous.
5. Agatified; ſuſceptible of the fineſt poliſh.

Genus III. *Granite.*

GRANITE is formed by the union of ſmaller or larger fragments of three different ſtony matters. Theſe are quartz, felt-ſpar, and mica.

On account of the quartz and feldt-ſpar which it contains, it gives fire with ſteel: its fracture is irregular and coarſe-grained: it is fuſible, but in various degrees, according as the three component matters are proportioned in the compoſition. It is ſuſceptible of a finer or an inferior poliſh according to the fineneſs of its grain and the hardneſs of its principles. Some ſpecies of it ſuffer alteration, and waſte away by the action of the external air. This laſt phænomenon enables us to diſtinguiſh ancient from modern granite. It has been ſubdivided into many ſpecies: But we ſhall reduce them all to the following *.

Species.

---

* The natural hiſtory of granites has been much ſtudied by modern naturaliſts. M. Sauſſure, in his *Voyage des Alpes*, has communicated a number of new and important facts on this head. Granites are not invariably formed of a mixture of thoſe three ſtones. Some of them, inſtead of mica, contain ſchorl; others contain both ſchorl and mica at the ſame time. A mixture of quartz and feldt-ſpar, without a third ſubſtance, conſtitutes *granitine*: quartz and ſchorl compoſe *granitello.*

Species.

1. White granite.
2. Grey.
3. Red.
4. Brown.
5. Green.
6. Black.
7. Dirty and friable granite, having ſuffered alteration by the action of fire.

Genus IV. *Porphyry.*

Porphyry is a ſtone ſpeckled with ſpots on a ground of red, or ſome other colour. It produces abundance of ſparks when ſtruck with ſteel.

It differs from granite in being harder and ſuſceptible of a much brighter poliſh: it ſeems to conſiſt of feldt-ſpar and ſchorl, united by a quartzoſe cement.

The paſte which conſtitutes the ground of porphyry is of a very fine cloſe grain; the other fragments united in it are generally much leſs than thoſe of granite. This ſtone is fuſible into a coloured glaſs. All the ſpecies of porphyry may be reduced to the following ſeven.

Species.

1. Red porphyry, with large ſpots.
2. Red porphyry, with ſmall ſpots.
3. Green porphyry, with large ſpots.
4. Green porphyry, with ſmall ſpots.

Species.

..itello. See an account of theſe particulars in Sauſſure's *Voyage dans les Alpes.* A.

Species.

5. Black porphyry, with large ſpots.
6. Black porphyry, with ſmall ſpots.
7. Coarſe porphyry, of a dirty red, almoſt without ſpots, nearly of the ſame nature with ſand-ſtone.

Genus V. *Ophites, or Serpentine.*

PLINY gave the name of *ophites* to a kind of ſtones ſpotted like a ſerpent's ſkin. Bucquet conſidered thoſe as a kind of porphyry, but harder, of a more ancient formation, and having their component parts much more intimately united than the other kinds. They have likewiſe received the name of *ſerpentine*, or *hard ſerpentine*. On comparing this ſtone with porphyry, it appears that they are both compoſed of a quartzoſe paſte, with feldt-ſpar and ſchorl; but that in ſerpentine the fragments of feldt-ſpar and ſchorl are large and rhomboidal, while in porphyry they are very ſmall.

Serpentine gives fire with ſteel; its fracture is fine and half ſcaly; it melts in the fire.

The following are moſt of the ſpecies of ſerpentine which we have had occaſion to ſee.

Species.

1. Ophites of a deep green ground, with large white ſpots.
2. Dark green ophites, with oblong ſpots of a paler green.
3. Ophites reſembling the preceding ſpecies; its ſpots very ſmall, and ſcarcely viſible: Many

Species.

ſavage nations uſe it for money: it has received the name of *thunder-ſtone.*

4. Brown ophites, with irregular oblong ſpots of a roſe-coloured white.

We are almoſt entirely ignorant of the circumſtances of the formation of ophites. We know not even whether it be owing to fire or water. But as they reſemble porphyry, we have for this reaſon placed them immediately after that genus.

ORDER II. EARTHS *and* STONES *Mixed by* FIRE.

Continuation of the Volcanic Products.

THE origin of theſe ſubſtances is well known; they are never found but in the neighbourhood of volcanoes, or in places where volcanic fires have formerly exiſted. Beſides, they poſſeſs all the characteriſtics of products of fire. Theſe, together with the compound ſtones above deſcribed, will form a complete liſt of volcanic products.

We include not under this name all the matters which are found near volcanoes. Many of them are not altered by fire, ſuch as moſt of the ſtones above deſcribed, more eſpecially granite, clays, &c. as well as many ſaline ſubſtances, together with calcined, melted, ſublimated, and vitrified matters. They exhibit nothing very remarkable, and were we to deſcribe them here, it would occaſion an unneceſſary repetition. We ſhall in another place take notice of their exiſting in the neighbourhood of volcanoes, and of the alterations produced on them by ſubterraneous fire.

Genus I. *Volcanic Aſhes.*

The name of *volcanic aſhes* has been improperly given to a kind of pulverized earthy matters of various colours, which are found in the neighbourhood of volcanoes. They appear to be compoſed either of a mixture of ſubſtances diſcharged from the volcano, or of lavas altered by the action of air and water. Bucquet thought them to be combinations of iron and clay. They are generally attracted by the magnet. We know only two ſpecies of them.

Species.

1. Rapillo, a pulverized matter, of a blackiſh grey, which is found round the edges of volcanic craters.

Rapillo contains garnets and ſchorls, the form of which is ſtill diſcernible, though their angles have been ſoftened and incruſted by ſome matter in fuſion.

2. Puzzolana. This ſubſtance has received its name from the town of Puzzoli, where it has been made uſe of ſince a very remote period: it is an argillaceous earth impregnated with iron, and variouſly coloured according as it contains a greater or a leſs proportion of the metal. There is grey, black, yellow, red, and brown puzzolana. It melts by fire into a black enamel. It is uſed to compoſe a kind of cement or mortar, which poſſeſſes the property of becoming hard in water. M. Faujas de St Fond found ſome of it in Vivarais. He thinks that it is formed by the alteration and attrition of porous lavas, and even of baſaltes. That philoſopher, in his reſearches on the nature of puzzolana, gives

an account of the proceſſes neceſſary for building with it, both under water, and where it is to be expoſed only to the action of the air.

Genus II. *Lavas.*

This name is given to matters which have been melted and half vitrified by volçanoes. They are uſually ſcattered over the ſides of mountains, the interior parts of which are inflamed with volcanic foci. They iſſue from the craters of volcanoes in burning ſtreams, which ſometimes overflow a wide extent of country, carrying deſtruction and deſolation wherever they direct their courſe. So conſiderable is their bulk, and ſo intenſe their heat, that they cool but very ſlowly, and are not quite cold till after ſeveral years. In cooling, they crack and ſeparate into maſſes, which are ſometimes of a regular form: and this ſeems to be the origin of baſaltes. In cabinets of minerals there is a great variety of theſe ſtones. They generally conſiſt of a grey paſte, of a lighter or a deeper ſhade; in grain and hardneſs ſubject to great varieties; with cryſtals or irregular fragments of ſchorl, garnet, glaſs, zeolite, &c. interſperſed; which makes a true mixture. It is impoſſible to point out any certain general properties of lavas; for they all differ from one another in grain, coheſion, hardneſs, colour, compoſition, &c. They are all in general very fuſible, and afford a kind of blackiſh enamel, like volcanic glaſs. M. Cadet found them to contain iron, copper, and ſiliceous and aluminous earth. Bergman believed them to conſiſt of ſiliceous, aluminous, and calcareous earths, with a mixture of iron. Many lavas, and more particularly thoſe

thoſe which are moſt compact, poſſeſs the property of acting upon the magnetic needle.

Species.

1. Soft lava of various colours, containing cryſtals of black ſchorl.
2. Soft lava of various colours, containing cryſtals of green ſchorl.
3. Soft lava, of various colours, with cryſtals of white ſchorl.
4. Reddiſh lava, with blackiſh cryſtals.
5. Yellowiſh ſaline lava.
6. Soft lava, with garnet cryſtals.
7. Porous lava, of a gentle luſtre (*Fr. Chatoyant.*)
8. Porous grey lava; volvic ſtone.
9. Soft blackiſh lava, with white cryſtals.
10. Grey lava, ſomewhat compact, with duodecahædral, opaque cryſtals, or garnets altered by fire.
11. Ancient lava, very compact, of a blackiſh grey, and ſpeckled with ſpots of a deeper colour.

Genus III. *Baſaltes.*

There is nothing more inaccurate in the writings of naturaliſts than their deſcriptions of baſaltes. Some have confounded both ſchorls and garnets with this ſubſtance. There is no where to be found an accurate definition of the word *baſaltes.* Some conſider them as products of volcanoes; others think them to be formed by water. The experiments and obſervations of Meſſieurs Deſmarets and Faujas de St Fond, induce us to prefer the former of theſe opinions. Regularity of form, abſolute opacity, and a conſiderable degree of hardneſs, ſuch as that it gives fire with ſteel, a grey aſhy colour, and an evident mixture of ſchorls, or ſmall fragments of vitrified matter, of a deeper colour than the maſs through which they are interſperſed, may be conſidered as the diſtinctive characteriſtics of baſaltes. They are likewiſe fuſible.

Among this genus there are ſtones of enormous bulk, and collected in vaſt maſſes, which appear to have been formed at ſome very remote period in antiquity. Such are, 1. The columns of the Giant's Cauſey in the county of Antrim in Ireland. 2. The rock of Pereneire near St Sandoux in Auvergne, which is very accurately deſcribed by M. Deſmarets. There are others regularly cryſtallized in ſmall priſms of three, four, or five faces, &c.: their form, ſize, and diſpoſition, are extremely various.

They are uſually arranged in regular order, one beſide another. No analyſis of them has yet been made from which any thing could be determined concerning their nature. They ſeem to be nothing but lavas apparently cryſtallized, in conſequence of the cracks which run through them in all directions while they are cooling *. Their arrangement and amazing varieties

---

* One theory which has been received concerning the formation of baſaltes, is, that when a ſtream of lava pours into the ſea, the impulſe of the water cauſes it to contract and ſplit into regular figures. But the ingenious M. Houel, in his *Voyage Pittoreſque, &c.* ſhows this theory to be inconſiſtent with facts. He propoſes another, in which he aſcribes the formation of baſaltic columns to the heterogeneity of the matters of which lavas are compoſed. An ingenious theory! but not ſufficiently confirmed by facts.

rieties give conſiderable weight to this opinion: it likewiſe appears, that water inſinuating itſelf into the chinks, depoſites in them different kinds of earth, and alters the correſponding ſides of the baſaltic columns: and this ſeems to be the cauſe that produces the yellow or brown cruſts with which they are covered.

Species.

1. Baſaltes in very long polygon priſms, not terminating in regular pyramids.
2. Baſaltes in ſhort truncated priſms, of three, four, five, or ſeven faces.
3. Baſaltes in ſhort polygon priſms, terminating on the upper end in a concavity, at the lower in a convexity; articulated baſaltes.
4. Small baſaltes, quadrangular, triangular, &c.; formed by the fracture of the larger columns, and united in the ſame group with them *.

Genus IV. *Scoriæ of Lavas.*

The melted matter of which lavas conſiſt is a mixture of various heterogeneous ſubſtances, differing in denſity and gravity. As it is ſlowly cooled, thoſe ſeveral ſubſtances are ſeparated, according to their gravities. Hence the ſcoriæ of lavas. Theſe are ſpongy ſub-

---

* For the hiſtory of theſe ſtones, and all the other products of volcanoes, ſee an excellent work intitled *Mineralogie des Volcans, par M. Faujas de St Fond, Paris*, 1784. F.

ſubſtances which have not been ſo thoroughly melted as the lava, and whoſe levity raiſes them to the ſurface of the maſs. In other reſpects they appear to be of the ſame nature with lava; the only difference being, that they are a more imperfect mixture. Scoriæ, as well as lavas, are found to contain ſchorl and garnet cryſtals.

Species.

1. Ponderous volcanic ſcoriæ, of a compact texture.
2. Black cellular volcanic ſcoriæ.
3. Black ſpongy volcanic ſcoriæ.
4. Black volcanic ſcoriæ, twiſted like a rope.
5. Yellow ochreous volcanic ſcoriæ.
6. Reddiſh volcanic ſcoriæ.

The two laſt ſpecies plainly appear to have ſuffered alteration from the contact of air, water, and acid vapours.

Such was the claſſification of earths and ſtones which Bucquet thought proper to adopt in the years 1777 and 1778. Great progreſs has ſince been made in the chemiſtry of mineralogy. Stones are now analyſed in almoſt every laboratory. Meſſrs Bayen, D'Arcet, Monnet, de Morveau, Sage, Mongez, and Pelletier, in France; Scheele and Bergman in Sweden; Achard, Bindheim, and Hupſch, at Berlin; de Sauſſure in Switzerland; Woulfe, Withering, and Kirwan, in England, have examined a great number of earths and ſtones: and in conſequence of thoſe analyſes, the claſſification of earths and ſtones muſt undergo a conſiderable change. Two of thoſe chemiſts have there-

therefore publiſhed new ſyſtems of mineralogy, in which their arrangements are founded on the nature of the component principles of minerals. But their methods are totally different from that of Bucquet, who ſought to aſſociate exterior characteriſtics with chemical properties. Bergman and Kirwan have paid no regard to phyſical qualities; the nature, the quantity, and the proportion of the component principles are the particulars on which they found their arrangements. Their ſyſtem, though it may contribute greatly to the advancement of chemical knowledge, cannot teach us to diſtinguiſh ſtones by their appearance and ſenſible properties. It was therefore abſolutely neceſſary to give, as we have done, ſome phyſical method, before entering on the examination of theſe ſyſtems. The one throws light on the other; and they may thus be equally uſeful to the ſtudent of mineralogy.

§ II. BERGMAN'S *Chemical arrangement of Earths and Stones* *.

BERGMAN, after ſhowing that external properties, if judiciouſly ſelected, may be *of uſe* in forming a claſſification of minerals, but are not of themſelves *fully*

---

* This ſection is an extract from Bergman's work, publiſhed in French, by M. Mongez, under the title of *The Mineralogiſt's Manual, &c.* F.——There is an Engliſh tranſlation of it by Dr Withering.

fully adequate to that purpoſe, eſtabliſhes his principal diviſions of claſſes and genera on the compoſition and intimate qualities of thoſe bodies. Every mineral is arranged by that principle which is the moſt powerful, or the moſt copious in its compoſition: all minerals, or foſſils, are in this ſyſtem divided into four claſſes; ſalts, earths, bitumens, and metals. We ſhall here take notice of none but the earths.

Bergman acknowledges five different kinds of ſimple earth; terra ponderoſa, lime, magneſia, clay, and ſiliceous earth *.

He firſt examines each of theſe as pure earths, tho' none of them is ever found ſuch in nature: he obſerves, that theſe five earths combine into twenty different ſpecies, ten of two, ſix of three, three of four, and one of the whole five. But he ranges among the ſpecies of earths all ſuch of their combinations with acids as are not ſoluble in one thouſand times their own weight of boiling water; and thoſe ſpecies are thus increaſed to a vaſt number. Beſides, two compound earths, though made up of the ſame component principles, may differ widely as to the proportion in which thoſe principles exiſt in them; even ſo much as to be eſſentially different in their nature. Theſe are the grounds on which Bergman and his commentator the Abbé Mongez, have diſtinguiſhed earths into different ſpe-

---

* Three of theſe five kinds of earth appear plainly to poſſeſs ſaline properties, namely, *barytes* or ponderous earth, magneſia, and lime; and we therefore reſerve the hiſtory of them to the ſecond part of the work. Bergman, whoſe intention was to divide ſtones according to their principles, was obliged to rank them among the earths, becauſe they are often united with each other. Many of the ſubſtances which that illuſtrious chemiſt has placed among ſtones, come in our method to be conſidered as ſalts. F.

ſpecies; for Mongez has made conſiderable additions to the labours of the Swediſh chemiſt. The following are the ſpecies into which they divide each of the primary earths.

Ponderous Earth *.

Species.

I. Pure ponderous earth. This is no where to be found in nature; it is obtained, as we ſhall afterwards ſee, by decompoſing ponderous ſpar.

II. Aerated ponderous earth; a combination of terra ponderoſa with the aerial acid. This compound has not hitherto been found in nature: Bergman thinks that it may exiſt in water in a ſtate of ſolution †.

III. Vitriolated ponderous earth; ponderous ſpar: a combination of ponderous earth with the vitriolic acid. Abundance of this ſubſtance is found in mines. The Bologna ſtone is a variety of it.

IV. Vitriolated ponderous earth, containing petroleum, mixed with ſelenite, alum, and ſiliceous earth; the hepatic ſtone of Cronſtedt. This is a bright yellow, brown, or black ſparry

---

[*] We ſhall here follow the denominations of Bergman. It will be eaſy to refer the ancient names both of earthy baſes and of the acids united with them, to the new and methodical denominations which we ſhall give thoſe bodies in the hiſtory of ſaline matters. See the end of this volume, and the ſecond. A.

[†] A natural compound preciſely of this ſpecies has been found in England ſince the death of Bergman. See the extract from Kirwan's Mineralogy. A.

ſparry ſubſtance; ſtrong ſmelling, and not effervescent with acids. A quintal of this natural compound contains, according to Bergman, 33 parts of ſiliceous earth, 29 of pure terra ponderoſa, and 5 of clay, beſides lime, water, and vitriolic acid.

Lime.

Species.

I. Pure or quick-lime. Bergman knew not whether this ſubſtance exiſted in nature.

II. Aerated lime; chalk, or calcareous earth; a combination of lime with the aerial acid. It often contains marine ſalt of magneſia, calcareous marine ſalt, clay, and ſiliceous earth or iron. In the bowels, or on the ſurface of the earth, it conſtitutes lac lunæ, congelations, calcareous ſtones, marbles, calcareous ſpars, concretions or ſtalactites, &c.

III. Bituminous aerated lime, or lime impregnated with petroleum; ſwine-ſtone. It is found in France at Villers-Cotterets, Plombieres, and Ingrande in Anjou; at Rattwik in Dalecarlia, Kinekulle in Weſtrogothia, Kraſnaſelo in Ingermania, in Portugal, in Sweden, &c. If violently rubbed, or heated, it diffuſes a fætid ſmell, which ſometimes affects the noſtrils in the ſame manner with cat's urine; and ſome authors have therefore given it the name of *lapis felinus.* It effervesces with acids, decrepitates, and loſes its ſmell and colour in fire. When diſtilled in large quantities, it affords, 1. A

Species.

fetid liquor, which turns the ſyrup of violets green, and effervefces with acids; 2. A blackiſh oil, of a ſtrong ſmell, reſembling that which is obtained from pit-coal; 3. Concrete volatile alkali. The reſidue contains a little marine ſalt. This ſubſtance owes its peculiar properties to the bitumen mixed with it.

IV. Fluorated lime; fluor mineral, or vitreous ſpar. A combination of lime with the ſpathoſe or fluoric acid, with a mixture of clay and ſiliceous earth, and a little of the marine acid.

V. Lime ſaturated with a peculiar acid, probably metallic *; ponderous ſtone; Swediſh *Tungſten.* This is the weightieſt of all ſtones. It is found in ſmall yellow or red grains in the mines of Baſtnaes, near Ritterhute in Weſtmania; at Marienburgh and Altenburgh in Saxony, it is ſparry, bright, and whitiſh. It is often confounded with white tin ore. It ſcarce yields to the action of fire, and is vitrifiable only at the ſurface: it is not ſoluble in boiling water; the vitriolic acid ſeparates the lime: by diſſolving it in volatile alkali, precipitated by the nitrous acid, a white powder is obtained, which is the peculiar acid diſcovered by Scheele. In order to recognize and diſtinguiſh

---

* Found to be ſo. See Scheele's Eſſays, and De Luyart's on Wolfram, both tranſlated into Engliſh.

Species.

guiſh it from other ſtones, we muſt firſt reduce it to powder, and then pour upon it a due quantity of the nitrous or of the marine acid. This mixture, when gently heated, aſſumes a fine yellow colour. (See *Le Journal de Phyſique*, 1783, *tome* 22.

VI. Aerated lime, contaminated * with a ſmall mixture of muriatic magneſia, or marine ſalt of magneſia.

VII. Aerated lime, contaminated with clay; falſe marl.

VIII. Aerated lime, contaminated with ſiliceous earth. Some hewing ſtones and marbles give fire with ſteel, on account of the fragments of ſilex or quartz which they contain.

IX. Aerated lime, contaminated with a mixture of argillaceous and ſiliceous earth; perfect; marl.

X. Aerated lime, contaminated with iron and mangaueſe: falſe white iron ore; black and duſty, or hard, red, or whitiſh. The mines of Halleſors exhibit theſe varieties †.

Magneſia.

I. Pure magneſia. This is always a product of art.

II. Aerated

---

[*] The word contaminated, *inquinatus*, is uſed by Bergman to denote the mixture of two or more earths, when no real combination takes place. We ſhall therefore ſometimes ſubſtitute the word *mixed* in its place. A.

[†] All theſe ſpecies are ſaline ſubſtances, which will be deſcribed in the hiſtory of ſalts.

Species.

II. Aerated magneſia, diſſolved in water ſaturated with aerial acid.

III. Aerated magneſia, mixed with ſiliceous earth. It ſcintillates and effervefces.

IV. Magneſia, intimately combined with clay and ſiliceous earth; ſteatites, Briançon chalk, ſoap-ſtone, lapis ollaris, ſerpentine, lapis nephriticus.

V. Magneſia, combined with a conſiderable portion of ſiliceous earth, and a ſmaller quantity of calcareous and argillaceous earth, and contaminated with calx of iron. Aſbeſtos; mountain cork; mountain leather; amianthus. Bergman found a quintal of amianthus to contain 64 parts of ſiliceous earth, 18$\frac{3}{5}$ths of magneſia, 6$\frac{9}{10}$ths of lime, 6 of vitriolated ponderous earth, 3$\frac{3}{10}$ths of clay, and 1$\frac{1}{5}$th calx of iron; a quintal of aſbeſtos afforded 67 parts of ſiliceous earth, 16$\frac{4}{5}$ths of magneſia, 6 of clay, 6 of lime, 4$\frac{1}{5}$th of calx of iron.

VI. Magneſia mixed with argillaceous and ſiliceous earth, and with pyrites; a kind of ore of alum deſcribed and analyſed by M. Monnet, (*Syſt. de Mineralogie, genre* 9. *page* 161.

VII. Magneſia mixed with argillaceous and ſiliceous earth, pyrites, and petroleum; magneſian aluminous ſchiſtus.

Clay.

I. Pure clay. It is precipitated from alum by aerated volatile alkali.

II. Clay mixed with ſiliceous earth. Porcelain

Species.

earth; Chineſe kaolin. Solid clay from Saint-Iriez in Limouſin, from Japan, and from Saxony. Pulverulent clay from Weſtmania, Boſerap, and China. Theſe earths are often mixed with mica. Clays for potteries and delft-ware are coarſer, but of a ſimilar nature.

III. Clay mixed with iron and ſiliceous earth. Boles or bolar earth, grey, yellow, red, brown, and black. Theſe, when waſhed, become terræ ſigillatæ. Common clays, of a green, blue, or red colour, are of this ſpecies.

IV. Clay mixed with ſiliceous and calcareous earths. Argillaceous marl; pipe clay; agaric mineral or foſſil.

V. Clay mixed with ſiliceous and magneſian earth. Lemnian earth; fuller's earth; ſoap-ſtone; ſmectites. Bergman obtained from Lemnian earth, Hampſhire clay, and Engliſh fuller's earth, a conſiderable quantity of ſiliceous earth, about $\frac{1}{5}$th of clay, and as much aerated lime, with $\frac{1}{20}$th of aerated magneſia, and the ſame quantity of oxide of iron. He gives to theſe earths the generic name of *lithomarga*.

VI. Clay contaminated with ſulphur and vegetable alkali: alum ore of Tolfa and Solfaterra. Bergman takes it to be a volcanic product.

VII. Clay mixed with ſiliceous earth, pyrites, and petroleum; aluminous ſchiſtus. It is found in Italy, in the diſtrict of Liege, in Sweden, and in Jemteland. Black crayons, ſuch as thoſe from Bechel, near Seez in Normandy, and

Species.

and the ampelites, are of this ſpecies. Tripolis are of the ſpecies of aluminous ſchiſti, more or leſs burnt. Such are thoſe of Poligné in Normandy and of Menat in Auvergne.

M. Mongez comprehends under this ſpecies thoſe ſchiſti which contain much clay, and more or leſs ſiliceous earth and bitumen. Moſt of them contain likewiſe a mixture of calcareous earth, and effervеſce with acids. The proportions in which the component principles are mixed in theſe ſchiſti are extremely various. Some of them are ſo bituminous, that they burn with flame; others are full of pyrites, and effervеſce in the air; ſome again are exceſſively hard, and give fire with ſteel. M. Mongez admits five varieties: 1. Hard argillaceous ſchiſtus, or writing ſlate: 2. Soft argillaceous ſchiſtus, or ſlate for roofing houſes: 3. Soft ſiliceous ſchiſtus, uſed in poliſhing metals: 4. Hard ſiliceous ſchiſtus, uſed for whetting razors; ſcythe-ſtone: 5. Hard calcareous ſchiſtus, which makes an indifferent lime, ſuch as that of Allevard in Dauphiny.

VIII. Clay combined with nearly half its weight of ſiliceous earth, a little aerated lime, and ſome oxide of iron; cryſtal gems. Bergman's fine diſcoveries concerning the nature of cryſtal gems, which, from their exceſſive hardneſs and apparent inalterability, were formerly thought not to be ſuſceptible of a chemical analyſis, have been

Species.

confirmed by the experiments of Meſſrs Margraf, Gerhard, and Achard. The following is the reſult of Bergman's analyſis of the five cryſtal gems, which are varieties of the ſpecies we are now conſidering.

	Clay.	Silic.	Lime.	Iron.	
Oriental emerald contains	60	24	8	6	100dth parts.
Oriental ſapphire -	58	35	5	2	
Saxon topaz - -	46	39	8	6	
Oriental hyacinth -	40	25	20	13	
Oriental ruby - -	40	39	9	10	

The means employed by this ingenious chemiſt for reſolving ſtones into their component principles, though very ingenious are very ſimple. (See *le Journal de Phyſique*, 1779, *tome* 14. *p.* 268; *tome* 21. *p.* 56 *et* 101) *.

IX. Clay combined with a portion of ſiliceous earth, equal to more than half the weight of the whole maſs, with a very ſmall quantity of aerated lime and ſome iron; garnet, ſchorl, tourmalin. In theſe ſtones the proportion of the iron varies. (See the analyſis of the Tourmalin of Tyrol, *by M. Muller, Journal de Phyſique, tome* 15. *p.* 182. *ann.* 1780).

X. Clay ſlightly combined with half the weight of the maſs, or rather more, of ſiliceous earth, and a ſmall quantity of lime; zeolite. M. Mongez conſiders the azure ſtone, *lapis lazuli*, as a zeolite. M. Margraaf found a ſmall

---

* Or rather Bergman's Eſſays.

Species.

ſmall quantity of gypſum, ready formed, in the *lapis.*

XI. Clay combined with a conſiderable quantity of ſiliceous earth and a little magneſia; talc, mica. The proportion in which the principles exiſt in this ſtone is not yet perfectly determined.

Genus V. *Siliceous Earth.*

I. Pure ſiliceous earth. This is obtained by melting white quartz with four parts of fixed alkali, diſſolving the whole in diſtilled water, and precipitating the earth with an acid. The precipitated earth is then waſhed and thoroughly dried.

II. Siliceous, united with a very ſmall proportion of argillaceous and calcareous earth: The ſeveral varieties of rock-cryſtal, of quartz, and of grit-ſtone.

III. Siliceous, united with argillaceous earth. Hydrophanes chalcedony or *oculus mundi*: according to M. Gerhard of Berlin, this ſtone contains a greater quantity of clay than of ſiliceous earth. Opal: M. Mongez conſiders cat's eye, fiſh's eye, and giraſol, as varieties of this ſtone. To theſe three he adds agate and its varieties; cacholong, cornaline, ſardonyx, gun-flint, and jade. They have not as yet been analyſed with ſufficient accuracy.

Species.

IV. Siliceous earth united with clay ſtrongly impregnated with iron; jaſper. M. Mongez conſiders the ſinople as a variety of the jaſper.

V. Siliceous earth united with ſuch a quantity of martial earth as renders it ponderous; falſe jaſper. M. Mongez calls this ſtone a metallic quartz. He diſtinguiſhes it into the black coloured by iron, and the red coloured by copper.

VI. Siliceous united with argillaceous earth, and a little lime; petroſilex. This ſtone ſometimes gives fire with ſteel, and effervesces with acids. It melts in a ſtrong fire.

VII. Siliceous earth united with clay, and a little magneſia; feldt-ſpar. It ſuffers a change of colour, and melts in the fire. Air does not decompoſe it. It gives fire with ſteel, and breaks at every ſtroke.

VIII. Siliceous earth united with magneſia, aerated and fluorated lime, and a portion of oxide of copper and iron; praſe, chryſopraſe. Bergman gives the compoſition of this ſtone from an analyſis of it by M. Achard.

I. APPENDIX.

Bergman, in his firſt appendix, treats of mineral ſubſtances mechanically mixed or united, in ſuch a manner

ner that the principles of the mixture or compoſition may be at once diſtinguiſhed by ocular obſervation. We ſhall mention none but mixtures of earths; ſuch are the ſtones known by the name of rocks, *ſaxa*. M. Mongez, who has made conſiderable additions to what Bergman had done on this head, diſtinguiſhes theſe ſtones or rocks into two genera. 1. The firſt, thoſe whoſe parts are not united by any cement, but ſimply adhere by juxta-poſition. Theſe are formed by the agglutination of a number of fragments. He diſtinguiſhes them into three ſpecies,—granite, gneis of Saxony, and horn-ſtone. 2. His ſecond genus comprehends ſuch mixed ſtones as have their parts incruſted in a common cement; as is the caſe with the four ſpecies of porphyry, ophites or ſerpentine, breccia, and pudding-ſtone. We ſhall here give the varieties of theſe ſtones acknowledged by this naturaliſt.

I. Granite is a compoſition formed by the union of quartz, feldt-ſpar, mica, ſchorl, and ſteatites, mixed in various proportions; conſiſting ſometimes of two of theſe ſubſtances, ſometimes of three, and ſometimes of four. Quartz is always the baſe.

Variety I. Granite of two ſubſtances; granitin.
- A. Quartz and feldt-ſpar.
- B. Quartz and ſchorl.
- C. Quartz and mica.
- D. Quartz and ſteatites.

Variety II. Granite of three ſubſtances.
- A. Quartz, feldt-ſpar, and mica. This is the moſt common, the moſt plentiful, and the moſt varied of all.
- B. Quartz, mica, and ſchorl.

C. Quartz, ſchorl, and ſteatites.

Variety III. Granite of four ſubſtances.

A. Quartz, feldt-ſpar, ſchorl, and mica.

B. Quartz, feldt-ſpar, ſchorl, and ſteatites.

II. GNEIS is a mixture of quartz in grains, and mica in a greater or a leſs proportion, with a conſiderable quantity of clay or ſteatites, which conſtitutes the baſe of the ſtone. This ſtone is foliated like the ſchiſtus. Expoſure to the air ſoon alters and waſtes it down, becauſe the clay abſorbs the moiſture. Many varieties of the gneis are found on the Alps of Dauphiny.

III. HORN-ROCK is a compact ſtone, conſiſting of very minute particles of an earthy aſpect, and exhibiting over its ſurface ſparkling points of mica. When moiſtened or ſtruck, it diffuſes a clayey ſmell. It hardens in the fire like clays, and when expoſed to a very ſtrong heat, melts into a blackiſh ſcoria or a black glaſs. Its colours are extremely various. M. Mongez thinks the Swediſh *trapp* a variety of the hornſtone.

IV. PORPHYRY ſeems to be compoſed of a fine hard paſte, of the ſame nature with red jaſper, containing either irregular or cryſtalline grains of quartz, white or reddiſh feldt-ſpar, and ſometimes of green or black ſchorl.

V. OPHITES, or ſerpentine, is a ſpecies of porphyry, of a green paſte, and greeniſh white ſpots. The ſpots of the ophites are generally oblong; whereas thoſe of porphyry are ſquare or rhomboidal. The thunderſtone is a variety of this ſpecies.

VI. Breccia, from the Italian word *briccia*, a crumb or fragment. This is a mixed ſtone of a much later formation than any of the above, formed of the ruins of the primary mountains, of irregular worn pieces of ſilex, &c. united by a common cement. M. Mongez makes no ſpecific diſtinction between breccias and pudding-ſtones; but gives to the latter a compound name, indicating the nature both of their fragments and of their cement. He diſtinguiſhes theſe ſtones into eight varieties: The calcareo-calcareous breccia, under which denomination both the breccia properly ſo called and the lumachello are included; the ſiliceo-ſiliceous breccia, or the pudding-ſtone*; the breccia conſiſting of calcareous and ſiliceous fragments, with a calcareous cement; the breccia with ſiliceous cement, and fragments of the calcareous and ſiliceous genus; the arenario-ſiliceous breccia,—of this variety is the grey ſtone of Chartres; the breccia with a cement and fragments of jaſper; the breccia with a cement and fragments of porphyry; and the volcanic breccia.

II. APPENDIX.

Volcanic Products.

M. Mongez, with Bergman, divides volcanic products into ſuch as are formed by fire, and ſuch as owe their

---

* According to this nomenclature, the firſt of the two names affixed to the breccia expreſſes the nature of its cement; the ſecond, that of its fragments.

their origin to water. The laſt are nothing but earthy matters, which having been diſſolved or ſuſpended in water, are by it depoſited in places adjacent to volcanoes, and among their products: of this kind are the calcareous and ſiliceous incruſtations, as well as the zeolites which are often found among volcanized ſubſtances.

M. Mongez divides the genuine products of volcanoes into three orders; 1. Earthy ſubſtances, but little altered by fire; ſuch as calcareous matters, clays, garnets, hyacinths, ſchorls, and mica. 2. Earthy ſubſtances which have been burnt and calcined; ſuch as volcanic aſhes or rapillo, and puzzolana, the tufa, the peperino of the Italians, pumice-ſtone, and the white earth which covers ſolfatara. 3. Earthy ſubſtances which have been in a ſtate of fuſion, or lavas; and of theſe he admits ſeveral kinds,—the ſpongy lava, the compact lava, the lava in ſtalactites, and volcanic glaſſes. After theſe diviſions, he mentions ſuch earthy volcanic products as are of an uncertain origin. Under this order he reckons particularly volcanic ſchorls, and ſtill more baſaltes, which he takes to be maſſes of trapp ſoftened by the humid vapours of volcanoes, and ſlowly dried after theſe have ceaſed to exhale.

---

§ III. *Chemical Claſſification of Earths and Stones, by Mr* KIRWAN.

IN the year 1784, Mr Kirwan, a celebrated chemiſt of London, publiſhed a work on mineralogy; in which he gives a general claſſification of minerals, founded on their chemical properties or combinations. The firſt part of his work contains earths and ſtones. He gives inſipidity, dryneſs, fragility, incombuſtibility, and inſolubility, as the characteriſtic properties of theſe ſubſtances. With Bergman, he diſtinguiſhes five genera of ſimple earths,—calcareous earth, ponderous earth or barytes, magneſia or muriatic earth, argillaceous earth, and ſiliceous earth. From a chemical analyſis, he arranges all known earths and ſtones under theſe five genera.

CALCAREOUS GENUS.

To this he refers twelve ſpecies.

Species.

I. Calcareous earth, not combined with any acid; virgin lime of volcanoes. *Falconer on Bath Waters, vol.* i. *p.* 156, 157; *Monnet. Mineral. p.* 515.

II. Calcareous earth, combined with aerial acid. Its varieties, which he arranges in two

Species.

two ſeries, are tranſparent calcareous ſpar, opaque ſpar, ſtalactites, tophi, incruſtations, petrifactions, agaric mineral or ghur, chalk, limeſtone, and marbles. *Bayen, Journal de Phyſique, tome* ii. *p.* 496.

III. Calcareous earth combined with the vitriolic acid, gypſum, ſelenite, or plaſter *. He admits two ſeries; the tranſparent and the opaque.

IV. Calcareous combined with the ſparry acid, fluor ſpar, petuntze of Margraf. Series I. Tranſparent fluor ſpars: II. Opaque fluor ſpars.

V. Calcareous earth combined with the acid of tungſten. Tungſten or ponderous ſtone. *Woulfe, Phil. Tranſ.* 1779, *p.* 26.; *Scheele's Eſſays.*

VI. Aerated calcareous earth, mixed with a diſcernible quantity of magneſia. Var. I. Compound ſpar, deſcribed by *Mr Woulfe, Phil. Tranſ.* 1779, *p.* 29. II. Creutzwald ſtone, analyſed by *M. Bayen* †, *Jour. de Phyſ. tome* xiii. *p.* 59.

VII. Aerated calcareous earth, mixed with a diſcernible quantity of clay. Var. I. Calcareous marl. II. Traveſtino, margodes, ſtony

---

* Mr Kirwan claſſes many earthy ſalts among ſtones; though they be even one half more ſoluble than the moſt ſoluble ſtones. A.

† It would be ſuperfluous to give here the proportions in which the ſeveral principles are united in theſe ſtones, as we will have occaſion to mention them in the chemical hiſtory of ſalts. We ſhall give the proportions only in Mr Kirwan's two laſt genera, which we conſider as genuine earths. A.

Species.

ſtony marl. *Ferber's Travels in Italy, p.* 117, 119.

VIII. Aerated calcareous earth, mixed with a diſcernible quantity of ponderous earth; barytic marl of Derbyſhire.

IX. Aerated calcareous earth, mixed with a diſcernible portion of ſiliceous earth. Var. I. Stellated ſpar. II. Calcareous grit; hard free-ſtone, *Moilon. Monnet, Mineralogy, p.* 116.

X. Aerated calcareous earth, mixed with a ſmall quantity of petroleum. Swine-ſtone.

XI. Aerated calcareous earth, mixed with a diſcernible quantity of pyrites; *pierre de St. Ambroix*, analyſed by the *Baron de Servieres, Journ. de Phyſ. tome* xxi. *p.* 394.

XII. Calcareous earth, mixed with a diſcernible portion of iron. Var. I. Aerated calcareous earth impregnated with iron, *Rinman, Mem. de Stock.* 1754. II. Tungſten impregnated with iron, *Cronſtedt, Mem. de Stock.* 1751.

To theſe twelve ſpecies of calcareous earth, Mr Kirwan adds ſix ſpecies of compound ſtones, in which calcareous earth predominates. 1. Mixtures of the ſimple calcareous ſpecies, ſuch as ſelenite and chalk, vitreous ſpar and tungſten. 2. Compounds made up of the calcareous and barytic ſpecies. Of this kind is a yellow ſtone of Derbyſhire, formed of chalk with ſmall lumps of ponderous ſpar. 3. Compounds of the calcareous and magneſian ſpecies; white marble mixed with ſteatites, the pietra telchina, and the verde antico.

antico. 4. Compounds of the calcareous and the argillaceous ſpecies, of chalk and ſchiſtus; ſuch as the green campan of the Pyrenees, the red campan, Florence marble, the griotte, the amandula, the cipolin of Rome (ſee *Bayen, Journ. de Phyſique, tome* xi. *p.* 499. 801, *et tome* xii. *p.* 51, 56, *et* 57.); of chalk and mica, as the cipolin marble of Autun, the macigno, the pietra bigia, and the columbina or turchina of the Italians. 5. Compounds of the calcareous and the ſiliceous ſpecies; ſcintillating marbles, marble with a mixture of lava. 6. Laſtly, compounds of calcareous earth, with two or more of the other genera; ſuch as calcareous porphyry, and the lime-ſtone mixed with mica.

BARYTIC GENUS.

Under this genus he reckons ſix ſpecies.

Species.

I. Ponderous earth combined with the aerial acid. A ſtone found by Dr Withering on Alſton Moor in Cumberland.

II. Barytes combined with the vitriolic acid. Ponderous ſpar.

III. Barytes combined with the ſpathoſe acid. This ſubſtance exiſts not in nature, but is a product of art.

IV. Barytes combined with the acid of tungſten. This is obtained in the ſame manner as the preceding.

V. Aerated barytes, mixed with a diſcernible quantity of ſilex and iron. Bindheim.

VI.

Species.

VI. Ponderous ſpar, mixed with ſilex, mineral oil, and earthy ſalts. Hepatic ſtone, white, grey, yellow, brown, or black.

MURIATIC OR MAGNESIAN GENUS.

Mr Kirwan reckons eight ſpecies of this genus, arranging under it both thoſe earths and ſtones in which magneſia predominates, and thoſe which, though containing more ſilex than magneſia, yet exhibit all the characteriſtics of the magneſian genus.

Species.

I. Magneſia combined with the aerial acid, and mixed with other earths. Var. I. Mixed with ſilex; *ſpuma maris*. The Turkiſh tobacco-pipes, and the Canadian pipe, are compoſed of this ſubſtance. II. Mixed with calcareous earth and iron; olive-coloured and bluiſh earth near Thionville. III. Mixed with clay, talc, and iron; greeniſh yellow Sileſian earth.

II. Magneſia combined with the aerial acid, with above four times its weight of ſilex, and a ſmall proportion of clay. Var. I. Steatites. II. Lapis ollaris.

III. Aerated magneſia combined with ſilex, calcareous earth, and a ſmall proportion of clay and iron. Var. I. Fibrous aſbeſtos. II. Coriaceous aſbeſtos; mountain cork.

IV. Aerated magneſia, combined with ſilex, aerated

Species.

ted calcareous earth, barytes, clay, and iron. Amianthus.

V. Pure magneſia, combined with a quantity of ſilex more than equal to its own weight, a third part of clay, nearly a third of water, and one or two tenths of iron. Serpentine, *lapis nephriticus*, Italian gabro.

VI. Pure magneſia, combined with twice as much ſilex, and leſs than an equal quantity of clay. Venetian talc, Muſcovy talc.

VII. Magneſia combined with the ſparry acid. This ſubſtance is not found in nature.

VIII. Magneſia combined with the acid of tungſten. This ſubſtance is not known to exiſt in nature.

To theſe eight ſpecies, Mr Kirwan adds five others; compounds in which magneſia predominates. 1. Compounds of the ſeveral ſpecies of magneſia with one another; ſteatites and talc, Briançon chalk; ſerpentine with ſteatites or aſbeſtos. 2. Compounds of the magneſian with the calcareous ſpecies; red or yellow ſerpentine, with ſpots of white calcareous ſpar, *potzovera*; the black is the *Nero di prato*, and the green the *verde di ſuza* of the Italians. 3. Compounds of the magneſian and the barytic ſpecies; ſerpentines with ſpots or veins of ponderous ſpar. 4. Compounds of the magneſian and the argillaceous ſpecies; ſteatites mixed with clay, mica, or ſchiſtus. 5. Compounds of the magneſian with the ſiliceous ſpecies; ſerpentine veined with quartz, feldt-ſpar, or ſchorl.

ARGIL-

ARGILLACEOUS GENUS.

Mr Kirwan reckons fourteen ſpecies of this genus.

Species.

I. Clay ſaturated with the aerial acid; *lac lunæ*, according to Schreber's analyſis.

II. Clay combined with the aerial acid, and mixed with ſilex and water; potter's clay, pipe and porcelain clay, &c.

III. Clay ſaturated with the vitriolic acid; embryon alum in ſcales like mica. *Baumé.*

IV. Clay ſaturated with the marine acid; marine embryon alum.

V. Clay combined with about one part and an half of ſilex, nearly one part of magneſia, and half a part of dephlogiſticated iron; mica.

VI. VII. VIII. IX. Clay combined with ſiliceous earth, magneſia, calcareous earth, iron, or a bitumen; ſlate, blue ſchiſtus, pyritous ſchiſtus, bituminous ſchiſtus, and argillaceous ſchiſtus.

X. Clay combined with a little ſilex, magneſia, and calcareous earth, with a quantity of iron calx, nearly equal in weight to the clay; hornſtone, or *horn-blende.*

XI. Clay combined with a quantity of ſilex equal to four times its own weight, with half its weight of calcareous earth, and ſomewhat more than its weight of iron; toadſtone.

XII. Clay united to from twice to eight times its own weight of ſilex, half its weight of lime,

and

Species.

and once or twice its weight of water; zeolite.

XIII. Clay united with four times its own weight of ſilex, and one third of iron; pitch-ſtone, lava.

XIV. Clay mixed with a diſcernible portion of red iron calx, and ſometimes with ſteatites; red chalk.

To theſe Mr Kirwan adds ſix compound ſpecies in which the argillaceous genus predominates.

SILICEOUS GENUS.

This genus, in Mr Kirwan's ſyſtem, comprehends twenty-ſix ſpecies.

Species.

I. Siliceous earth nearly pure; quartz, cryſtal, ſand.

II. Siliceous earth, with one-fourth clay, and one-fortieth calcareous earth; ſilex, gun flint. See *Wiegleb. Act. nat. Curioſ. t.* 6. *p.* 408.

III. Siliceous earth, with from one-fourth to one-third clay, and from one-twelfth to one-fifteenth calcareous earth; petroſilex.

IV. Siliceous earth, with one-third clay, and one-ſixth or one-ſeventh iron calx; jaſper.

V. Fine ſiliceous earth, mixed in various proportions

Species.

tions with iron and other earths; agate, opal, chalcedony, onyx, cornaline, and ſardonyx. Precious ſtones of the ſecond order.

VI. Siliceous earth, with from an equal quantity to nearly three times its own weight of clay, from a ſixth part to an equal quantity of calcareous earth, and from one-eighteenth to an equal quantity of iron; ruby, topaz, hyacinth, emerald, ſapphire. Precious ſtones of the firſt order.

VII. Amethyſt. The principles of its compoſition are not yet known.

VIII. Siliceous earth, with one fifty-fifth of calcareous earth, a ſmaller quantity of magneſia, and a very ſmall quantity of iron, copper, and ſparry acid; chryſopraſe.

IX. Siliceous earth, with blue fluor ſpar, and a little gypſum; *lapis lazuli.* M. Margraf found in it chalk, gypſum, ſilex, and iron. M. Rinman obſerved it to contain a portion of the ſparry acid.

X. Jade. M. Kirwan conjectures it to conſiſt of ſilex, magneſia, and iron.

XI. Siliceous earth, with clay, ponderous earth, and magneſia; feldt-ſpar, petuntze, and Labradore ſtone. 100 parts of feldt-ſpar contain 67 parts of ſilex, 14 of clay, 11 of ponderous earth, and 8 of magneſia.

XII. Siliceous zeolite. This ſubſtance is found at Mæſſiberg. It differs from the true zeolite in giving fire with ſteel, which the other

Species.

does not; and this property is a proof that ſilex is one of its principles.

XIII. Siliceous earth, with clay equal to more than a third part of its weight, and one-ninth of chalk, with no iron; white garnet of Mount Veſuvius. 100 parts of it contain, according to Bergman, 55 of ſilex, 39 of clay, and 6 of chalk.

XIV. Siliceous earth with clay, chalk, and one-tenth of iron; garnet. Bergman ſays that 100 parts of this ſtone contain 48 of ſilex, 30 of clay, 12 of calcareous earth, and 10 of iron.

XV. Siliceous earth, with a good deal of clay, nearly one-tenth of chalk, and a little iron and magneſia; ſchorl.

XVI. Bar ſchorl, German *ſtangen ſhoerl*; found by M. Fichtel on the Carpathian mountains. It is found among lime-ſtone, is of a priſmatic form, and gives a ſlight efferveſcence with acids. M. Bindheim obtained from 100 parts of this ſchorl, 61 of ſilex, 21 of chalk, 6 of clay, 5 of magneſia, 1 of iron, and 3 of water.

XVII. Tourmalin. The following are, according to Bergman, the proportions of the principles of the tourmalins of Tyrol, Ceylon, and Brazil.

	Clay.	Sil.	Cal. E.	Iron.	
Tourmalin of Tyrol	42	40	12	6	100dth parts.
——— of Ceylon	39	37	15	9	
——— of Brazil	50	34	11	5	

Species.

XVIII. Baſaltes, trapp. 100 parts contain, according to Bergman, 52 of ſiliceous earth, 15 of clay, 8 of calcareous earth, 2 of magneſia, and 15 of iron.

XIX. Rowly rag. A grey granulated ſtone, which heat renders magnetic and melts, and which in the air acquires an ochreous cruſt. 100 parts of it, according to Withering, contain 47.5 of ſiliceous earth, 32.5 of clay, and 20 of iron.

XX. Silex, clay, iron, and calcareous earth, melted together by volcanic fire.

1. Cellular lavas, improperly called pumice-ſtones. Theſe have been very imperfectly melted. Bergman found them to contain from $\frac{45}{100}$ to $\frac{50}{100}$ of ſilex, from $\frac{15}{100}$ to $\frac{20}{100}$ of iron, $\frac{4}{100}$ or $\frac{5}{100}$ of pure calcareous earth; and the reſt of the compoſition clay.
2. Compact lavas. Theſe have undergone a ſecond fuſion, and have therefore but few cavities. They ſound when ſtruck.
3. Vitreous lavas, or lava entirely melted into black, green, blue, &c. glaſs. M. Sauſſure, by melting together, more or leſs thoroughly, certain quantities of horn-rock, marl, and ſchiſtus, has produced imitations of theſe lavas. (*Voyage dans les Alpes, p.* 127).

XXI. Siliceous earth, united with about a tenth part of magneſia, and a very ſmall portion of calcareous earth; pumice-ſtone.

Species.

XXII. Siliceous earth, with leſs than its own weight of magneſia and iron; martial magneſian ſpar. Piſolite found at Sainte Marie, by M. Maret.

XXIII. Siliceous earth, with one-third its own weight of aerated calcareous earth; Turkey ſtone. Oil hardens it.

XXIV. Siliceous earth, mixed with a little iron and calcareous earth. Rag-ſtone.

XXV. Quartz conſolidated with leſs than its own weight of calcareous earth or clay, and a little iron; grit reducible to ſand by pounding. Var. I. Grit with a calcareous cement; of Fontainebleau: it effervеſces with acids. II. With an argillaceous cement. This variety does not effervеſce. It is uſed for building, for whet-ſtones, and for filtering water, &c.

XXVI. Siliceous earth conſolidated with ſemi-phlogiſticated calx of iron; brown or black ſcintillating ſtone, which becomes red and exfoliates in the air. Semi-phlogiſticated iron agglutinates earths; but iron, when very much calcined, poſſeſſes not the ſame agglutinative power. This fact has been demonſtrated by Meſſrs Edward King and Gadd.

To theſe twenty-ſix ſpecies of the ſiliceous genus, Mr Kirwan annexes ſix other ſpecies in which that earth predominates. The varieties which he includes under theſe ſpecies, are compounds frequently found in in mountains of ancient formation. The Engliſh chemiſt draws this ſupplement to the ſiliceous genus from M. Sauſſure's obſervations on the Alps. Among theſe varieties are, the ſeveral kinds of granite, puddingſtones, granitelloes, granitines, porphyry, gneis, variolite, &c.

CHAP. IV.

Of the Chemical Analyſis of Earths and Stones.

THOUGH, within theſe few years, the chemical analyſis of earths and ſtones has been much more induſtriouſly proſecuted than at any former period, yet ſtill it muſt be confeſſed, that our knowledge of their component principles is far from being ſufficiently extenſive or accurate, to be aſſumed as the foundation of a methodical arrangement of them. Hence the diverſity of the chemical claſſifications of theſe ſubſtances which have been hitherto offered to the public; and for this reaſon have we been induced to give an account of the different methods ſucceſſively propoſed by three celebrated chemiſts in the courſe of a very ſhort period of time.

The chief advantage which has been gained from the various reſearches of late made into the nature and component principles of earths and ſtones, is the diſcovery of proper means for diſtinguiſhing theſe. The method of analyſing theſe ſubſtances is not a little complex; and I mean to give only a general account

of

of it in this chapter. In fact, as the ſtudent of chemiſtry, who has read only the foregoing part of this work, though acquainted in ſome degree with the phænomena of fire, air, and water, muſt be entirely ignorant of the properties of ſaline bodies, which are ſo efficaciouſly employed in ſeparating and examining the conſtituent principles of earths and ſtones; if we were here to ſpeak of the uſe of ſolvents in analyſing theſe matters, we ſhould both deviate from that order and regularity which are ſo neceſſary in laying down the elements of phyſical ſcience, and likewiſe run the riſk of becoming unintelligible: I ſhall therefore reſerve a minute and particular account of the chemical decompoſition of earths and ſtones by acids and alkalis to a different part of the work*, explaining here nothing but its general principles.

When we wiſh to diſcover the chemical properties of a ſtone or an earth, we muſt begin with a careful examination of its phyſical properties, its form, hardneſs, gravity, colour, &c. The extraneous ſubſtances, of which there is always a greater or a leſs quantity mixed with ſuch bodies, muſt next be ſeparated from it, ſo as that it may be purified from all mixture, by picking, waſhing, &c. A ſtone ſhould be reduced to powder, or, if the expreſſion may be allowed, to the ſtate of earth, before we attempt to examine its principles. The firſt trial that is made is generally with fire. A few ounces are expoſed in a well-baked crucible of clay or porcelain, to the heat of a ſtrong furnace, ſuch as Macquer's; that of a potter's or a glaſsmaker's is ſtill better for the purpoſe. It is to be obſerved of the crucibles uſed in this operation, that the argillaceous

---

* See the treatiſe *on the Analyſis of Waters*, at the end of this work.

argillaceous earth of which they are chiefly compoſed has often a conſiderable ſhare in producing the alteration which the ſtony ſubſtance ſeems to ſuffer from heat: but we have no way of avoiding this inconvenience; and indeed it becomes of little conſequence in a comparative analyſis of a great number of ſtones. Of late years, the uſe of the blow-pipe for treating mineral matters with fire, has been introduced; and in the chemical examination of an earth or a ſtone, this inſtrument may be employed together with the above deſcribed means for decompoſition. Thoſe ſubſtances are expoſed to the fire, either alone or ſeveral of them mixed together, or with a mixture of ſome ſaline matters to be afterwards deſcribed *. Laſtly, they may be likewiſe treated with a machine for pouring vital air on coals, of which I have given a deſcription in my *Memoires de Chimie*, and which produces a heat that for intenſity may be compared to the focus of a glaſs lens, ſuch as that of the academy. Theſe operations produce either a fuſion more or leſs perfect, or ſome change of colour, conſiſtency, form, &c. which is to be carefully deſcribed. The proceſs muſt be farther carried on, by putting the ſtony matter into an earthen retort, fitted up with a receiver and a pneumato-chemical apparatus †, in order to collect whatever water and aeriform fluids may be diſengaged. Matters which afford theſe products are properly ſalino-earthy ſubſtances, though they be conſidered as ſtones by

---

* See Bergman's paper on the blow-pipe, with Mongez's notes *Manuel de Mineralogiſte*; or Cullen's Engliſh tranſlation of Bergman.

† See a deſcription of this apparatus under the article *Gaz* of the Chemical Dictionary, in M. Sigaud de la Fond's work on the different kinds of air. A.

by naturaliſts; yet, as they are often found mixed with genuine earths, it is therefore proper to mention here the general mode of examining them. The action of fire ſhows whether a ſtone be ſiliceous, aluminous, or mixed. But as moſt ſtones are of the latter kind, and many of them conſiſt of ſeveral, ſome even of five or ſix, different ſubſtances united in various proportions, other proceſſes are likewiſe to be employed for determining the principles of their compoſition. Theſe conſiſt in treating them with ſeveral acid and alkaline ſolvents, the ſucceſſive application of which ſeparates all the principles of which they conſiſt.

The action of air, and of water in vapour, may likewiſe contribute to make us underſtand the nature and conſtituent parts of earthy and ſtony matters. Some of them ſuffer no alteration from theſe agents; others are divided, and gradually aſſume a new form, colour, and conſiſtency. Theſe phænomena belong chiefly to ſtones of a very compound nature, and containing much iron. Laſtly, lixiviation with cold and warm water, ſhows whether they contain ſaline matters, however difficult it may be found to bring theſe to ſolution.

Such are the means by the uſe of which modern chemiſts have been able to determine the nature and the component principles of ſo great a number of earths and ſtones. I have here given but a very ſhort and general account of them. In the hiſtory of ſaline matters, we ſhall give all thoſe particulars concerning them which cannot be conveniently or advantageouſly introduced here.

SECTION II.

CHAP. I.

Of Saline Subſtances in general; their Characteriſtics, Nature, and the Method of arranging them.

SALINE ſubſtances, of which there are a very conſiderable number, poſſeſs peculiar properties by which they are diſtinguiſhed from thoſe which we have hitherto been examining. The properties which have been employed by chemiſts as characteriſtics of ſaline matters, are ſuch as leave their real nature ſomewhat uncertain: being common to many other bodies beſides ſalts, they extend this claſs of ſubſtances far beyond its juſt limits. Taſte and ſolubility in water, which have been always given as characteriſtics of ſaline ſubſtances, belong to many bodies which are not ſaline; as for inſtance, to all mucilages and animal matters. Theſe two properties again exiſt in a very low and imperfect degree in ſeveral ſaline ſubſtances. Naturaliſts have not been more accurate in their definitions of ſalts: the tranſparency and cryſtalline form which many naturaliſts have conſidered as peculiar to them,

them, belong equally to many other matters, eſpecially earths, while ſome ſalts are quite deſtitute of them. Macquer has, therefore, aſſerted, with great truth, that the true limits which divide ſaline matters from other claſſes of ſubſtances are not well known.

Yet as we *muſt* take *ſome* ſide, and form ſome determinate notions concerning the properties of theſe matters, we ſhall take a general view of them, before proceeding to the hiſtory of each particular ſalt.

We acknowledge as ſaline ſubſtances, all ſuch as poſſeſs the greater part of the four following properties: 1. A ſtrong tendency to combination, or affinity of compoſition: 2. A ſtronger or fainter taſte: 3. A greater or a leſs tendency to ſolution: 4. Abſolute incombuſtibility. Before proceeding to conſider each of theſe properties by itſelf, we muſt obſerve, that in proportion as a body contains more or fewer of them, and thoſe in a greater or leſs degree, it is more or leſs of a ſaline nature. From this, however, we muſt not conclude, that matters poſſeſſing theſe properties but in a very faint degree are not ſaline. Were we to admit ſuch a principle, we ſhould expoſe ourſelves to frequent errors; as it ſometimes happens that two ſalts, which in a ſolitary ſtate poſſeſſed theſe properties in a very low degree, afford ſtill fainter indications of them after being combined. In ſuch caſes recourſe muſt be had to chemical analyſis, which, by ſeparating the ſubſtances, will render their chemical properties more obſervable.

§ I. *Tendency to Combination conſidered as a Characteriſtic property of Salts.*

MOST ſalts have a tendency to combine with many different ſubſtances. Among ſalts we find the moſt active bodies in nature, capable of forming an infinite number of combinations, by entering into union with others. Chemiſts have, therefore, always made moſt uſe of ſaline matters; ſome of which they have honoured with the names of *ſolvents* and *menſtrua*. Yet this tendency to combination is far from being the ſame in all ſalts. Some of them poſſeſs it in ſo ſtrong a degree, that they corrode and deſtroy, or diſſolve whatever touches them, even vitrifiable and quartzoſe ſtones not reſiſting their attacks; ſuch is the power of many of thoſe pure ſalts that are known by the names of *acids* and *alkalis*. Others, though not poſſeſſed of ſuch a force of combination, unite readily with many bodies. Laſtly, there are ſome among them, whoſe tendency to combination is but very trifling, and ſcarce ſuperior to that of earthy matters. But the cauſe why, in theſe latter, the tendency to combination is ſo ſmall is, their being in a great meaſure ſaturated, as is obſervable of moſt neutral ſalts. After this, we cannot well be ſurpriſed that ſalts are ſcarce ever found in a pure or ſolitary ſtate in the bowels of the earth.

§ II. *Taſte conſidered as a Characteriſtic of Salts.*

TASTE has been always conſidered as ſo eſſential a property of ſaline ſubſtances, that ſeveral philoſophers have conſidered them as the only bodies in nature poſſeſſed of this property, and the principle of all taſte. Though this opinion be not demonſtratively certain, as there are many bodies, ſuch as metals, which have a diſcernible taſte, though not ſaline, while, again, ſeveral ſaline ſubſtances have ſcarce any taſte; yet it muſt be acknowledged, that moſt ſalts poſſeſs the property of taſte; and this property is therefore to be conſidered as one of their leading characteriſtics. The taſte of ſalts, like their other properties, is different in different ſpecies. In order to underſtand aright on what circumſtances it depends, and whence the cauſes of its varieties, we muſt firſt endeavour to diſtinguiſh what conſtitutes the peculiar nature of this property. By taſte, we uſually underſtand an impreſſion made on a certain organ which nature has given us for the purpoſe of diſtinguiſhing by it ſome material body, and from which we judge of that body as uſeful or noxious, and determine either to make uſe of it or reject it. It is therefore the action of the ſapid body on the nerves of the tongue and palate of animals, which informs them that one ſubſtance may be of uſe, or another hurtful to them. But can this property of bodies affect only the nerves of the tongue? will it not act with equal force on the whole nervous ſyſtem? Thoſe who are acquainted with the phænomena of the animal œconomy, that the action which conſtitutes taſte or ſapidity,

dity, muſt affect all the other nerves, and muſt always be proportioned to the ſenſibility of the ſubjects and the organs on which it operates. This idea of taſte naturally leads us to think, 1. That this quality of bodies will make almoſt no impreſſion on ſuch parts of the body as have but few nerves, or of which the nerves have but little ſenſibility, on account of their being covered; as on the ſkin where they are defended by the reticular membrane and the epidermis. 2. That this quality of bodies will act with the moſt energy on thoſe organs in which the nerves are largeſt, moſt numerous, and of a form the moſt proper for receiving an extenſive contact, and a violent emotion from ſalts; the epidermis being ſo thin as to leave the nerves almoſt naked. The ſuperior ſurface of the tongue, the roof of the mouth, and all the innert part of the mouth in general, are ſuſceptible of the ſenſation of taſte, from a vaſt number of bodies which make no ſuch impreſſion on the leſs delicate ſenſibility of the other parts of the ſkin. 3. That bodies which have no taſte and no power of affecting the ſkin, may notwithſtanding this act upon organs which are more delicate, and have nerves of greater ſenſibility, ſuch as the ſtomach and the inteſtines.

Admitting theſe facts, we may diſtinguiſh taſtes and ſapid bodies into three claſſes, under which all the ſaline ſubſtances that we are to examine may be arranged. The firſt claſs comprehends ſuch ſalts as have the ſtrongeſt taſte, and affect the ſkin in the moſt ſenſible manner. The impreſſion of theſe ſalts is ſo powerful, that it occaſions a very lively ſenſation of pain; and where its action is continued for ſome time, it entirely deſtroys the organization and texture of the ſkin. This property is called *cauſticity,* and the ſalts which

which poſſeſs it are named *cauſtics.* The ſecond claſs conſiſts of ſalts which have a milder taſte, and affect only the nerves of the organs through which we receive that ſenſation: theſe are diſtinguiſhed from one another by names expreſſing the ſeveral impreſſions which they make on thoſe organs; ſuch as bitterneſs, aſtringency, acidity, acridity, urinous taſte, &c. To the third claſs we ſhall refer ſaline ſubſtances, the taſte of which is ſenſible only to the ſtomach and the inteſtines; but the number of theſe ſalts is very ſcanty.

Some obſervations are neceſſary on the mutual relations of theſe ſeveral claſſes of ſalts. It is firſt to be obſerved, that between thoſe which poſſeſs the peculiar properties of any of the three claſſes in the weakeſt, and thoſe which poſſeſs the ſame properties in the ſtrongeſt degree, there are many varieties; there are ſtronger and weaker cauſtics; ſome inſtantly deſtroy the texture of organized ſubſtances, others require a conſiderable time to produce that effect. The ſame fact may be obſerved of bitter, aſtringent, or urinous ſalts, as well as of thoſe which act only on the nerves of the ſtomach. Secondly, When we conſider theſe varieties of the ſeveral claſſes, we are naturally led to think, that all taſtes are but different degrees of the ſame property, from that of the ſtrongeſt cauſtic ſalt to that of the ſaline ſubſtance, whoſe action is ſcarce ſenſible to the nerves of the ſtomach. This obſervation implies, that all taſtes actually depend on the ſame cauſe, and participate of the ſame principle.

We cannot adopt an happier method for diſtinguiſhing the cauſe of taſte, than to conſider that taſte which is the ſtrongeſt of all, obſerve its phænomena, and attend to its action. Cauſticity muſt therefore be the ſubject of our conſideration: a property which has always attracted the curioſity of chemiſts. Lemery, obſerving that very hot bodies were uſually very cauſtic, and that all ſalts poſſeſſing the property of cauſticity have been ſtrongly heated before acquiring it, aſcribed this property to the particles of fire lodged in cauſtic bodies. M. Baumé has implicity adopted Lemery's opinion. Meyer, an apothecary of Oſnaburgh, made a ſeries of reſearches into the nature of cauſtic ſalts, and formed a very plauſible theory, which was at firſt warmly embraced by a number of chemiſts, but is no longer mentioned with the reſpect which it once obtained. He attributed cauſticity to a principle which he conſidered as a compound of fire and a peculiar acid: this, in imitation of the ancient chemiſts, he named *cauſticum*, or *acidum pingue*. He traced it thro' its various combinations, as Stahl had done with phlogiſton. But his ſyſtem has the ſame defect with Stahl's; the exiſtence of his *cauſticum* has not been demonſtrated. Dr Black, by a ſeries of experiments on the ſame matters which Meyer examined, has levelled the ſevereſt blow againſt *his* theory; proving, by rigid demonſtration, that lime and alkalis, inſtead of deriving their cauſticity from a *fat acid* principle, become acid in conſequence of loſing a ſalt, to be afterwards mentioned under the name of the *Carbonic Acid*.

Macquer has undeniably been the moſt ſucceſsful inquirer into the cauſe of cauſticity. The doctrine which he lays down on that article in his Chemical Dictionary is ſo plain, and ſupported by ſuch concluſive facts, that we cannot refuſe aſſenting to his opinion. After obſerving that cauſtic bodies deſtroy and corrode our organs, by entering into combination with the principles of which they are compoſed, he remarks, that

that in proportion as this combination takes place, the cauſtic gradually loſes its ſtrength, and becomes abſolutely deſtitute of cauſticity, when it has diſſolved as much of the animal matter as its force and quantity are equal to. Thus the *lapis cauſticus*, or pure fixed alkali, gnaws and corrodes the ſkin when applied to it; but loſes its corroſive and ſolvent power when it ceaſes to act on that organ. This ſalt really acts by a chemical power, for it exerts its force even on the inſenſible ſkin of a carcaſe; as M. Poulletier has ſhown by accurate experiments, and on all animal ſubſtances in general. Cauſticity therefore depends on tendency to combination; and the ſenſations with which it affects our organs are occaſioned by the combination of the cauſtic with the matter of which the organs are compoſed. In the ſame manner a cauſtic loſes its virtue in the laboratory, by combining with any ſubſtance with which it has a ſtrong affinity; and in a word, the cauſticity of a body is always in the proportion of its tendency to combination. That ſalt which has the fainteſt taſte is already ſaturated with ſome ſubſtance; and by ſeparating it from that ſubſtance, we cauſe it to regain a taſte, ſtronger or weaker, according as the ſeparation is more or leſs complete. The whole hiſtory of ſaline matters concurs to ſupport this opinion, as will appear in what follows.

§ III. *Solubility conſidered as a Characteriſtic of Salts.*

SOLUBILITY in water has been given by all chemiſts as one of the moſt eminent characteriſtics of ſalts; yet this property, like taſte and tendency to combination, is ſubject to varieties. Some ſalts poſſeſs it in ſuch a degree, that without very long and refined proceſſes, it is impoſſible to ſeparate them entirely from water. Others are not ſo extremely ſoluble, and the degrees of their ſolubility may be preciſely aſcertained; as, for inſtance, moſt neutral ſalts. Laſtly, There are ſome ſaline ſubſtances, whoſe tendency to ſolution is ſo faint and indiſtinct, that they ſeem to differ more in nature from the other claſſes of ſalts than from earths and ſtones; and all ſalts of this character have been by moſt naturaliſts conſidered as earths and ſtones. It is indeed extremely difficult to fix the preciſe limits between theſe two claſſes of mineral bodies; and chemiſts have not as yet agreed in determining them. Mr Kirwan, in his mineralogy, ſeems to have adopted Bergman's opinion; who thinks that all ſubſtances are to be conſidered as earths, which require more than a thouſand times their own quantity of water to maintain them in a ſtate of ſolution, while all ſuch as are ſoluble in a ſmaller proportion of water, ſhould be diſtinguiſhed as ſalts. Were this propoſition generally received among chemiſts, as I think it well deſerves to be, that diverſity of opinions and terms which has hitherto prevailed on this point might be avoided; and they have a direct tendency to render the

the ſcience more obſcure and perplexing to beginners.

The relation which I have taken notice of, as ſubſiſting between the taſte and the ſolubility of ſalts, is preciſely the ſame with that which ſubſiſts between taſte and tendency to combination. The cauſe of theſe relations may be eaſily underſtood by obſerving, that ſolution in water is a real chemical union of a ſalt with a fluid, and muſt therefore depend on the ſame laws with taſte and tendency to combination. In fact, the more taſte and ſolvent force a ſalt has, the more readily does it diſſolve in water. This law holds invariably with regard to all ſaline matters, and even depends on their nature and eſſential properties.

§ IV. *Incombuſtibility conſidered as a Characteriſtic of Salts.*

IT is more difficult to form a determinate idea of this fourth than of the three preceding characteriſtics of ſaline matters. No chemiſt has as yet conſidered theſe ſubſtances under this point of view. A number have even thought, that ſome ſalts, and among others nitre, are actually combuſtible.

In order to ſee clearly that this is a miſtake, and that all mineral ſaline ſubſtances are abſolutely incombuſtible, the ſtudent of chemiſtry muſt have a much fuller knowledge of the properties of thoſe ſubſtances, than he can have acquired from peruſing the foregoing part of this work. However, as we think this one of the moſt eſſential and important characteriſtics of ſalts, we we ſhall here give a ſhort view of the doctrine which we are induced to advance on this head, and which will be fully illuſtrated and incontrovertibly eſtabliſhed, in our particular examinations of ſaline ſubſtances.

It appears from M. Lavoiſier's fine experiments, that many combuſtible matters form by their combuſtion peculiar acids. Combuſtion, as above explained, is nothing but the combination of the baſe of vital air, or the oxigenous principle with combuſtible bodies. Every body which has been completely burnt, that is, which has been ſaturated with the oxigenous principle, returns into the claſs of incombuſtibles; or what is juſt the ſame, its tendency to combine with the oxigenous principle is ſatisfied, and it cannot unite with a new quantity of oxigene, or abſorb any more of it. This being admitted, it plainly follows, that, as a number of ſalts are reſidues of various combuſtible bodies, and even an entire claſs of ſaline ſubſtances are found to have oxigene for one of their principles, and exhibit the characteriſtics of ſubſtances which have been expoſed to combuſtion, theſe cannot be any longer ſuſceptible of combuſtion. A numerous train of facts, which ſhall be hereafter related, concur to juſtify theſe aſſertions: they prove ſalts to be compound bodies, moſt of them formed by the union of certain combuſtible bodies with the oxigenous principle. From this it is eaſy to underſtand that incombuſtibility deſerves to be regarded as one of the moſt certain and invariable characteriſtics of ſaline matters. We hope that this will be completely demonſtrated of the claſs of acid ſalts, when we come to enter particularly into the hiſtory of thoſe ſubſtances.

Yet there is one claſs of ſalts which, though evidently compound bodies, are not known to contain any portion of the oxigenous principle: all the alkalis are of this claſs. But theſe are either compounds of incombuſtible bodies, or if ſome combuſtible matter enters into their compoſition, as we ſhall have occaſion to obſerve of ammoniac or volatile alkali, it is united with ſome ſubſtance evidently incombuſtible, which hinders the combuſtibility of the other matter from being obſerved.

§ V. *Of the general Nature and Compoſition of Saline Matters.*

STAHL, after ſtudying the nature of ſalts with much attention, was perſuaded that they were generally formed of earth and water. He collected all that chemical reſearches could ſupply to ſupport and illuſtrate his theory. But ſince that illuſtrious æra of chemical ſcience has been ſuceeded by one ſtill more illuſtrious, for both the multiplicity of the reſearches proſecuted, and the importance of the diſcoveries which theſe have produced; Stahl's theory, which is very perſpicuouſly explained in the works of Macquer, is no longer ſufficient to explain the nature and compoſition of ſalts. We are no longer content with thoſe remote analogies which forced the moſt diſcordant facts into an unnatural union, and bewildered the underſtanding by exhibiting to it illuſive lights. Philoſophers now chooſe rather to confeſs their ignorance, than to advance ill-founded theories, which may ſooner or later be refuted by experiment.

Although the chemical nature of ſalts be not yet entirely known, and facts allow us not to agree with ſome of the moſt eminent philoſophers, in acknowledging one ſaline principle as the baſe and element of all ſalts; yet the component principles of this ſingular and numerous claſs of ſubſtances are ſomewhat better known now than formerly. We know that moſt of them contain a very conſiderable quantity of the oxigenous principle; which principle is fixed in ſome combuſtible matter. This has been fully ſhown to be the compoſition of a number of acids; and we have the ſtrongeſt reaſon from analogy to conclude, that moſt other ſalts of that claſs have the ſame character. Water, though not one of the immediate principles of ſalts, is often found united to them, and has a ſtrong affinity with them. As to the matter of fire conſidered as phlogiſton, which ſome of the moſt eminent chemiſts have admitted as a component principle in ſalts, the nature and exiſtence of that matter are too uncertain to admit of our adopting any determinate opinion in reſpect to it. The caſe is not the ſame with the calorie principle; it ſeems evidently to conſtitute one of their component principles; in ſome, however, it exiſts in a much ſmaller proportion than in the reſt, which appear in general to owe to it their fluidity, fuſibility, and volatility. The exiſtence of earth in any conſiderable number of ſalts has never been experimentally demonſtrated. We know only that all the ſaline bodies which nature exhibits, are mixed with a larger or a ſmaller quantity of various earthy ſubſtances. But theſe, properly ſpeaking, do not belong to them; they form no part of their compoſition, and may be ſaid to be only acceſſories. The only ſubſtances at preſent acknowledged as general principles of ſaline matters, are

ſeveral

ſeveral combuſtible bodies, the oxigenous principle, a few incombuſtible matters, and the caloric principle. It is well known that moſt acids are reſidues of burnt bodies, and contain oxigene and combuſtible matter combined together in various proportions. Whatever more has been advanced in treatiſes on chemiſtry concerning the nature of ſalts, is nothing but ingenious or ridiculous hypotheſis, unſupported by any ſolid baſis of facts.

§ VI. *Of the Diviſion and Arrangement of Mineral Saline Matters.*

THE ſalts belonging to the mineral kingdom are very numerous. A number of them are products of nature, formed by the action of fire, water, and air, and by the diſſolution of organic matters. But moſt of thoſe which are employed in chemiſtry owe their formation to art, or at leaſt have not hitherto been found among the products of nature. In order to give a methodical view of the hiſtory of theſe ſubſtances, we ſhall divide them in the ſame manner as ſtones, into orders, genera, and ſpecies. All ſaline matters may be arranged under two orders.

The firſt contains thoſe ſaline ſubſtances which have been named *ſimple*, and which we ſhall diſtinguiſh by the name of *primary ſalts*, becauſe they ſerve as principles to thoſe of the ſecond order.

The ſecond conſiſts of the ſecondary, compound, or neutral ſalts. Theſe are formed by the combination of two or more of the former order, and are of conſequence much leſs ſimple than they.

Each of theſe orders ſhall be divided into ſeveral genera, and theſe again into ſpecies.

Nine genera, and eighty-ſix ſpecies of ſimple and compound ſalts together, are at preſent known to exiſt in the mineral kingdom; and theſe we ſhall ſucceſſively examine *.

---

* There are three ſalino-terreous ſubſtances, three acids, and ten mineral acids. Theſe laſt, united with aluminous earth, with the three ſalino-terreous baſes, and with the three alkalis, compoſe 70 compound or neutral ſalts. A.

CHAP. II.

Of the three Salino-Terreous Subſtances *.

ORDER I. SIMPLE *or* PRIMARY SALTS.

WE give the name of *ſimple* or *primary ſalts* to thoſe matters which were formerly known by the name of *ſimple ſalts*, and are ſtill ſo called by ſome chemiſts. As it has been ſhown by fair experiments that moſt of them are really compounds, therefore the title of ſimple ſalts cannot with any propriety be applied to them, except when they are compared with the ſalts of the ſecond order. The name of *primary ſalts* ſeems the moſt ſuitable for diſtinguiſhing them, becauſe they form by combination thoſe neutral or compound ſalts which we call *ſecondary*. We ſhall divide this order into three genera, ſalino-terreous ſubſtances, alkalis, and acids. The examination of the firſt will occupy this chapter; in the two following we ſhall give the hiſtory of alkalis and acids.

Genus

---

* The title of this chapter is the general denomination of the firſt genus of the firſt order of ſimple or primary ſaline matters. A.

Genus I. *Salino-terreous Subſtance.*

By this name we denote three ſubſtances which have been hitherto regarded as earthy matters, but whoſe properties plainly ſhow them to be more properly ſaline *. As theſe ſubſtances poſſeſs the diſtinguiſhing properties of ſalts, in conjunction with the characteriſtics of earthy matters, yet, diſplaying the latter in a leſs eminent degree; we therefore rank them before the ſalts, uſing them as a link of connection between ſalts and earths: They differ alſo from earths as having a ſtronger tendency than theſe to combination, as will appear from an examination of their properties.

It is proper to obſerve, that in our examination of theſe ſalino-terreous matters, as well as in our account of the primary ſalts, we ſuppoſe them pure and ſolitary, though they be never found ſo in nature; and we avoid mentioning the methods by which they are obtained, from a deſire not to break through that elementary order which we have determined to follow through the courſe of the work. When we come, in the hiſtory of neutral ſalts, to give an account of their decompoſition, we will then have occaſion to deſcribe the methods by which chemiſtry ſeparates thoſe ſubſtances, as well as the ſimple or primary ſalts, ſo as to afford them pure.

This firſt genus contains three ſpecies of ſalino-terreous bodies.

Species

---

* We have already given ſome account of them in lithology; but then only as making a part of natural hiſtory. A.

Species I. *Barytes.*

The firſt name of this ſubſtance was *ponderous earth*, given it by the Swediſh chemiſts Gahn and Scheele; who diſcovered it in ponderous ſpar: Bergman and Mr Kirwan have already given it the Latin name *barytes*. Its ſpecific gravity, according to Mr Kirwan, is ſomething more than 4000. Nature no where affords this earth in a pure but always in a combined ſtate. It was firſt diſcovered and diſtinguiſhed as a peculiar earth by the chemiſts above-mentioned. Meſſrs Margraf and Monnet had obſerved it, but confounded it with abſorbent or calcareous earth. Yet the laſt of theſe chemiſts had obſerved it to poſſeſs ſome peculiar properties, and ſuſpected it to be an earth of a different nature from lime. Its properties, in a pure ſolitary ſtate, have not as yet been very accurately examined: its combinations have been more ſtudied; and what moſt eminently diſtinguiſhes it from other analogous ſubſtances, is its very ſingular affinities, and the ſalts which it forms by combination with acids.

Pure barytes, obtained by means which ſhall be afterwards deſcribed, appears under a pulverulent form, very fine and white. I have never found it to affect the tongue with any diſcernible taſte.

It is not yet known whether this ſubſtance be liable to alteration from light.

The ordinary fire of our furnaces does not reduce it to fuſion: But if heated in a clay crucible, it communicates a blue or greeniſh colour to the crucible, and aſſumes itſelf a ſlight tinge of the ſame. This phænomenon ſeems to ariſe from its power of re-action on clay.

M. d'Arcet ſays, that it melts when expoſed to a very violent heat in a clay or iron crucible.

When expoſed to the air, it acquires an acceſſion of weight, and combines, though very ſlowly, with the carbonic acid contained in the atmoſphere: the effects of vital air upon it are unknown. We are equally ignorant of the manner in which the oxigenous and the azotic principle act upon this ſaline earth. The azotic is perhaps one of its conſtituent principles.

It diſſolves in water, but not without difficulty; for 900 parts of that fluid are requiſite to diſſolve one of barytes. Water thus ſaturated gives a pale green colour to the tincture of violets *, and ſtill more readily to that of mallows or radiſhes. This ſolution, when expoſed to the air, is covered with a thin pellicle; and if ſtripped of it, a new one is produced. This phænomenon is owing to the carbonic acid in the atmoſphere: the ſame thing happens to lime-water, though in a leſs eminent degree. The ſolution, when evaporated in cloſe veſſels, leaves a reſidue of barytes; and the weight of the reſidue affords a proof of the ſolubility of that ſubſtance. It is almoſt unneceſſary to obſerve, that in this, as in all other proceſſes of the ſame nature, diſtilled water is to be uſed.

Barytes acts but very feebly, either by the humid or the dry way, on ſiliceous and aluminous earth †. Yet

---

* By tincture of violets, we mean a ſolution of the colouring part of violet flowers in water. This tincture when newly made is preferable to the ſyrup of violets, as being much eaſier affected. But the ſyrup may be employed in all inſtances in which the ſaline matters under examination act with a determinate energy; and we ſhall therefore often mention it inſtead of the tincture. A.

† We muſt here obſerve, that in order to give a regular account of the

Yet it facilitates the fuſion of thoſe earths, and aſſumes a blue or greeniſh colour when heated with the latter of them. Barytes is leſs copious in nature than either of the other two ſalino-terreous ſubſtances; but it is probably more copious than it is thought to be. Formerly, it was not known to exiſt in any body but barytic ſulfate or ponderous ſpar; it was ſome time ſince found in England, combined with the carbonic acid, and cryſtallized like a tranſparent ſpar. That ſalt will be afterwards deſcribed. Some modern chemiſts think it to be a metallic calx or oxide. Its weight, that of the compounds into which it enters, and the precipitate which it affords, when a ſolution of it with an acid is mixed with an alkaline pruſſiates, made Bergman long ſuſpect it to be of that nature. We are told, that M. Gahn, a ſcholar of that celebrated chemiſt, has actually obtained the barytes under a metallic form; but this fact needs confirmation. Its nature therefore is ſtill unknown; becauſe we have never yet been able to ſeparate its principles, or imitate its compoſition. I ſuſpect, as I have already hinted, that the azotic principle, or the baſe of mephitic air, is one of its component parts.

Pure

---

the reciprocal action of bodies on each other, no combination of any two bodies is mentioned till after thoſe two have been deſcribed. Thus in the hiſtory of barytes, I have mentioned only the manner in which it is affected by light, by the caloric, the oxigenous, and the azotic principles, by water, and by ſiliceous and aluminous earth, becauſe none but theſe have as yet been deſcribed. As we advance in the hiſtory of natural ſubſtances, we ſhall learn all the combinations of which it is ſuſceptible. Thus we ſhall both preſerve our order inviolate, and communicate all the neceſſary information concerning the matters of which we treat. A.

Pure barytes is not applied to any uſe; ſolutions of it in water in acids are uſed as re-agents, as we ſhall elſewhere have occaſion to obſerve.

Species II. *Magneſia.*

That magneſia which is obtained from Epſom ſalt, or ſulfate of magneſia, and which is likewiſe found in mother water of nitre, and in a great many ſtones, &c. is no where in nature to be met with in a ſtate of purity, but always combined with acids. Dr Black is the firſt chemiſt who has accurately determined the diſtinction between it and lime.

This ſubſtance, which is obtained by methods to be afterwards deſcribed, appears under the form of a very fine white powder, reſembling meal both in appearance and to the touch. Its gravity, according to Kirwan, is about 2.33. It has no taſte ſenſible to the tongue; but it affects the ſtomach as a gentle purgative. It communicates a pale green to the tincture of violets and mallows, and cauſes turnſol to aſſume a blue colour. The manner in which light affects magneſia is not well known: it cannot be very powerfully.

According to the experiments of M. d'Arcet, this ſubſtance does not melt when expoſed to a ſtrong heat. Macquer too obſerved, that it remained unaltered in the focus of the burning lens of the garden *De l'Infante.* M. Morveau heated magneſia for two hours in the ſtrongeſt fire that can be produced in Macquer's furnace, with the ſame effect. M. Butini, a citizen of Geneva, who has publiſhed ſome valuable experiments on magneſia, has obſerved, that violent ignition contracts and condenſes magneſia in ſuch a manner as to to render it capable of attacking and corroding an iron ſurface. We are informed that a ſmall cube formed of a paſte of magneſia and water, and expoſed to the focus of Parker's lens, was ſuddenly contracted in all its dimenſions. This property ſeems to indicate a relation between magneſia and aluminous earth; which two ſubſtances are often found combined together in nature, as was obſerved in the hiſtory of ſteatites, aſbeſtos, and ſerpentines, &c.

Magneſia, though heated in a retort, loſes not the portion of water which it contains: but when ſubjected to this proceſs, it acquires a very diſcernible phoſphoric quality, as has been obſerved by M. Tingry, apothecary at Geneva. It ſuffers no alteration from air till after being long expoſed to it. M. Butini kept ten grains of calcined magneſia in a porcelain ſaucer covered with paper, in a dry room, for near two years; the only change which it ſuffered was by gaining one-eighth of a grain of additional weight. It appears that this ſubſtance combines ſlowly with the carbonic acid diffuſed through the atmoſphere.

It diſſolves in water but imperfectly and with great difficulty. Four ounces and two drams of pure water, after ſtanding three months in a bottle, with a dram of calcined magneſia, and being boiled together with that ſubſtance, afforded M. Butini, by evaporation, a reſidue which he eſtimated at one-fourth of a grain.

Mr Kirwan ſays, that 7692 times its own weight of water is neceſſary to diſſolve it in the ordinary temperature of the atmoſphere; that is to ſay, at about 60° of Fahrenheit's thermometer. Notwithſtanding this averſion to ſolution, magneſia forms a kind of paſte with water: that paſte, indeed, is not ductile, but brittle; and the water is readily ſeparated from it by the action of fire, or even of the dry atmoſphere. A ſolution of magneſia has no ſenſible taſte; and it produces but a very trifling alteration on the colour of ſyrup of violets.

We are not yet well acquainted with the manner in which magneſia acts on pure earths. We know, however, that it does not vitrify with either ſiliceous or aluminous earth ſeparately; but when heated with both together, it is ſuſceptible of fuſion.

Its action on barytes has not yet been examined.

The intimate nature of magneſia is not better known than that of barytes. It has never been ſhown by experiment to be a modification of ſome other ſaline ſubſtance, as ſome chemiſts have imagined it to be; for magneſia has not yet been either ſeparated into principles by analyſis, or imitated by a ſynthetic proceſs. In the preſent ſtate of chemiſtry, therefore, it is to be conſidered as a ſimple ſubſtance.

Pure magneſia, which Dr Black calls *cauſtic*, is uſed in medicine as an abſorbent and purgative. For heartburnings and other complaints occaſioned by acidity, it is preferable to common magneſia: becauſe the carbonic acid which this laſt contains is diſengaged in the primary paſſages by the acids, and produces flatulencies, with all that train of complaints which accompany them: it preſerves fleſh for a long time, and even reſtores putrefied bile. Bergman aſcribes to it likewiſe the property of rendering camphor, opium, reſins, and gum-reſins, ſoluble in water, and of forming ſome valuable dyes; though cauſtic magneſia be ſcarce ſoluble in water. Theſe preparations are unknown in France.

Species

Species III. *Lime.*

Quicklime is a white ſubſtance, of more conſiſtency than the two preceding matters: it appears in the form of a grey white ſtone. Its taſte is hot, acrid, and urinous; it poſſeſſes this property in ſo conſiderable a degree as to inflame the ſkin when applied to it. Its ſpecific gravity is about 2.3; its form pulverulent and friable; it is found in places adjacent to volcanoes; as M. Monnet has obſerved on the hills of Auvergne.

Lime turns ſyrup of violets green, giving it a much more intenſe colour than it acquires from either barytes or magneſia: indeed, it almoſt deſtroys the original colour, and in a ſhort time produces in its ſtead a dirty yellow.

Lime, when expoſed to a ſtrong fire, ſuch as that of a glaſs-houſe, remains unaltered; and, in a ſolitary ſtate, it is not ſuſceptible of fuſion. Parker's burning-glaſs appears to have brought it to the beginning of fuſion; but the lime was placed on a ſupport of charcoal. When heated in a clay crucible, its edges ſometimes appear to melt; but this phænomenon is occaſioned by its acting on the earth of the crucible.

When expoſed to the action of the air, lime ſwells, breaks, and falls into powder; it then increaſes greatly in bulk, and is called *lime ſlaked in the air.* Theſe phænomena are more remarkable, and take place more rapidly when the air is in a humid ſtate. This dry ſlaking produces heat; and the dilatation is ſo conſiderable as to burſt caſks, or other wooden veſſels in which lime may be contained. After being ſlaked with air, this ſubſtance appears under the form of a very fine white duſt; it has acquired a very conſiderable increaſe of weight, and its taſte is become much fainter. Theſe phænomena are occaſioned chiefly by the water contained in the atmoſphere, and the force with which the lime tends to unite with it. And by heating lime which has been ſlaked with air in a retort, till it becomes red-hot, water is obtained, and the lime returns to its original ſtate.

Water acts very powerfully on quicklime. Pour a ſmall quantity of that fluid on a quantity of lime, the water is inſtantly abſorbed; and the maſs of lime appears as dry as before; but it ſoon burſts and breaks into pieces. The heat excited in it by this operation is ſo ſtrong, as to produce a remarkable hiſſing noiſe: the water is reduced to vapour of a peculiar ſmell, which communicates a green colour to paper tinged with mallows. The lime ſoon falls down to a powder; and the heat, motion, and ſmoke, gradually diſappear. If the proceſs is performed at night, in a place perfectly dark, a great many luminous points are obſervable all over the ſurface of the lime. All theſe phenomena depend on the activity with which this ſalino-terreous ſubſtance unites with water. But, in order to produce them, we muſt employ but a very ſmall portion of the fluid; only ſo much as the lime can abſorb without appearing wet. It appears that the heat diſengaged from theſe two bodies, when they combine with ſuch rapidity, changes their ſtate; and that the lime, when ſlaked, and reduced to a ſtate of pulverization, contains water in a dry and ſolid form. This dry ſtate of water which takes place in many of the combinations in which heat performs a part, and produces ſolid compounds, whoſe ſpecific heat is leſs than that of the bodies of which they are formed, has not yet ſufficiently en-

engaged the attention of chemiſts; indeed it has been but lately obſerved. When lime has abſorbed as much water as it can contain, without becoming wet, it is then called *dry ſlaked lime;* water no longer excites any heat in it, and only diſſolves it without producing any very diſcernible motion. By mixing lime with a proper quantity of water, we obtain milk of lime; and by adding ſo much water as may be neceſſary to effect a complete ſolution of this ſalino-terreous matter, we produce a liquor perfectly tranſparent. Mr Kirwan ſays, that about 680 times its weight of water is neceſſary to maintain it in ſolution at the temperature of 60°.

This ſolution, which is known by the name of *lime water*, is clear and limpid. It is but very little heavier than common water, has an acrid urinous taſte, communicates a deep green to ſyrup of violets, and even produces upon it an entire alteration of colour. Lime-water, when evaporated in cloſe veſſels, affords very pure water, leaving a reſidue of quick-lime at the bottom of the veſſels: But this reſidue needs to be very ſtrongly heated, in order to ſeparate entirely the water which ſtill adheres to it: After which that fluid excites heat in it in the ſame manner as before its ſolution.

Lime-water, when expoſed to the air, is covered with a dry pellicle, which becomes gradually thicker and more ſolid. If the firſt pellicle be taken off, a ſecond is formed, and this proceſs may be repeated till all the water be evaporated. Theſe pellicles have been improperly termed *cream of lime.* This was formerly thought to be a peculiar ſalt, formed by the union of the fineſt calcareous earth with water; and much has been written concerning this pretended ſalt of lime. But it is now well known from the experiments of the celebrated Black, that the cream of lime poſſeſſes ſaline properties leſs active than thoſe of lime, and that it is a peculiar neutral ſalt formed by the combination of lime, with a certain acid contained in the atmoſphere; and the cream is never formed on lime-water, except when it is expoſed to the air. We will elſewhere examine this ſalt under the name of *carbonate of lime* or *chalk.* The manner in which the oxigenous and the azotic principle affect lime is not yet known; it is probable that this baſe abſorbs and fixes ſome part of azotic gas, and at leaſt contains the baſe of that gas.

Lime combines with ſiliceous earth in both the humid and the dry way If ſand be mixed with lime newly ſlaked, or with quick-lime ſprinkled with a ſmall quantity of water at the time of mixing, the two bodies become conſiſtent, and form what is called *mortar.* This mixture is liable to many varieties; from the ſtate and quantity of the quick-lime, the quantity of water with which it has been ſlaked, the circumſtance of the ſand being mixed with it at the inſtant of its ſlaking, or not till ſome time afterwards; and from the ſize, the roundneſs, the inequality, the moiſture, or dryneſs of the ſand *. Mortar is alſo compoſed of clay baked into bricks, and of puzzolana, which is nothing but clay baked by volcanic fire, and altered by the contact of the air.

Though lime, as well as ſiliceous earth, be abſolutely infuſible by itſelf; yet if theſe two ſubſtances be heated together, the former in a greater proportion than the latter, they are ſuſceptible of fuſion, as has been obſerved by Meſſrs d'Arcet and Gerhard. Lime likewiſe melts with a quantity of aluminous earth equal to one-third of its own weight; and Mr Kirwan ſhows, that

---

* See Recherches par M. de la Faye, ſur la preparation que les romains donnoient à la chaux, Paris 1777-8, premiere et ſeconde partie. A.

that it has a greater affinity with this than with ſiliceous earth. A mixture of all the three ſubſtances melts eaſier and more completely than a mixture of lime with any one of the other two. Thus one part of lime and one of aluminous earth will occaſion the fuſion of two parts, or even of two and an half of ſiliceous earth. From this fact we underſtand why ſo many ſtones, apparently hard, ſcintillating, and quartzoſe, melt notwithſtanding, when expoſed to a ſtrong fire. The combination, or even the mixture of calcareous earth and clay; with ſiliceous earth, occaſions this phænomenon.

It is not yet known in what manner lime acts on barytes.

One part of calcareous earth produces the fuſion of one-half part of magneſia. The glaſs formed by this mixture, in fire completely diſſolves and reduces to fuſion a quantity of ſiliceous earth equal to the quantity of the lime. Accordingly, equal parts of magneſia, lime, and ſiliceous earth, when expoſed to fire together, afford a perfect glaſs.

The intimate nature of lime is unknown. The firſt chemiſts who attempted to explain by phyſical reaſonings the phænomena which lime diſplays in its combinations, and eſpecially when ſlaked, aſcribed them to the fixation of particles of fire in the calcareous ſtone during its calcination. Such was Lemery's theory. Meyer was of opinion that pure fire was not ſuſceptible of ſuch a combination, and that there was a peculiar acid which combined with it in the lime. This ſubtle kind of ſulphur was the *acidum pinque*, or *cauſticum* of that chemiſt. But this doctrine, which has ſince been repeatedly offered to the world under different names, is overthrown by a ſeries of experiments clearly demonſtrating its falſity. Many modern chemiſts think, that the matter of heat is combined in lime; and that by its diſengagement during the ſlaking of this ſubſtance, the light obſerved by Meyer and M. Pelletier, the ebullition and the evaporation of the water, as well as the peculiar fetid odour exhaled on the occaſion, are produced. It appears, however, from what has been ſaid, that the principles and compoſition of lime are ſtill unknown. Some very diſtinguiſhed naturaliſts have thought it to be in all probability a certain preparation of ſiliceous or aluminous earth effected by the organs of animals; but that is by no means certain. It is ſurely, however, formed by marine animals; its conſtituent parts are certainly united and combined under water during the life of thoſe organic beings; and the azotic principle is certainly *one* of its conſtituent parts: Yet all this is inſufficient to determine the opinion of modern naturaliſts, who require accurate and repeated experiments.

Lime is made uſe of in many of the arts; more eſpecially in building. In medicine, lime-water is ſucceſsfully preſcribed in ulcerous caſes, &c. It has been thought a powerful lithontriptic. But long experience has ſhown, that it does not always operate the cures expected from it; and that where the uſe of it is too long continued, it produces on the animal fluids an alteration approaching to ſcurvy or ſepticity.

CHAP. III.

Genus II. *Alkali Salts.*

ALKALIS come to be treated of before acids, becauſe they appear to be more ſimple and leſs decompoſable, and becauſe they reſemble in ſome properties the ſalino-terreous ſubſtances. They have an urinous burning cauſtic taſte: they turn ſyrup of violets green, excite heat in uniting with water, abſorb both the moiſture and the carbonic acid of the atmoſphere, and diſſolve earths by the ſtrength of their tendency to combination. Three ſpecies of alkalis are known; potaſh, or vegetable fixed alkali; ſoda, or mineral fixed alkali; and ammoniac, or volatile alkali.

Species I. *Potaſh.*

THIS ſpecies, which we denominate *potaſh*, has been called *vegetable, fixed alkali;* becauſe, though often met with in minerals, it is found in greateſt abundance in vegetables. It has likewiſe been named *alkali of tartar*, becauſe a conſiderable quantity of it may be obtained

tained from that ſaline ſubſtance; which will afterwards come under our examination. Dr Black was the firſt who diſcovered potaſh in a ſtate of purity. Formerly this ſalt was called *cauſtic fixed alkali*, to diſtinguiſh it from common fixed alkali.

This ſalt, in a ſtate of conſiderable purity, is white and of a dry ſolid form; its ſapidity is ſo ſtrong, that it diſſolves the texture of the ſkin. It communicates inſtantaneouſly to the ſyrup of violets a deep green colour, much more obſervable than that which lime cauſes it to aſſume. It alters, and almoſt entirely deſtroys this colour, changing it to a brown yellow.

We know not in what manner light affects this ſalt.

Potaſh, when expoſed to the action of fire in cloſe veſſels, is inſtantly ſoftened, and by the time when it begins to appear red, becomes entirely liquid. If it be then poured on a ſmooth hard ſurface, it cools into a white, opaque, brittle maſs. It is not decompoſable by heat. A moſt intenſe heat, ſuch as that of the furnace of a glaſs-houſe, is requiſite to volatilize it. In all of theſe operations it diſſolves part of the clay veſſels in which it is contained.

When expoſed to the open atmoſphere, it attracts moiſture ſtrongly, diſſolves into a liquid, and gradually paſſes into the ſtate of a neutral ſalt, by abſorbing the acid diffuſed through the atmoſphere. For this reaſon, it acquired on ſuch occaſions an increaſe of weight, and becomes capable of effervefcing with acids; which never takes place when it is in that ſtate of purity in which we have ſuppoſed it. To preſerve it pure, therefore, it muſt be kept in cloſe veſſels entirely full of it.

Potaſh diſſolves very readily in water; it then excites

cites a conſiderable degree of heat, and exhales a fetid lixivious odour. The ſolution of it is colourleſs; and when very pure it affords no precipitate. To ſeparate it from the ſolvent the ſolution muſt be evaporated to dryneſs in cloſe veſſels. If this operation be performed in open veſſels, the acid of the atmoſphere is attracted, and renders the pot-aſh effervefcent. And this abſorption takes place ſo readily; that if a ſolution of this ſalt be expoſed to the open air for ever ſo ſhort a ſpace of time, it ſuffers an alteration, and is in fact neutralized. In a flaſk which it does not entirely fill, and which is frequently opened, it is liable to the ſame alteration. The action of the oxigenous and the azotic principles on this alkali is not known.

Potaſh combines with ſiliceous earth in the dry way, and cauſes it to melt together with itſelf: the two compoſe a tranſparent body, known by the name of *glaſs*. This body is liable to varieties from the various proportions in which the ſiliceous ſand and the fixed alkali are united in it. Two parts of the ſalt with one of earth afford a ſoft brittle glaſs, which attracts moiſture, and becomes at length opaque and fluid. This glaſs is ſoluble in water, on account of its containing ſo much more than an equal proportion of alkali. The ſolution is called *liquor of flints*. It at length depoſites part of the earth which it contains in white ſemi-tranſparent flakes, apparently mucilaginous, and ſo light that they ſubſide but very ſlowly. Acids ſeize the alkali, and precipitate the earth, which is called *earth of flints*. But to make this proceſs ſucceed, care muſt be taken that the liquor of flints be not too much diluted by the water. In that caſe, the particles of the earth being too much divided, remain ſuſpended in the liquor, and evaporation is requiſite to produce the preci-

precipitate. Several chemiſts are of opinion, that earth of flints is not the ſame with ſiliceous earth; on which they think the alkali has produced an entire alteration. They think it to be more like aluminous earth, and believe that by combination with acids, it affords the ſame ſalts which are obtained by combining acids with aluminous earth. Such was the opinion of Pott and M. Baumé. But Scheele has ſhown, that that portion of the earth precipitated from liquor of flints, which is ſoluble in acids, is part of the aluminous earth of the veſſel in which the operation is performed, diſſolved by the mixture of alkali and ſiliceous earth.

The art of making glaſs is entirely chemical, as glaſs is nothing but a combination of fixed alkali with ſiliceous earth. The purity, the proportion, and the complete fuſion of theſe two ſubſtances by a fire ſufficiently intenſe, and kept up for a proper length of time, are the three conditions requiſite for the preparation of glaſs, of a proper tranſparency, of ſufficient hardneſs, and liable to no alteration from the attacks of air. We ſhall afterwards learn what other ſubſtances are mixed with theſe two in this compoſition, in order to render the glaſs more weighty and tranſparent, and to communicate to it ſeveral other properties which render it fitter for the purpoſes to which it is applied.

Potaſh acts not with the ſame force on aluminous as on ſiliceous earth: but the phænomena which it exhibits, when applied to it, are not yet well known.

This ſalt appears to be ſuſceptible of combination with barytes, magneſia, and lime. But its combinations with theſe ſubſtances have not yet been ſo accurately

rately examined as to admit of our giving a particular account of them here.

Although potaſh has never yet been decompoſed; yet a number of facts with which the reader ſhall be hereafter made acquainted, concur to ſhow that it is not a ſimple ſubſtance. Stahl, who conſidered ſimple ſalts as a combination of earth and water, thought that fixed alkali differed from the acids only by containing a greater proportion of earth: and in this manner he accounted for its dryneſs, &c. Potaſh, in all probability is a combination of the three preceding earths with the azotic principle. Some analogies lead me to think that it contains lime. But this conjecture is not yet ſupported by a ſufficient number of facts.

Potaſh is uſed in ſurgery to corrode the ſkin, and produce inflammation and ſuppuration in certain caſes.

Species II. *Soda.*

THIS ſaline ſubſtance, which exhibits the ſame general characteriſtics with the foregoing, has received the name of *mineral fixed alkali:* It is found in abundance, combined with a peculiar acid ſalt in ſea-water, and in ſome ſpring-waters: ſometimes too it is met with in vegetables, but much ſeldomer than the foregoing. This ſalt has been called *marine alkali*, from its making a part of marine ſalt; and *alkali*, or *ſalt of ſoda*, becauſe it is ofteneſt obtained from that ſubſtance. We prefer the ſimple name of *ſoda*.

The taſte of ſoda is equally ſtrong and cauſtic with that of potaſh. It turns the ſyrup of violets green, and produces the ſame alteration as the other on that colour:

lour: it appears naturally in a dry and ſolid form. It melts in fire as it begins to become red-hot: a violent heat volatilizes it: it acts on almoſt all the veſſels in which it can be expoſed to heat.

When expoſed to atmoſpheric air, it attracts its moiſture, and the peculiar acid which it contains; ſo as to become gradually a neutral ſalt. The manner in which it is affected by the oxigenous principle and vital air is not yet known.

It diſſolves in water with heat, and the diſengagement of a fetid lixivious odour. It cannot be obtained pure after this ſolution but by evaporation in cloſe veſſels. The lixiviate, when expoſed to the air, readily abſorbs its acid, and becomes neutral. Therefore, to preſerve it pure, it muſt be kept in cloſe veſſels.

Soda readily combines with ſiliceous earth in the dry way, ſo as to compoſe glaſs. Glaſs-makers have even obſerved it to be more fuſible, and to adhere more readily and firmly with this earth than potaſh; to which they on this account prefer it. And therefore what was ſaid above concerning the uſe of potaſh in glaſs-making, may be applied to ſoda. Laſtly, this alkali, as well as potaſh, combines with acids and a great many other bodies, as we ſhall afterwards underſtand.

After this account of the properties of ſoda, we muſt obſerve, that there is no very remarkable difference between potaſh and ſoda when both are in a ſtate of purity. It is only in their combinations that the difference of their natures can be diſtinguiſhed. When combined with the ſame acid, they afford neutral ſalts totally different from each other; and this is the more ſurpriſing, becauſe it is impoſſible to diſtinguiſh the one from the other when they are in a pure cauſtic ſtate, as we have here examined them. Bergman adds another diſtinctive property of theſe ſalts which is well worth knowing; they have not the ſame affinity with acids. Potaſh has a ſtronger affinity with theſe ſaline ſubſtances than ſoda; and is capable to decompoſe neutral ſalts, conſiſting of combinations of the latter. We ſhall take farther notice of this when we come to examine ſecondary or neutral ſalts.

The compoſition or intimate nature of ſoda is equally unknown with that of potaſh. The ſame analyſes lead me to think that ſoda, as well as potaſh, is a combination of an earth with the azotic principle; and that it is the difference of the earthy baſe which forms the characteriſtic difference between the two ſalts. Magneſia is poſſibly the baſe of ſoda, as I have for ſome years hinted in my lectures, and M. Lorgna has ſince attempted to prove. But the facts on which this opinion is founded, are not ſufficiently exact and numerous to juſtify our conſidering it as a certain truth. As to its uſes, it is employed in making glaſs, in preparing ſoap, &c.

Species III.

What we call *ammoniac* is a ſalt commonly known by the name of *volatile alkali*. It is diſtinguiſhed from the two foregoing ſalts by a keen ſuffocating ſmell and a remarkable volatility. This ſalt, like the fixed alkalis, was not known in a ſtate of purity before the ingenious experiments of Black and Prieſtley. A certain imperfect neutral ſalt was miſtaken for it, which is ſolid and cryſtallized, and poſſeſſes indeed ſome of the properties of volatile alkali, but is really a compound

pound of two ſaline ſubſtances. The property of effervefcing with acids, which has been aſcribed to volatile alkali, belongs only to that neutral ſalt, which ſhall be afterwards deſcribed.

That which is known in the laboratory under the name of *cauſtic*, or *fluor volatile alkali*, and in pharmacy by the name of *volatile ſpirit of ſal ammoniac*, is not pure ammoniac; it is only a ſolution of ammoniac in water. Dr Prieſtley has ſhown, that by the operation of a gentle heat, a permanent gas may be extracted from it; and that the water, when deprived of this gas, gradually loſes its alkaline properties. This aeriform fluid is ammoniac, and is known by the name of *ammoniac gas*. This is the body whoſe properties we muſt examine, if we wiſh to know thoſe of genuine *volatile alkali;* as Macquer has very properly obſerved.

To obtain this elaſtic fluid, put into a ſmall retort or a glaſs matraſs a certain quantity of the *alkaline ſpirit*. Adapt to the retort, or the matraſs, a curved tube or ſyphon; the extremity of which is to be immerſed into a pneumato-chemical machine filled with mercury; ſo that it may be received under an inverted glaſs filled with the ſame fluid. Heat the bottom of the retort or matras with burning charcoal or the flame of ſpirit of wine. Suffer the firſt part of the elaſtic fluid, which is moſtly common air from the veſſel and the tube, to eſcape; and as ſoon as the ebullition becomes ſtrong, collect the gas in the inverted glaſs. The diſtillation muſt not be carried ſo far as to evaporate the water; or at leaſt the tube which is uſed ſhould in the middle ſwell into a bowl that may be kept cool, ſo as to condenſe the vapour: the ammoniac gas will then be obtained very dry and pure.

The gas thus obtained reſembles air, and has the ſame tranſparency and elaſticity. It is rather lighter, however; its ſmell is more penetrating; and its taſte is acrid and cauſtic. It inſtantly converts the blue colour of violets, mallows, and radiſhes, into a deep green, but does not alter it, as the pure fixed alkalis do. It kills animals, and corrodes the ſkin, if expoſed for any time to its contact.

Though it does not ſerve to maintain combuſtion, but extinguiſhes bodies in inflammation, yet it increaſes before extinguiſhing the flame of a wax-candle: it renders its bulk ſomewhat more conſiderable, and cauſes it to aſſume a pale yellow colour round the edge. This fact proves that ammoniac gas is partly inflammable.

Porous bodies, ſuch as charcoal, ſponge, &c. abſorb it.

Dr Prieſtley has diſcovered, that the electric ſpark, in paſſing through ammoniac gas, renders its bulk three times greater than before, and diſengages from it a portion of hydrogenous gas. The cauſe of this phænomenon is hitherto unknown; only it appears that the ammoniac is decompoſed in this experiment, and that the two matters, of which, as we ſhall preſently ſhow, it is compoſed, are ſeparated, and paſs into the ſtate of elaſtic fluids.

Ammoniac gas is one of thoſe elaſtic fluids which heat dilates the moſt. Atmoſpheric air does not combine with this gas; it only dilates and divides it. The action of vital air on this fluid has not yet been examined.

Water readily abſorbs ammoniac gas: if in the ſtate of ice it immediately melts with cold; but on the contrary, this gas communicates heat to fluid water. Water ſaturated with this gas, or liquid ammoniac, is the ſubſtance known by the name of *fluor* and *cauſtic volatile alkali.* We ſhall hereafter ſee that the pureſt and moſt concentrated volatile alkali is prepared by receiving the gas into diſtilled water till the liquid be ſaturated with it.

Ammoniac gas has no diſcernible action on earths or ſalino-terreous ſubſtances; but it acts vigorouſly on acids and a number of neutral ſalts, as we ſhall hereafter ſee. Liquid ammoniac has the ſame properties as the gas; only it poſſeſſes them in a leſs eminent degree: For the gaſeous aggregation being, according to one of the laws of affinity, much weaker than that of liquids; of conſequence, ammoniac gas muſt have a greater tendency to combination than liquid ammoniac.

This ſalt has been conſidered as a combination of fixed alkali with a combuſtible ſubſtance. What gave riſe to this conjecture was, that, in many inſtances, fixed alkalis, when heated with inflammable matters, produce ammoniac. But it was not known whether, on ſuch occaſions, fixed alkali entered entire into the compoſition of ammoniac, or only ſupplied a peculiar principle, which, by combining with part of the combuſtible matter, formed this ſalt. The nature of ammoniac is at preſent ſomewhat better known. The fine experiment of Dr Prieſtley, in which he changed alkaline into inflammable gas, by means of the electric ſpark, has made ſeveral chemiſts ſuſpect this laſt ſubſtance to be one of the principles of ammoniac. M. Berthollet having engaged in a particular ſeries of experiments with a view to determine this, has at length ſhown ammoniac to be a compound of the

the hydrogenous and the azotic principles, with a certain quantity of the caloric. He has drawn this induction from obſerving the action of oxigenated muriatic acid on ammoniac, the decompoſition of ammoniacal nitrate in cloſe veſſels, and the reduction of metallic oxides by means of ammoniac. Each of theſe facts ſhall be particularly examined in our hiſtory of the compound ſubſtances into which ammoniac enters. Here we will content ourſelves with obſerving, that by heating combinations of the oxides of copper and gold with ammoniac, water and azotic gas are obtained, and the metals are reduced. In ſuch operations the ammoniac is decompoſed, and its hydrogene combining with the oxigene of the metallic oxides, forms the water; the metals are left pure, and the azote, the other principle of ammoniac, becoming free, combines with the caloric, and the two are diſengaged in azotic gas. Berthollet concludes ammoniac to conſiſt of ſix parts of azote and one of hydrogene, with a certain quantity of caloric.

Ammoniac diluted in water is adminiſtered in a great many diſeaſes. It is aperient, and powerfully inciſive. It acts ſtrongly on the ſkin; it is preſcribed as a remedy for the bite of vipers, and for cutaneous and venereal complaints, &c.

As it is acrid and cauſtic, it is to be very cautiouſly applied. Externally applied, it is very ſerviceable in diſcuſſing tumours, eſpecially ſuch as are formed by coagulated milk, lymph, &c. I have preſcribed it ſucceſsfully in theſe caſes: it is a ready cure for burnings; and is often ſucceſsfully applied for chiblains, &c. It has been long uſed, and under a variety of names, as a moſt active ſtimulant in caſes of ſyncope, apoplexy, &c. But it ſhould be uſed in very moderate quantities in theſe latter caſes; it is dangerous to adminiſter it internally, unleſs diluted in a large quantity of water. Alarming excoriations have ſometimes been produced on the duct of the æſophagus and the membranes of the ſtomach, in caſes where it has been raſhly adminiſtered.

CHAP. IV.

Genus III. *Acids.*

ACIDS are known by their ſour taſte when diluted in water; they convert blue vegetable colours to red; many of them appear under a gaſeous form; they combine rapidly with alkalis; they act much more powerfully than alkalis on combuſtible bodies, often reducing them to a ſtate of calcination. As inflammable matters, eſpecially metals, are found to contain a conſiderable quantity of oxigene after they have been expoſed to the action of acids, while theſe again are found to have paſſed at the ſame time into a combuſtible ſtate; from theſe facts it may be inferred that acids are by no means the ſimple bodies they were thought to be, but are in general compounds of an inflammable matter, combined with the oxigenous principle.

We are acquainted with ten different ſpecies of acids in the mineral kingdom. We find alſo, in the ſame diviſion of nature, the phoſphoric acid, united with iron, lead, and lime.

The carbonic acid.

The muriatic acid.

The

The fluoric acid.
The nitric acid.
The ſulphuric acid.
The boracic acid.
The molybdic acid.
The tunſtic acid.
The arſenic acid.
The ſuccinic acid.

We ſhall here treat of the firſt ſix, which are moſt plenteous and beſt known; the other four will be examined elſewhere.

Species I. *The Carbonic Acid.*

We give the name of the *carbonic acid* to an acid which occurs in great abundance through the whole of nature, and which appearing often in the ſtate of an aeriform fluid, was at firſt called by the Engliſh *fixed air;* afterwards by Meſſrs Bewly and de Morveau *the mephitic acid;* by Macquer *mephitic gas;* by Bergman *the aerial acid;* and by Bucquet *the cretaceous acid.* The propriety of the denomination which we have adopted will afterwards appear.

This ſubſtance was not always thought to be an acid. Its leading properties were obſerved by Paracelſus, Van Helmont, Hales, &c. But we are indebted to Meſſrs Black, Prieſtley, Bewly, Bergman, and the Duke de Chaulnes for our knowledge of its acidity.

The gaſeous carbonic acid poſſeſſes all the apparent characteriſtic properties of air. Like air, it is inviſible and elaſtic; and when incloſed in a glaſs veſſel, or floating in the atmoſphere, it cannot be certainly diſtin-

diſtinguiſhed from that fluid. It is one of the principles of atmoſpheric air, but the moſt ſcanty in the compoſition *. It is found perfectly pure in ſubterraneous cavities, which it entirely fills, as in the *grotto del cane.* It is combined with a great number of natural bodies, ſuch as mineral waters and many neutral ſalts; ſpirituous fermentation produces great quantities of it. It is alſo formed by reſpiration and the combuſtion of coals: Laſtly, it is conſtantly exhaled from all parts, and more eſpecially from the leaves, of plants in the ſhade.

Though this acid, in the ſtate of an elaſtic fluid, has all the appearance of air, yet it poſſeſſes different phyſical properties; its ſpecific gravity, for inſtance, is double that of air. Like all other fluids, it may be poured from one veſſel into another; it flows from the cock of a wine-caſk, after the wine is drawn off; its taſte is pungent and ſubacid; it is inſtantaneouſly fatal to animals, becauſe it affords no ſupply for reſpiration; it extinguiſhes flaming tapers, and all bodies in combuſtion. It communicates to the tincture of turnſol a bright red colour. That colour vaniſhes gradually in the air as the acid evaporates. It produces no alteration on the colour of violets, as it acts but very feebly on very deep and fixed colours.

This acid has but a very faint tendency to combination;

---

* M. Lavoiſier's ingenious experiments have led him to conſider atmoſpheric air as a compound of vital air, carbonic acid, and azotic gas, moſt commonly in the following proportions.

Vital air, - - - -	27
Carbonic acid - - - -	1
Azotic gas - - - -	72
Total - -	100

tion; the weakeſt indeed of all bodies of the kind. It ſuffers no diſcernible alteration from the contact of light.

Heat dilates it, but produces no change on its nature.

It mixes with vital air without ſuffering any alteration; and the mixture will maintain reſpiration as long as the carbonic acid does not exceed a third part of it. On this account, it admits of being uſed as a remedy in diſeaſes of the lungs.

It combines with water but very ſlowly. By ſhaking theſe two fluids together, ſo as to bring them as much as poſſible into contact with one another, they are made to unite and form an acidulous liquor. Bergman gives this ſolution the name of *aerated water.* But this name belongs more properly to water containing atmoſpheric air, which it may ſerve to diſtinguiſh from boiled water that has been deprived of its air by heat. The colder water is, the more of the carbonic acid does it diſſolve. But there is a point of ſaturation; even the coldeſt water cannot abſorb a greater quantity than what is equal to its own bulk.

Water ſaturated with carbonic acid is ſomewhat heavier than diſtilled water. Agitation makes it ſparkle; it has a pungent, acidulous taſte, and reddens the tincture of turnſol. It is decompoſable by heat; which ſoon brings it to a ſtate of ebullition, and diſengages the elaſtic acid. The contact of air produces the ſame effect more rapidly in proportion as its temperature is higher. Therefore, in order to preſerve this acidulous liquor, it muſt be incloſed in veſſels properly ſtopped, and ſtanding in a cool place, or under ſtrong compreſſion.

This acid ſolution abounds through nature. Of it acidulous and gazeous waters, ſuch as thoſe of Pyrmont, Seltz, &c. conſiſt.

As this acidulated water is a remedy in all putrid diſorders, either by drinking or bathing, naturaliſts have invented an apparatus for impregnating with eaſe, and with all poſſible quickneſs, any quantity of water with as much of the carbonic acid as it can maintain in ſolution. Dr Prieſtley, in the year 1772, gave the firſt account of a proceſs for acidulating water that was offered to the public. Dr Nooth has invented a machine for this purpoſe, which has been improved by Mr Parker, and ſtill farther improved by Mr Magellan. It is at preſent to be found in all philoſophical laboratories. There is an excellent deſcription, and an engraving of it, in Dr Prieſtley's Experiments on the different kinds of Air, p. 112 to p. 118; and in Mr Magellan's letter in the ſame work, vol. v. page 83.

The carbonic acid does not act upon ſiliceous earth. It is well known that acidulated water alone never cryſtallizes ſiliceous earth; a fact which was ſome years ſince communicated to the public.

The carbonic acid unites with aluminous earth, barytes, and magneſia. With theſe ſubſtances it forms various neutral ſalts, which we ſhall afterwards have occaſion to examine.

The combination of this acid with lime diſſolved in water, gives riſe to an invariable phænomenon, which always indicates the preſence of the acid. As ſoon as it touches the liquid, it produces white clouds, which ſoon thicken and form a plenteous precipitate. Theſe clouds are owing to the chalk, or carbonate of lime, formed by the combination of lime with the carbonic acid. This new ſalt not being ſoluble in pure water, is ſeparated, and ſubſides to the bottom of the fluid.

Lime

Lime water is therefore a teſt, by which we may diſtinguiſh the nature and the quantity of the acid under examination. If, after this precipitation, more of the acid be added, the precipitate will again be diſſolved by the additional quantity of the carbonic acid, and will diſappear. Here is a ſecond characteriſtic by which this acid may be known. The chalk thus diſſolved by the addition of a ſecond quantity of the carbonic acid, is again precipitated when the liquor is heated or expoſed to the air, or laſtly, by all proceſſes which carry off the ſuperfluous quantity of carbonic acid. Thus, I have remarked, that the cauſtic fixed alkalis and pure ammoniac, when poured into a ſolution of chalk with the carbonic acid, cauſe a precipitation by abſorbing part of the acid.

Acidulated water, if poured into lime-water, produces upon it preciſely the ſame effects.

The carbonic acid combines rapidly with the three alkalis. If a ſmall quantity of pure cauſtic fixed alkali, in a liquid ſtate, be put into a veſſel filled with this acid, obtained from chalk or from beer in a ſtate of fermentation, and the mouth of the veſſel be immediately cloſed with a wet bladder, the bladder will be ſeen to contract gradually, on account of the vacuum produced in the veſſel by the alkali abſorbing the carbonic acid. The combination of theſe two ſalts is attended with heat; and the ſides of the veſſel are ſoon covered with cryſtals which become gradually larger. This ſalt is called *carbonate of potaſh*, or *carbonate of ſoda*, according as the one or the other of theſe fixed alkalis is employed. Theſe two genuine neutral ſalts were formerly called *ſalt of tartar*, and *ſalt of ſoda.* We ſhall examine their properties in the following chapter.

Am-

Ammoniac gas, and the aeriform carbonic acid, brought into contact in a cloſe veſſel, alſo produce inſtantaneouſly a vacuum, heat, and a thick white cloud which forms into regular cryſtals, or ſimply into a cruſt, on the ſides of the veſſels. This is an imperfect neutral ſalt, to which we may give the name of *ammoniacal carbonate*, and which was formerly called *concrete volatile alkali*, *Engliſh ſalt*, &c.

The carbonic acid does not adhere to all of theſe baſes with the ſame force. According to Bergman, barytes is the ſubſtance with which it has the greateſt affinity; next in order come lime, potaſh, ſoda, magneſia, and ammoniac. We will have occaſion in the hiſtory of neutral ſalts to take notice of the facts on which Bergman has eſtabliſhed this order of affinities.

The nature and compoſition of this gaſeous acid have for ſome years much engaged the induſtry of chemiſts. Prieſtley, Cavendiſh, Bergman, and Scheele, ſeem to agree in thinking it a compound of vital air with phlogiſton. But as the exiſtence of that principle has been with reaſon queſtioned by a number of celebrated French chemiſts, who have urged many difficulties and objections againſt it, to which no ſatisfactory anſwer can be given, we cannot therefore admit of this theory. I once thought that the carbonic acid might be a compound of inflammable gas with pure air: but the diſcovery of the nature and the decompoſition of water renders that conjecture improbable; and M. Lavoiſier has ſupplied in its room a fact ſupported by demonſtrative evidence.

That chemiſt, to whom the ſcience is indebted for ſo many ingenious and nice experiments, burnt a certain quantity of charcoal, deprived of all its hydrogeneous gas by a previous calcination in cloſe veſſels, in inverted

inverted glaſſes, filled with mercury above a portion of vital air: for he had obſerved, that if the operation were performed without the precaution of calcining the coal, drops of water would be obtained, and would neceſſarily render the calculation inaccurate. This operation was performed by means of a quarter of a grain of agaric tinder, placed on a bit of coal, and covered with a very ſmall quantity of phoſphorus: a piece of iron wire bent, and made red hot, paſſed thro' the mercury, ſo as to kindle the phoſphorus; the phoſphorus communicated the inflammation to the agaric tinder, which again communicated it to the coal; the inflammation was very rapid, and accompanied with much light. The whole apparatus being cold, M. Lavoiſier introduced into the glaſs a portion of liquid cauſtic fixed alkali; which abſorbing the acid formed during the combuſtion, left part of the vital air as pure as at the beginning of the experiment. This chemiſt is of opinion, that in this experiment the oxigenous principle, which by combining with the caloric former vital air, produced a portion of the carbonic acid, by combining with the matter of the coal, while the other principle of the ſame vital air was diſengaged under the form of heat and light. A portion of aſhes remained; and the quantity of the acid formed, was equal in weight to the vital air conſumed and the weight which the coal had loſt. From a number of experiments of this kind, M. Lavoiſier concluded, that a quintal of the carbonic acid, the name of which the reader may now perceive to be founded on its nature, conſiſts of about 28 parts of pure carbonaceous matter, and 72 of oxigene.

He thinks, that in the reſpiration of animals, a real carbonaceous matter is actually diſengaged from the blood,

blood, which, by combining with the oxigene of the atmoſphere, forms the carbonic acid, which is conſtantly produced by reſpiration; and that in the ſame manner the carbonic acid, diſengaged in ſpirituous fermentation, is produced by the combination of the carbonaceous matter of ſugar with the oxigenous part of water.

Several philoſophers have obſerved, that this acid, in a ſtate of fluid elaſticity, poſſeſſes the property of preſerving animal ſubſtances, retarding their putrefaction, and even reſtoring them to a ſound and freſh ſtate after putrefaction has begun to take place. From this fact Macbride has inferred, that the acid unites with the body, thus reſtoring to it what it loſt by putrefaction. This latter phænomenon, in his opinion, is occaſioned by the natural decompoſition of organic matters, and the diſſipation of the carbonic acid they contain, which he calls *fixed air;* and therefore he aſſerts the uſe of this acid to be indiſpenſably neceſſary, in order to afford animals a ſupply of what they are ſo conſtantly loſing, and to reſtore the fluids when altered by motion and heat. He acknowledges the exiſtence of this acid in freſh vegetables, more eſpecially in ſuch as are ſuſceptible of fermentation; as a decoction of barley which has been ſuffered to germinate, the infuſion of raiſins, &c. all of which, he thinks, may be with equal propriety preſcribed in diſeaſes occaſioned by the ſeptic motion of the humours; ſuch as the ſcurvy.

Water impregnated with the carbonic acid has been alſo propoſed as a remedy in putrid bilious fevers; and has been uſed with ſucceſs in a number of inſtances. The Engliſh are ſaid to uſe the carbonic acid, mixed in a low and unequal proportion with common air, in diſeaſes of the lungs.

It has been ſtrongly recommended as a lithontriptic, or ſolvent of the ſtone in the bladder. But there is no well authenticated inſtance of its being ſucceſsfully uſed in France againſt this dreadful diſtemper. Beſides, this is contradictory to what Scheele and Bergman have diſcovered concerning the ſtone in the bladder; of which we ſhall elſewhere ſpeak.

The newſpapers have given accounts of a number of cancerous caſes cured in England by the uſe of carbonic acid. But we can aſſert, that we have often ſeen it uſed in ſuch caſes, and have even tried it ourſelves, ſtill without effect. After the firſt applications, the cancerous ulcer ſeems to aſſume a more favourable aſpect; the ſanies which uſually flows from it becomes white, conſiſtent, and ſomewhat pure; the fleſh aſſumes a freſh lively colour; but theſe flattering appearances are fallacious, and do not continue; the ulcer ſoon returns to its former ſtate, and its progreſs goes on as before.

The period of the firſt diſcovery of this acid by Dr Black is to be conſidered as one of the moſt illuſtrious æras of chemical ſcience. To point out the influence of this diſcovery upon the ſcience, we ſhall here offer the following remarks. 1. It has made us acquainted with a peculiar acid. 2. It has explained the cauſe of the effervеſcence of the common alkalis, chalk, calcareous ſpar, and magneſia, when mixed with acids ſtronger than themſelves. 3. It has enabled us to diſtinguiſh all alkaline matters as exiſting in two ſtates, *pure and cauſtic*, or *ſoft, with the property of cauſing effervеſcence*. 4. It has thrown new light on the hiſtory of the elective attractions of ammoniac and chalk for the acids. 5. It has furniſhed us with one of the firſt inſtances of an acid preferring lime to the fixed alkalis. 6. The hiſtory of places containing mephitic air, caverns which

which are inſtantly fatal to the life of animals, is become ſince this diſcovery more ſimple and intelligible. 7. To the former analyſes of waters, we have been enabled to add by this diſcovery an accurate knowledge of gaſeous, ſpirituous, and acidulous waters; ſo that we can now produce by rule the moſt perfect imitations of them. 8. It has likewiſe made us much better acquainted with the ſolutions of iron contained in various waters; and has taught us how to make up martial waters exactly reſembling thoſe of nature. 9. It has made us acquainted with a new claſs of neutral ſalts, alkaline and metallic, which have the carbonic acid for one of their principles, and to which we ſhall therefore give the name of *carbonates* in this work. 10. It has opened a new tract for the reſearches of naturaliſt and chemiſts, and rouſed that ardour for ſuch purſuits, to which we are indebted for all the fine diſcoveries which have been made ſince that period. The name of Black will therefore be famous in the annals of chemiſtry as long as the ſcience ſhall be cultivated.

As to the production of this acid by the electric ſpark paſſing through vital air, we muſt obſerve, that in the experiments of M. Landriani, the iron uſed as the conductor of the electric fluid, is evidently the cauſe of the phænomenon by means of the plumbago, &c. which it contains. The trifling quantity of the acid obtained is an unequivocal proof of this.

There are, no doubt, many caſes in which the carbonic acid is decompoſed and reſolved into its principles, as well as other acids: Thus, for inſtance, water ſaturated with this acid is much fitter than diſtilled or common water for the production of vital air on leaves expoſed to the rays of the ſun: the vegetable ſubſtance ſeems to abſorb the carbonaceous matter, while the light,

acting

acting like heat, contributes by ſeparating the oxigene to the production of vital air. It is likewiſe very remarkable, that certain oxides of iron, diſtilled in a pneumato-chemical machine, afford only carbonic acid as they paſs to the ſtate of æthiops or black oxide of iron. This depends either on the carbonaceous matter, or the plumbago contained in ſeveral kinds of iron. The carbonaceous matter, by abſorbing part of the oxigene of the iron, forms the acid which is diſengaged. Theſe newly diſcovered facts will be explained more at length in ſome of the following chapters of this work.

Species II. *The Muriatic Acid.*

In the laboratories, the name of *marine acid*, or *ſpirit of ſalt*, or *liquid muriatic acid*, is given to a fluid of the conſiſtency of water, of a taſte ſtrong enough to corrode our organs when it is concentrated; but which, when diluted in water, affects the tongue only with a ſourneſs and ſtipticity. This fluid, when perfectly pure, is abſolutely colourleſs. When it is red, or citron coloured, like the marine ſalt of the ſhops, it owes its colour to ſome combuſtible ſubſtance, frequently to iron, which alters it. This acid is obtained either from marine ſalt or muriate of ſoda, as we ſhall ſee in the hiſtory of that ſalt. If ſtrong and concentrated, it exhales when expoſed to the air a white vapour or ſmoke. It has a lively penetrating ſmell, which when faint or much diluted, reſembles the ſmell of citrons, or the apple called the *golden rennet.* It is then called the *fuming muriatic acid.* Its vapour riſes moſt copiouſly when the air is moiſt. If, on opening a flaſk full of this acid, you put your hand to its orifice, you feel a ſenſible heat; which is occaſioned by the combination of the acid in the ſtate of vapour with the water of the atmoſphere.

The muriatic acid communicates a deep red to the ſyrup of violets, and all blue vegetable colours, but does not abſolutely deſtroy them. This liquor, however concentrated and fuming, is not muriatic acid in a pure and ſeparate ſtate; but muriatic acid combined with a conſiderable quantity of water. Dr Prieſtley has eſtabliſhed this truth beyond a doubt, by ſhowing that this acid may be reduced to a gas, and rendered permanent in that ſtate, over a portion of mercury, by the temperature and preſſure of the atmoſphere: it is therefore the properties of this gas we muſt examine, if we wiſh to acquire a knowledge of thoſe of the muriatic acid, unmixed and in a ſtate of purity.

The muriatic acid gas is obtained by heating the liquid fuming acid in a retort, the extremity of which enters a bell-glaſs full of mercury. The gas being much more volatile than the water, paſſes through the retort into the glaſs; it diſplays all the apparent properties of common air, but is more ponderous. It has a keen penetrating odour; and is ſo cauſtic that it inflames the ſkin, and often occaſions violent itchings. It ſuffocates animals, and extinguiſhes the flame of a taper, after magnifying it and cauſing it to aſſume a green or bluiſh flame round its edge. Spongy bodies abſorb this acid.

Light does not appear to alter it in any ſenſible degree. Heat rarefies it, and increaſes its elaſticity amazingly. Atmoſpheric air, mixed under bell-glaſſes with muriatic gas, cauſes it to aſſume a fumy or vaporous form, and is gently heated; from which it appears that a combination actually takes place. When the air is humid, theſe vapours are more diſcernible: M. d'Arcet has obſerved that they are not perceptible on the tops of high hills, where the air is very dry. The white vapours exhaled by the muriatic acid gas are therefore owing to the water contained in the atmoſphere. Neither the liquid acid nor the gas abſorbs vital air in a ſtate of elaſticity, in any ſenſible degree; yet ſome properties, which we ſhall mention by and by, enable them to combine with the oxigenous principle. It is aſſerted that the liquid muriatic acid may be cauſed to abſorb a portion of vital air, by ſhaking them violently together.

The muriatic acid gas combines rapidly with water. Ice, on coming into contact with it, inſtantly melts to abſorb it. Water uniting with this gas acquires a conſiderable heat. When ſaturated with it, it cools and becomes the ſame with the liquid acid from which the gas was obtained; it exhales white vapours, is colourleſs, reddens ſyrup of violets, &c. We ſhall afterwards ſee, that the moſt concentrated and pure liquid muriatic acid is obtained by ſaturating pure water with the elaſtic fluid.

The muriatic acid gas has no power of action on ſiliceous earth; it combines with aluminous earth, and by that combination forms aluminous muriate.

It unites with the ſalino-terreous ſubſtances, forming in combination with them barytic, the magneſian, and calcareous muriates.

Its combination with potaſh is *the febrifuge ſalt of Sylvius*, or muriate of potaſh: with mineral alkali or ſoda, it gives marine ſalt, common ſalt, or muriate of ſoda.

The muriatic gas when brought into contact with the ammoniac gas, acquires a conſiderable heat. The two elaſtic fluids penetrate each other, a white cloud inſtantly riſes, the mercury is elevated in the glaſſes, and the ſides of the glaſſes are ſoon covered over with ramified cryſtals, which are ſal ammoniac, or ammoniacal muriate. If the two gaſes are very pure, they diſappear entirely when the concretions are formed, and the heat diſengaged. This experiment among others proves, 1. That bodies which paſs from a liquid to a ſolid ſtate, abſorb in their tranſition a certain quantity of the caloric principle, or the matter of heat; for the cauſe which converts the muriatic acid into a gas, is its receiving an additional quantity of heat. 2. That the heat abſorbed by elaſtic fluids, in their *aerification*, is diſengaged when they return to a liquid or ſolid ſtate. 3. That the elaſticity of fluids is produced by their abſorbing and combining with heat; and that all aeriform fluids are compound bodies, which owe their form to fixed heat, or the caloric principle, as we have elſewhere ſhown.

The muriatic acid abſorbs the carbonic acid; but the reciprocal action of theſe two acids has not yet been properly examined. The muriatic is known to be the ſtronger of the two; for it diſengages the carbonic from all its baſes, and enters itſelf into combination with them. Bergman arranges its attractions for the different alkaline baſes in the following order, proceeding from that with which it has the ſtrongeſt to that with which it has the weakeſt affinity: barytes, potaſh, ſoda, lime, magneſia, ammoniac, aluminous earth.

The intimate nature of the muriatic acid, and the principles of its compoſition, are unknown. Beccher imagined it to conſiſt of ſulphuric acid with *mercu-*

rial earth; becauſe he had obſerved that acid to have a ſtrong affinity, and combine very readily, with all the bodies in which he admitted the exiſtence of this principle, ſuch as arſenic, mercury, &c. Stahl has not illuſtrated Beccher's opinion concerning this acid. And among all the ingenious experiments of the moderns, there is none which throws any light on the conſtituent principles of the muriatic acid. As its baſe is unknown to us, we cannot determine whether it admits of two ſtates of ſaturation with oxigene; in one of which, the baſe being completely ſaturated, the acid muſt be ſtronger, while in the other the baſe being combined with a ſmaller quantity of oxigene, the acid muſt be weaker, according to what has been obſerved of the nitric, the nitrous, the ſulphuric, and the ſulphureous acids. Even the exiſtence of oxigene in the muriatic acid has not yet been fully evinced; it is only from analogy that it has been admitted.

Scheele is the only chemiſt who has done any thing of conſequence on this head. In the year 1774, he made an important diſcovery concerning the different ſtates in which this acid exiſts. By diſtilling a quantity of muriatic acid upon oxide of manganeſe, he obtained this acid in the form of a yellowiſh gas, of a very pungent ſmell, amazingly expanſive, and capable of diſſolving any metal with facility, mercury or gold not excepted. He thought that, in this inſtance, the manganeſe, which he imagined to be very greedy of phlogiſton, abſorbed the phlogiſton of the muriatic acid; and he therefore called this acid, after it had undergone this operation, *dephlogiſticated marine acid;* and thought that it diſſolved gold from its avidity to unite with a new portion of phlogiſton. No unequivocal experiment, however, demonſtrated the exiſtence of the inflammable principle in this acid: and in the year 1780, I ſuſpected that it was the baſe of vital air contained in the manganeſe, which entered into union with the muriatic acid; as may be ſeen in the firſt edition of my Elements under the articles *Aqua Regia* and *Manganeſe, &c.* M. Berthollet, my fellow-academician, has ſhown that conjecture to be a certain truth, by a ſeries of accurate and ingenious experiments.

A diſtillation of the muriatic acid on oxide of manganeſe, afforded him yellow vapours without the help of fire. If the retort be heated, and the vapours received in flaſks full of water, and immerſed in ice, a very ſmall portion of the acid is diſſolved, but the water is ſoon ſaturated; after the ſaturation of the water, the reſt of the gas aſſumes a concrete form, and falls in cryſtals to the bottom of the liquor. This ſalt melts, and riſes in bubbles with the moſt moderate heat.

The oxigenated muriatic acid in a liquid form, or diſſolved in water, has, according to M. Berthollet, an harſh though not an acid taſte; it whitens and deſtroys vegetable colours, without changing them firſt into a red; it neither expels the carbonic acid from its baſes, nor produces any efferveſcence with alkaline ſubſtances ſaturated with that acid; in ſhort, it poſſeſſes not the uſual properties of acids. If heated with quicklime, it efferveſces, and gives out vital air, ſo that the remains is nothing but calcareous muriate; which is evidently produced by the diſengagement of the oxigene with which the acid was ſaturated. The oxigenated muriatic acid produces likewiſe an efferveſcence when it combines with pure ammoniac. The reſult of this combination is, on the one hand, water; on the other, azotic gas. In this inſtance, the oxigenated muriatic acid and ammoniac are both decompoſed; the hydrogene, which is

one

one of the principles of the ammoniac, unites with the oxigene, with which the muriatic acid is ſuper-ſaturated, and by their union the water is formed; while again, the azote, the other principle of the ammoniac, uniting with the caloric, eſcapes under an elaſtic form, and produces the effervescent motion obſerved in this experiment. Laſtly, the oxigenated muriatic acid converts metals into oxides, and diſſolves them without occaſioning effervescence. It deſtroys vegetable colours, as it paſſes into the ſtate of common muriatic acid. All theſe experiments prove, that Scheele's dephlogiſticated muriatic acid, is a combination of this acid in a pure ſtate, with the baſe of vital air, or the oxigenous principle; and that its proper name is, *aerated or oxigenated muriatic acid*, as I have ſhown in my firſt edition. M. Berthollet has not yet determined what quantity of oxigene the muriatic acid muſt abſorb, in order to acquire the properties of oxigenated muriatic acid *. In March 1787, he diſcovered that oxigenated muriatic gas, received into a lixiviate of cauſtic potaſh, forms a cryſtallizable neutral ſalt, which, like nitre, or even in a greater degree, produces detonation on burning coals; affording by the action of the fire very pure vital air, or oxigenous gas, and leaving a reſidue of the muriate of potaſh. Theſe experiments concur to ſupport the theory which I offered to the public ſeven years ſince, concerning the nature of the oxigenated muriatic acid; for the detonation of oxigenated muriate of potaſh is plainly owing to its containing an extraordinary quantity of oxigene. Soda forms only a deliqueſcent ſalt with the oxigenated muriatic acid.

The muriatic acid is made uſe of in ſeveral of the arts,

---

* See *Journ. de Phyſique, tome* xxvi. *page* 321, *Mai* 1785.

arts, and more eſpecially in the art of aſſaying in the humid way *. In medicine, it is well diluted in water, and adminiſtered as a diuretic, an antiſeptic, and a cooler; it is the chief ingredient of the Prior de Chabrieres cure for ruptures. It is externally applied as an eſcharotic, to deſtroy altered fleſh, as a cure for the gangrene in the throat, aphthæ, &c. Mixed with a certain quantity of water, it compoſes a bath for the feet, uſed by ſome people, and conſidered as a ſecret, for drawing the gout from the more vital to the inferior parts.

But the oxigenated muriatic acid has been known for too ſhort a ſpace of time to admit of its being much uſed in the arts. M. Berthollet thinks that it may be ſucceſsfully employed for diſcovering in a few minutes or hours, what effects the action of air would produce on coloured ſtuffs, and thus determining the fixity or alterability of the colours: he has of late recommended it for whitening linen and unbleached yarn: and the firſt trials, which have been in Paris on a pretty extenſive ſcale, promiſe favourably. It may likewiſe be advantageouſly employed for whitening in a ſhort time the yellow, and more eſpecially the green wax from our iſlands.

Species III. *The Fluoric Acid.*

THE fluoric acid, diſcovered by Scheele, has received this name becauſe it is obtained from a ſort of earthy neutral ſalt, with which we ſhall afterwards get acquainted under the name of *fluor ſpar*.

---

* See Bergman, de Docimaſia humida, Opuſc. Vol. II. &c. Or the Engliſh tranſlation of his *Opuſcula*.

This acid when pure has a gaſeous form, and we muſt examine its properties as it exiſts in that ſtate. The fluoric acid is more ponderous than common air. It extinguiſhes lights and kills animals. It has a pungent penetrating ſmell, nearly the ſame with that of the muriatic acid gas, but rather leſs keen. Its cauſticity is ſuch that it corrodes the ſkin, however ſhort the ſpace of time during which it is expoſed to its contact. It ſuffers no ſenſible alteration from light. Heat dilates it, but without changing its nature.

The water contained in atmoſpheric air enables it to deſtroy the tranſparency of the fluoric acid, and convert it into a white vapour; which it does more or leſs readily, according as it contains a greater or a leſs quantity of water. This phænomenon reſembles that which the muriatic acid preſents on the ſame occaſion; but the ſmoke of the fluoric gas is thicker than that of the other.

The fluoric acid gas unites eagerly with water, and heat is produced at the inſtant of their union. A peculiar phænomenon appears on this occaſion, namely, the precipitation of a very fine white earth, which appears to be ſiliceous earth. From this circumſtance it appears that the acid is far from being pure in the ſtate of elaſtic fluidity. It becomes pure, therefore, only when the earth, which adhered to it when it was volatilized, has been ſeparated by the action of water. A ſolution of this gas in water conſtitutes the acid ſpirit of luor; the ſmell and cauſticity of which are very ſtrong when the water is ſaturated with it. This liquid acid communicates a ſtrong red colour to the ſyrup of violets. According to Scheele and Bergman, it poſſeſſes the ſingular property of diſſolving ſiliceous earth. Although the fluoric acid gas, on uniting with water,

ter, depoſites a conſiderable quantity of this earth, yet it ſtill retains ſo much that alkalis cauſe it to afford a new precipitate.

Dr Prieſtley obſerved, that the fluoric acid gas corroded and penetrated common glaſs, and found it neceſſary to uſe thick glaſs bottles for his experiments. Macquer thought that the acid produced this effect only when in a gaſeous ſtate, but was incapable of attacking glaſs when liquid or diluted in water. This opinion is founded on the circumſtance of water's precipitating the ſiliceous earth, which is maintained in a ſtate of ſolution in the fluoric gas. But it is to be remembered, that the water does not entirely ſeparate the earth from the acid ; and therefore the fluoric acid muſt retain, even in a fluid ſtate, the power of acting on glaſs and ſiliceous ſtones.

The liquid fluoric acid may be decompoſed like ſpirit of ſalt by heating it in a retort, the extremity of which enters a bell-glaſs full of mercury. By this means the acid is obtained in gas, and leaves the water pure.

The two French chemiſts who, in the year 1773, publiſhed, under the name of M. Boullanger, a ſeries of experiments on the vitreous ſpar, or the ſparry fluor, are of opinion that the acid of this ſpar is nothing but a combination of muriatic acid with an earthy matter, which water only is capable of ſeparating from it. But Scheele has ſucceſsfully combated this opinion. He conſiders it as a peculiar acid, ſtrikingly diſtinguiſhed from all others by the various combinations of which it is ſuſceptible. And his opinion is at preſent very generally received among chemiſts.

The fluoric is the only mineral acid capable of diſſolving ſiliceous earth. Bergman and Scheele were of opinion,

opinion, in the year 1779, that this earth might very probably be a compound of the fluoric acid with water; becauſe the fluoric acid gas depoſites no ſmall quantity of ſiliceous earth, when brought into contact with water. But an experiment of M. Meyer's has ſince proved, that the earth precipitated on that occaſion comes from the glaſs veſſel, part of which is diſſolved by the acid. That chemiſt took three cylindrical tin veſſels, into each of which he put an ounce of *vitreous ſpar* and three ounces of ſulphuric acid, which having a greater affinity than the fluoric acid with lime, is ſucceſsfully employed to ſeparate this latter acid: to one of theſe mixtures he added an ounce of pulverized quartz; to the ſecond an ounce of powder of glaſs; the third he left pure without any addition: in each of the cylinders he hung a wet ſponge, and cloſing up the veſſels, expoſed them to a moderate temperature. Half an hour after, he found a ſiliceous duſt depoſited on the ſponge of the mixture containing the glaſs; at the end of twelve hours, the ſponge of the veſſel containing the quartz was likewiſe covered over with an earthy incruſtation; but even after ſeveral days the ſponge of the third veſſel exhibited no ſuch appearance. Bergman ſent an account of this experiment to M. de Morveau, letting him know at the ſame time, that he now gave up his opinion concerning the formation of ſiliceous earth by the combination of the fluoric acid gas with water. The precipitation is therefore owing to the glaſs diſſolved by the fluoric acid gas; and the acid is not pure till after the precipitate has been ſeparated from it by water and alkalis.

The fluoric acid, either in a gaſeous or a liquid ſtate, unites with aluminous earth, forming with it

alumi-

aluminous fluate *, a ſweet taſted neutral ſalt, which readily aſſumes the conſiſtency of a thick jelly.

It combines alſo with barytes: the ſalt reſulting from that combination, to which we give the name of *barytic fluate*, is a pulverulent ſubſtance.

With magneſia the fluoric acid forms a cryſtallizable ſalt, *magneſian fluate.*

It forms a precipitate with lime-water, producing inſtantly *calcareous fluate.*

It combines with potaſh to form *fluate of potaſh;* with ſoda, it produces *fluate of ſoda;* laſtly, combining with ammoniac, it forms the ſalt which we call *ammoniacal fluate.*

This ſhort account of theſe ſaline combinations ſhows the fluoric acid to be evidently different from the muriatic. Its affinities with the different baſes afford new proofs in ſupport of the ſame truth. Bergman obſerves, that the fluoric acid, when united with potaſh, may be ſeparated from it by lime-water, which cauſes the ſolution of that ſalt to afford a precipitate. The ſame thing takes place on a ſolution of the barytic fluate, which becomes muddy when lime is put into it. Bergman gives its elective attractions in the following order; lime, barytes, magneſia, potaſh, ſoda, ammoniac: But he confeſſes that more experiments are neceſſary to eſtabliſh fully this order of affinities.

The fluoric acid gas has not as yet been applied to any purpoſe in the arts: but its power of diſſolving ſiliceous earth will in all probability render it very uſeful in chemical operations, when once proceſſes for obtaining

---

* According to the methodical nomenclature which we have propoſed, the word *fluorate* is here to be uſed; but we abridge it into *fluate:* and we ſhall do the ſame for the ſulphuric acid, uſing *ſulphate* inſtead of *ſulphurate.* A.

taining it more conveniently than at preſent ſhall be introduced.

Species IV. *The Nitric Acid.*

What is called *ſpirit of nitre* in the laboratory, is a combination of this acid with water. In a liquid ſtate and pure, the acid is white; but if altered in the ſmalleſt degree, it becomes yellow or red ; and there ariſes from it in great abundance a vapour of the ſame colour. It is ſo cauſtic that it burns and deſtroys inſtantaneouſly the organization of the muſcles. It reddens ſyrup of violets, and entirely deſtroys its colour.

On being expoſed to the rays of the ſun, it acquires, according to Scheele, an higher colour and greater volatility; and from this it appears that light acts upon it: As it acquires a deeper colour, vital air is diſengaged from it.

Heat volatilizes this acid, and ſeparates the colouring matter in the form of red vapours.

When red, it unites eagerly with water, which aſſumes, in conſequence, a green or blue colour: it appears to have acquired a conſiderable degree of heat in entering into this combination. When united with a large quantity of the fluid, it forms *aquafortis.*

The white and the red nitrous acids were formerly conſidered as being of the ſame ſubſtance, only concentrated in different degrees; the ſtrongeſt coloured was thought to be the moſt concentrated of the two. But we are now better acquainted with the nature of this ſaline ſubſtance, and know it to be capable of exiſting in two different ſtates. In one of theſe the acid of nitre is deſtitute of colour, more ponderous, and leſs volatile, and emits only a white ſmoke; in the other, it is of a colour varying in ſhade from a yellow to a brown red, is more light and volatile, and is conſtantly emitting red vapours, in greater or leſs abundance, according to the temperature to which it is expoſed. Bergman diſtinguiſhes between theſe two ſtates of the acid of nitre, by giving to the one the name of *dephlogiſticated*, to the other that of *phlogiſticated;* we give to the former, the white, the name of the *nitric acid;* to the coloured, the name of the *nitrous acid.* The cauſe of theſe diſtinctions will hereafter be ſhown: Only, we may here obſerve, that if the coloured and fuming nitrous acid be diſtilled in a glaſs retort, the red part goes firſt off in vapour, and what remains is a white and colourleſs acid. The deeper the colour of the ſpirit of nitre ſubjected to diſtillation, ſo much the greater is the quantity of the vapours obtained, and ſo much the leſs the portion of white acid remaining in the retort; and *vice verſa*, when the nitrous acid heated in the retort is of a bright red colour, very little vapour, but a great deal of the white acid is obtained. This inſtance ſhows the red acid to be more volatile than the white. And as all coloured ſpirit of nitre is compounded of the two, they are to be ſeparated by a proceſs of diſtillation judiciouſly conducted. In this operation a certain quantity of vital air is always diſengaged, which may be collected by applying a pneumato-chemical machine to a balloon. We muſt remark, that when the veſſels are red-hot, certain red vapours are conſtantly ſeparated even from the whiteſt nitric acid; and the colour of the acid is alſo changed, ſo that it becomes of a flame red:. But the change produced by heat immediately diſappears when the acid returns to its

its former temperature, and the vapour alſo returns to a liquid. The ſame thing happens when a portion of the nitrous acid, highly coloured, is united with water; a red vapour is diſengaged and paſſes into the atmoſphere; the heat which then takes place, increaſes the colour of the acid which had been weakened by the water; what remains after the evaporation is not nitrous, but nitric acid; and the change is inſtantaneous. When heat, by the aſſiſtance of light, produces this change on the nitric acid, a quantity of vital air or oxigenous gas is diſengaged, proportioned to that of the nitrous gas which is formed on the occaſion. This decompoſition of the nitric acid, and the change of it into the nitrous, takes place in conſequence of the mutual affinities between light, the caloric, and the oxigenous principles. In this inſtance the glowing heat of our veſſels acts like that of the rays of the ſun.

The nitric acid acts not upon ſiliceous earth: it combines with barytes, with magneſia, with lime, and with the three alkalis: with theſe ſubſtances it forms the aluminous, barytic, magneſian, and calcareous nitrates, nitrate of potaſh, nitrate of ſoda, and ammoniacal nitrate. All of theſe ſalts ſhall be hereafter particularly examined. The ſalts formed by the union of the ſame baſes with the nitrous acid are ſomewhat different from theſe, and are diſtinguiſhed in our methodical nomenclature by the name of *nitrites.*

The nitric unites with the carbonic acid, abſorbing it eagerly. The mutual action of theſe two bodies is not yet well known.

The nitric enters very rapidly into combination with the muriatic acid. The alchemiſts gave the name of *aqua regia* to this compound, becauſe they uſed it to diſſolve gold, the king of metals: we ſhall henceforth call it the *nitro-muriatic acid.* It muſt have always appeared ſingular, that two acids, neither of which is by itſelf capable of acting upon gold, ſhould by combination acquire the power of diſſolving it. The alchemiſts, content with having found a ſolvent for that precious metal, gave themſelves no concern about the cauſe of the phænomenon. It is but a few years ſince two Swediſh chemiſts, Scheele and Bergman, firſt ſought to diſcover what alterations the nitric and the muriatic acids produced on each other by mutual combination. Scheele obſerved, what we have already taken notice of, that by diſtilling a portion of muriatic acid on lime or oxide of manganeſe, the acid was cauſed to diffuſe a yellowiſh vapour of the ſame ſmell with *aqua regia*, which deſtroyed blue vegetable colours, and acted with a powerful force upon metals,—more eſpecially upon gold, which it diſſolved as well as the nitro-muriatic acid. He thought that it acquired theſe properties in conſequence of being deprived of its phlogiſton by the oxide of manganeſe, and that what cauſed it to act ſo forcibly on combuſtible bodies was its eagerneſs to regain the principle which it had loſt. For this reaſon he gave it the name of *dephlogiſticated marine acid.* Our firſt obſervation here is, that this explanation of theſe phænomena is directly contradictory to the theory of Stahl, which Scheele in general appears to have adopted and extended: for the muriatic acid is ſaid to acquire, by the loſs of its phlogiſton, a ſet of properties which Stahl attributed to the preſence of that principle; namely volatility, a ſtrong ſmell, and a power of acting on inflammable matters. Beſides, we are of opinion, that all of theſe phænomena may be much more ſatisfactorily explained ed by the new theory: and this we ſhall very ſoon ſhow.

Bergman thinks that the nitric acid ſeizing on the phlogiſton of the muriatic acid, is partly diſſipated into vapour, and that what remains of the muriatic acid is then preciſely in the ſame ſtate with the vapour which ariſes from the diſtillation of this acid on oxide of manganeſe. Thus, what enables the nitro-muriatic acid to diſſolve gold, is its containing a portion of *dephlogiſticated marine acid:* and this mixed acid is often nothing but marine acid. Such is the opinion of the celebrated chemiſt of Upſal. The following appears to me a better account of the facts. When a quantity of nitric acid is poured upon a quantity of muriatic acid, heat is excited between the two liquors, and they aſſume a colour; an efferveſcence takes place, and a kind of mixed ſmell ariſes, not ſo pungent as that of the muriatic acid, but quite peculiar, and reſembling that which this acid affords when diſtilled on oxide of manganeſe. Mr Berthollet has diſcovered, that a portion of oxigenated muriatic acid is diſengaged during this rapid re-action of the two acids. On this occaſion, therefore, the muriatic acid deprives the nitric of part of its oxigene, and is diſſipated in the form of oxigenated muriatic gas; yet a portion of it ſtill remains ſaturated with oxigene and nitrous gas; and this mixture is *aqua regia.* From this we underſtand why ſo ſmall a proportion of the nitric acid is neceſſary to communicate to the muriatic the properties of aqua regia; and why both the nitro-muriate of gold, and the nitro-muriatic acid, afford when diſtilled nothing but muriatic acid. But we muſt obſerve, that, as much more nitric acid than is neceſſary, is generally uſed to ſuper-ſaturate the muriatic acid with oxigene, the

the nitro-muriatic acid which reſults from this compoſition contains both acids, and they act each according to its peculiar nature, forming peculiar and diſtinct ſalts with all the bodies expoſed to their action. It would therefore be a ſervice of ſome importance to chemiſtry, to determine what quantity of the nitric acid is neceſſary to ſaturate a given quantity of the muriatic with oxigene, and cauſe it to aſſume the character of the nitro-muriatic acid, without containing any aquafortis, which only alters it and renders its effects uncertain. Hence it appears neceſſary, in recording accurate chemical experiments, to mention the proportion in which the two acids have been mixed to produce the *aqua regia* made uſe of.

This mixed acid has leſs ſpecific gravity than either of the two acids of which it is compoſed. It has a peculiar ſmell, commonly a citron colour, often inclining to orange. Its action on natural bodies diſtinguiſhes it from all other acids. Light extricates from it a portion of oxigenous gas or vital air. Heat ſeparates from it oxigenated muriatic acid. *Aqua regia* combines with water in any proportion, and always excites heat as it enters into combination with that fluid. It diſſolves aluminous earth, but very ſlowly: it unites with barytes, magneſia, lime, and the alkalis; and from theſe combinations there reſult mixed ſalts, which cryſtallize either ſeparately or together, according as they are more or leſs ſoluble. *Aqua regia* is much uſed both in chemiſtry and in the art of aſſaying; as we ſhall ſhow more at large when we come to ſpeak of metallic ſubſtances.

Since the æra of Dr Prieſtley's diſcoveries, chemiſts have laboured much to diſcover the intimate nature and the component principles of the nitric acid. It was ſhown, in the firſt place, that the opinion which aſcribed the formation of the nitric to the ſulphuric acid, and repreſented the former as a modification of the latter, was founded on fallacious experiments. Soon after, it was obſerved, that this acid is formed of peculiar principles; and the following obſervations led to a certain diſcovery of its nature.

The nitric acid had been long obſerved to act with great force on combuſtible bodies, more eſpecially on the metals. On ſuch occaſions, it exhales into the atmoſphere a conſiderable quantity of red vapours, and is often indeed entirely diſſipated under that form. The combuſtible body expoſed to its action is ſoon reduced to the ſtate of a burnt body, or oxide; nay, it often cauſes combuſtible bodies, ſuch as oils, charcoal, ſulphur, phoſphorus, and ſeveral of the metals, to emit a ſudden flame. Stahl aſcribed this effect to the rapidity with which the acid combined with the phlogiſton of combuſtible bodies. But that theory did not afford a ſatisfactory explanation of the phænomenon.

Dr Prieſtley, by receiving into a glaſs veſſel filled with water the vapour diſengaged during the action of the nitric acid on a piece of iron, obſerved, that inſtead of a red vaporous fluid, a tranſparent colourleſs gas reſembling air was obtained on that occaſion; and to this he gave the name of *nitrous gas*.

This gas poſſeſſes all the apparent properties of air, but differs greatly from it in reſpect to chemical properties. It has rather leſs gravity, is unfit for maintaining either combuſtion or reſpiration, is ſtrongly antiſeptic, has no ſenſible taſte, and takes a long time to alter the colour of ſyrup of violets. Nitrous gas appears to ſuffer no alteration from light. Heat dilates it. Vital air readily combines with it; thus reducing

ducing it to the ſtate of nitrous acid. Atmoſpheric air produces the ſame effect upon it, but not ſo forcibly. This combination diſplays ſeveral phænomena which well merit our attention. As ſoon as air comes into contact with nitrous gas, though both the fluids were before colourleſs, they become inſtantly red like the nitrous acid: a pretty lively heat is then excited; the water riſing in the receiver abſorbs all theſe red vapours, and thus acquires the character of aquafortis. The purer the air is, the more readily do theſe phænomena take place, the more ſtriking do they appear, and the ſmaller is the proportion neceſſary to change a given quantity of nitrous gas into nitrous acid. M. Lavoiſier has diſcovered, that ſixteen parts of atmoſpheric air are neceſſary to ſaturate ſeven and one-third of nitrous gas, while four parts of vital air are ſufficient for the complete ſaturation of the ſame quantity of the ſame gas. Macquer thought this beautiful phænomenon preciſely ſimilar to combuſtion. It is in fact accompanied with heat, the abſorption of air, and the production of a ſaline matter; and the red colour which then appears may be conſidered as a kind of flame.

As in this artificial compoſition of the nitrous acid, the air produces different effects, according as it is more or leſs pure, Dr Prieſtley thinks that nitrous gas may ſerve as a teſt to enable us to diſtinguiſh what quantity of vital air any other kind of air contains; if we aſſume as two terms,—the moſt impure air, or gas unfit for reſpiration, ſuch as the carbonic acid, which produces no change whatever on nitrous gas,—and vital air, which produces the greateſt alteration upon it. This aſſay conſiſts in employing known and proportional quantities of theſe two gaſes, and obſerving when they are mutually and completely ſaturated. That air is the pureſt of which the ſmalleſt quantity is ſufficient to ſaturate a given quantity of the nitrous acid, and *vice verſa*.

Several philoſophers have endeavoured to find means for performing this experiment with the moſt rigid accuracy. The Abbé Fontana has been the moſt ſucceſsful: he has contrived an *eudiometer*, of which an exact deſcription is to be found in M. Ingenhouſz's experiments on vegetables. By means of that inſtrument, the degrees of the purity or impurity of the air may be eſtimated with the utmoſt nicety; but, as the author himſelf acknowledges, ſuch ſkill and attention are neceſſary in making uſe of it, that to avoid miſtakes and erroneous calculations is exceedingly difficult.

It is farther of conſequence to obſerve, that theſe experiments, though extremely ingenious and of conſiderable utility, have not been attended with all the advantages expected from them, in regard to that branch of medicine, the object of which is the preſervation of health. They ſhow what quantity of air fit for reſpiration is contained in that under examination; but they afford no information concerning the manner in which the noxious qualities of this fluid affect the ſeveral parts of the human ſyſtem with which it is brought into contact by reſpiration: they explain not how it acts on the ſtomach, the ſkin, or the nerves; all of which are affected by almoſt every alteration of the air, though only medical obſervation can inform us in what manner.

Chemiſts have for a number of years been divided in their opinions concerning the cauſe of the production of the nitrous acid from the mixture of nitrous gas with vital air. Dr Prieſtley, the diſcoverer of the fact, is of opinion, that nitrous gas is merely nitrous acid ſuper-ſaturated with phlogiſton; and that as pure air has a greater affinity than the acid with phlogiſton, it therefore, entering into combination with it, leaves the nitrous acid in a ſtate of liberty. But this theory is far from affording a complete explanation of the phænomenon: for when the elaſtic fluids with which the experiment is performed are very pure, there is abſolutely no reſidue left; and beſides, the nitrous acid formed during the proceſs weighs conſiderably more than the portion of nitrous gas which was made uſe of to produce it.

M. Lavoiſier imagined that this property of nitrous gas—to produce nitrous acid when brought into contact with vital air, might lead him to a knowledge of the component principles of the acid. By combining two ounces of ſpirit of nitre, of known ſtrength, with a given quantity of mercury, he obtained 196 cubic inches of nitrous gas; and 246 cubic inches of vital air. While the former gas was diſengaged, the mercury changed its form; after the vital air was diſengaged, it returned to a metallic ſtate, when it was found to have ſuffered no loſs. From theſe facts he deduced the following inferences with great accuracy of reaſoning.——1. As the mercury ſuffered no loſs during the proceſs, the formation of the elaſtic fluids cannot be aſcribed to it. 2. Theſe muſt therefore have been formed by the decompoſition of the nitrous acid. 3. The nitrous acid made uſe of on the occaſion, the gravity of which was to that of diſtilled water as 131,607 to 100,000, appears therefore to have been formed of three principles, nitrous gas, vital air, and water, united in the following proportions to the pound: nitrous gas, 1 ounce 51¼ grains; of vital air, 1 ounce 7 drams 2½ grains; and of water, 13 ounces and 18 grains. 4. Nitrous gas is nitrous acid deprived of its oxigene or vital air. 5. In all proceſſes in which nitrous gas is obtained, the nitric acid is decompoſed, and its oxigene abſorbed, by the combuſtible body with which it has a greater affinity.

Yet this opinion is attended with one difficulty. M. Lavoiſier found that he could not reproduce by the reunion of theſe products the whole quantity of the acid from which they were obtained; at leaſt one half was entirely loſt: and he had much more pure air than was neceſſary for the complete ſaturation of the nitrous gas. He acknowledges himſelf unable to account for this circumſtance. Macquer imagined it to depend on the loſs of the phlogiſton, or light, which he conſidered as one of the principles of the nitric acid: this he thought might eſcape through the pores of the veſſels during the decompoſition of the acid, leaving behind part of its pure air, which being leſs ſubtle, could not make its way out with the ſame facility. We ſhall ſoon ſee this not to be the true cauſe of the phænomenon.

The portion of ſuperfluous gas which remains after the nitrous gas has been ſaturated with vital air, ſtill remained an objection againſt M. Lavoiſier's theory. And though this ſuperfluity was quite a trifle in this experiment, as 7⅓d parts of nitrous gas, with 4 parts of vital air, left no more than $\frac{1}{14}$th of their total bulk; yet ſtill he was at a loſs how to account for it. Indeed he has ſince informed us, that the reſidue was much leſs when the matters made uſe of were very pure and very nicely proportioned. In ſhort, we will immediately ſee that vital air and nitrous gas may be obtained

obtained ſo pure as to combine without leaving any reſidue.

No ſuch difficulty occurs in conſidering the aeriform reſidue formed by the combination of 16 parts of atmoſpheric air with 7⅓d of nitrous gas: we know it to be the mephitis or azotic gas contained in the atmoſpheric air. We underſtand likewiſe how the contact of water comes at length to alter nitrous gas and change it into an acid: it is by means of the air which it contains.

But even after this theory of M. Lavoiſier's, the nature of the nitrous gas ſtill remained unknown; and it has ſince been explained by a fine experiment of Mr Cavendiſh's. That chemiſt put into a glaſs tube ſeven parts of vital air not obtained from the nitric acid, with three of azotic gas or atmoſpheric mephitis; and by cauſing the electric ſpark to paſs through the mixture, he effected a great diminution of its bulk, and even changed it into nitric acid. The induction which he draws from theſe facts is, that the nitric acid is a combination of ſeven parts of vital air to three of azotic gas; and that, when deprived of a part of the firſt of theſe principles, as happens in the ſolution of metals, &c. it paſſes into the ſtate of nitrous gas: Nitrous gas, therefore, is, in his opinion, nothing more than a combination of azotic gas with a ſmaller proportion of vital air than what is requiſite to form nitrous acid. Theſe experiments, and the ingenious theory founded upon them, throw great light on the formation of the nitric acid by the putrefaction of animal matters. We know that a great quantity of azotic gas is diſengaged from theſe matters when putrefying; and it is evident how neceſſary air is for the production of this acid, as experience ſhows it to be formed by the combination and fixation of theſe two elaſtic fluids.

It is alſo eaſy to determine the difference between the pure white acid of nitre and the coloured fuming acid to which the northern chemiſts give the name of *phlogiſticated;* or between the nitric and the nitrous acids. The laſt is found where the principles are not combined in the proportion proper for forming the pure nitric acid,—that is, when the combination conſiſts not of three parts of the azotic and ſeven of the oxigenous principle. But as a variety of circumſtances, and in general all phlogiſticating proceſſes, diminiſh the proportion of the oxigene by waſting more or leſs of it, hence we may naturally infer, 1. That this acid is very liable to alteration, and muſt often be more or leſs coloured and fuming: 2. That in proportion as it is deprived of more or leſs of its oxigene, it may paſs through many ſtates, from that of the pureſt nitric acid, which contains the greateſt proportion of oxigene, to nitrous gas, which contains not enough to conſtitute it an acid: 3. That if nitrous gas be deprived of what oxigene remains in it, it becomes azotic gas or mephitis: 4. That as the mutual adheſion of the oxigenous and azotic principles is very trifling, moſt combuſtible bodies having a greater affinity with the former than the azotic principle has, the nitric acid cannot but be decompoſed with great facility by many bodies. Theſe four remarkable particulars in the hiſtory of the acid of nitre, ſerve to explain a great many phænomena. We now underſtand, 1. That in this acid the azotic gas and vital air have loſt much of their caloric, and are therefore reduced to azote and oxigene. 2. That when this acid is decompoſed by a combuſtible body, the nitrous gas then diſengaged does not require

ſo

ſo much caloric to maintain it in a ſtate of elaſtic fluidity, as vital air and azotic gas. 3. That theſe two fluids cannot combine when in a gaſeous ſtate. 4. That of conſequence the vital air obtained from nitrous preparations ſtrongly heated, ſuch as *red precipitate*, nitrate of lead, common nitre, &c. muſt contain a certain portion of mephitis or azotic gas; of which gas, the reſidue, remaining after the union of the vital air with the nitrous gas, conſiſts. No ſuch reſidue is ever obſerved to remain, when the vital air made uſe of has been obtained from the leaves of vegetables or from manganeſe. 5. That the caſe is ſometimes the ſame with nitrous gas; it may contain a portion of azotic gas or mephitis: and this happens when this gas is prepared with bodies which, being very greedy of oxigene, abſorb it almoſt entirely from the nitric acid; ſuch as iron, oils, &c. 6. That the nitrous acid when coloured, and containing an exceſs of nitrous gas or of azote, or the baſe of mephitis, is in a ſtate very different from that in which the two principles are no more than mutually ſaturated; and that as the difference between theſe two ſtates of this acid is ſo very conſiderable, they ſhould therefore be diſtinguiſhed by different names. To the white acid, which, though the moſt uncommon, *is* the pureſt, we give the name of the *nitric acid*, obſerving the ſame analogy in this as in the reſt of our new denominations; and to its neutral ſalts we give the name of *nitrates*. The red again we call *the nitrous acid*, and its ſaline combinations *nitrites*. There is indeed but ſeldom occaſion to ſpeak of the laſt of theſe claſſes of neutral ſalts: for though the red and fuming, or the nitrous, be the moſt common of the two acids, it very ſeldom retains its proper character when united with alkaline baſes; the

the ſuperfluous quantity of the nitrous gas uſually eſcapes as the combination is taking place, and what remains is pure nitric acid.

The affinities of the nitric acid with the alkaline baſes are the ſame as thoſe of the muriatic; and Bergman arranges them in the ſame order, as follows,—barytes, potaſh, ſoda, lime, magneſia, ammoniac, aluminous earth. According to that celebrated chemiſt, the nitrous or *phlogiſticated* acid has the ſame affinities as the pure acid of nitre. It is ſtronger than any of the preceding acids, and diſengages the carbonic, fluoric, and muriatic acids, from their baſes.

The acid of nitre, under the name of *aquafortis*, is applied to a great many purpoſes in the arts; more particularly, it is uſed to diſſolve mercury, copper, ſilver for hatters, engravers, and gilders, in aſſaying and working metals, &c. It is likewiſe uſed in ſurgery, to deſtroy warts and other little indolent uninflamed tumours. It is uſed in many pharmaceutical preparations, ſuch as *mercurial water*, *red precipitate*, *the alkaline martial tincture*, *the yellow unguent*, &c. &c. We ſhall take notice of theſe and the other uſes to which it is applied in their proper places.

Species V. *The Sulphuric Acid.*

The ſulphuric acid, which has hitherto been called the *vitriolic acid*, is a very cauſtic ſaline ſubſtance, which, when concentrated, burns and cauterizes the ſkin, reddens ſyrup of violets without deſtroying its colour, and when diluted in a large proportion of water, has a ſour, ſtiptic taſte. This acid, when pure, appears under the form of a very tranſparent oleaginous

nous fluid, twice the ſpecific weight of diſtilled water, deſtitute of ſmell, and united with water, from which there are as yet no means known of ſeparating it. It has received the name of the *vitriolic acid*, becauſe it uſed formerly to be obtained from martial vitriol by diſtillation. At preſent it is obtained both in France and England by the complete combuſtion of ſulphur, as we ſhall explain more at large when we come to give the hiſtory of that combuſtible ſubſtance. Its nature, therefore, and the manner in which it is obtained, render it moſt proper to give it in a methodical and regular nomenclature, the name of the *ſulphuric acid.*

When highly concentrated, it is from its conſiſtency named very improperly *oil of vitriol.*

This acid is ſuſceptible of a concrete form; which it may be made to aſſume either by expoſing it to cold, as we ſhall afterwards ſee, or by combining it with various elaſtic fluids.

We know not yet, in what manner light acts on the ſulphuric acid. Some chemiſts have aſſerted, that when oil of vitriol is expoſed in cloſe veſſels to the rays of the ſun, it gradually aſſumes a colour, and there is even ſome ſulphur formed. But this fact is not altogether eſtabliſhed by proofs; nay, there is even a ſtrong probability againſt it; for we ſhall hereafter ſee, that the ſulphuric acid cannot become ſulphur without loſing its pure air or oxigene;—and it is evident that ſuch a ſeparation cannot take place in cloſe veſſels.

Stahl thought the ſulphuric acid to be diffuſed thro' all nature, and to be the principle of all other acids. The firſt of theſe aſſertions was founded on this fact, that linen impregnated with potaſh, and expoſed to the air, is at length converted into ſulphate of potaſh; that

that is, into a neutral ſalt formed by the union of this alkali with the ſulphuric acid. This aſſertion is at preſent known to be falſe; for ſuch linen contains not an atom of ſulphate of potaſh, but a good deal of carbonate of potaſh, or the combination of this alkali with the carbonic acid. With reſpect to the ſecond, nothing can be more improbable. Late experiments have ſhown that each of the acids is formed of peculiar principles; and that there is no principle common to one with another of them, but the baſe of vital air, which is common to them all.

The ſulphuric acid, when heated in a retort, ſoon loſes part of its water, is in ſome degree concentrated, and is not volatilized unleſs expoſed to a ſtrong heat. If coloured, it loſes its colour by the action of fire, and becomes white. This *double* change which it undergoes at *one* time, is called the *concentration* and *rectification* of the acid. While it is taking place, a very odorous and penetrating gas is diſengaged, which was the colouring principle of the acid, and with which we ſhall afterwards get acquainted under the name of the *ſulphureous acid gas*. Although this proceſs appears to render the ſulphuric acid whiter and more pure, yet it muſt be carried farther when we wiſh to obtain the acid in its higheſt purity: in fact, in this ordinary concentration, we only free the acid of the water and the ſulphureous acid gas united with it, without ſeparating any of the fixed matters, by which it may likewiſe be altered: To effect this, we muſt diſtil the acid to dryneſs, by changing the receiver, after performing the firſt part of the operation: there remains then in the retort a ſmall quantity of a white reſidue, which is found to contain ſulfate of pot-aſh, and ſome other ſub-

ſubſtances which are diſſolved in the acid as it is formed.

The concentrated ſulphuric acid attracts moiſture when expoſed to the air, and loſes part of its ſtrength and cauſticity: it at the ſame time aſſumes colour, deriving it from the combuſtible matters which float in the atmoſphere, on which this acid acts with no ſmall force. It often abſorbs nearly twice its own weight of water from the atmoſphere.

The Duke d'Ayen, by a ſeries of curious experiments, performed during the violent cold in the month of January 1776, has ſhown, that this acid, when highly concentrated, may be made to freeze by expoſing it to the cold temperature of from thirteen to fifteen degrees of Reamur's thermometer; but when diluted in two or four parts of water, is no longer liable to the ſame change of ſtate by cold: and that if when frozen it be left expoſed to the air, it ſoon becomes fluid, even though the cold be more intenſe than that which cauſed it to freeze. This laſt phænomenon is owing to its abſorbing water from the atmoſphere, and the heat produced while the two are entering into combination.

The ſulphuric acid unites with water, diſplaying, as it enters into union with it, all the phænomena of a ſudden penetration and an intimate combination. It produces at the ſame time a lively heat and a ſort of hiſſing; a peculiar fœtid odour is likewiſe diſengaged. The hiſſing noiſe excited on this occaſion is owing to the diſengagement of the air contained in the water, which is ſeen to make its way out in the form of little bubbles. The taſte of the acid, when thus diluted in water, is much weaker than in its concentrated ſtate, its fluidity is much more conſiderable, and it now bears the name of *ſpirit* *of vitriol.* The water may be volatilized by heating it; and it may be thus reſtored by concentration to the ſtate of concentrated ſulphuric acid.

This acid acts not in any manner on ſiliceous earth or quartzoſe ſtones, nor on the ſame earth when melted with the admixture of ſmall pieces of the fixed alkalis. It combines with aluminous earth, barytes, magneſia, lime, and alkalis. In theſe combinations it forms aluminous ſulphate, or *alum;* barytic ſulphate, or *ponderous ſpar;* ſulphate of magneſia, or *epſom ſalt;* ſulphate of lime, or *ſelenite*; ſulphate of potaſh, or *vitriolated tartar;* ſulphate of ſoda, or *Glauber ſalt;* and ammoniacal ſulphate. Its elective attractions for theſe ſalts are the ſame with thoſe of the muriatic and the nitric acids; but it adheres more firmly to theſe ſubſtances than any of the other mineral acids; and is capable of diſengaging them.

The action of the ſulphuric on the other acids has not as yet been properly examined; we know only, 1. That it abſorbs great quantities of the carbonic acid. 2. That it unites ſo readily with the muriatic acid, that when we mix the two together heat is excited, and a great quantity of muriatic acid gas is diſengaged in white vapours. Boerhaave, in his Chemiſtry ſays, that the muriatic acid renders *oil of vitriol* concrete: perhaps this property may be found to belong to the oxigenated muriatic acid. 3. That if the pure white nitric acid be poured on a quantity of ſulphuric acid blackened by ſome combuſtible body, it deprives it of its colour, and renders it tranſparent; and when this mixture is heated, it exhales a quantity of the nitrous gas. 4. That nitrous gas when united with this acid, has the power of making it aſſume a concrete form; as ſhall be ſhown more particularly in the article of the decompoſition of nitrate of potaſh by means of ſulphate of iron.

The manner in which the ſulphuric acid acts on combuſtible bodies, leads us to an idea of its nature and component principles. Whenever any combuſtible body, ſuch as a metal, or ſtill more a vegetable or an animal matter, is brought into contact with the concentrated ſulphuric acid, that body paſſes ſooner or later into the ſtate of a burnt matter, and the acid is decompoſed.

All matters containing oil become black, if immerſed in ſulphuric acid concentrated and cold. The acid firſt aſſumes a brown colour, which ſoon paſſes into a black. If an inflammable ſubſtance in combuſtion, ſuch as a burning coal, be immerſed into a quantity of ſulphuric acid, the acid immediately aſſumes the ſmell and volatility of burning ſulphur; a white ſmoke ariſes from it of a lively ſuffocating ſmell. If, in order to comprehend better what paſſes when theſe combinations take place, we bring this acid into contact with ſome combuſtible body of a more ſimple character than organic ſubſtances, whoſe alterations may be more eaſily traced and eſtimated, we may then attain a knowledge of the principles of the ſulphuric acid. If we heat for this purpoſe a mixture of this acid concentrated with mercury in a glaſs retort, the extremity of which enters a bell-glaſs filled with this metallic fluid, as ſoon as the acid is brought to boil, it emits a permanent gas of a ſtrong pungent ſmell, reſembling that of burning ſulphur.

This aeriform fluid is known by the name of the *ſulphureous acid gas:* it is ſomewhat more ponderous than air; it extinguiſhes lights, kills animals, reddens and diſcolours ſyrup of violets. According to Dr Prieſtley,

ley, it enters into combination with water with leſs rapidity than the muriatic acid gas; it diſſolves chalk, camphor, and iron; coals, and all bodies that are porous in any conſiderable degree, abſorb it. Though it has been conſidered as a permanent gas, yet by the application of an intenſe cold, it may be condenſed ſo as to become liquid. M. Monge accompliſhed this.

The ſulphureous is a certain modification of the ſulphuric acid, which combines with the alkalis to form neutral ſalts different from thoſe which they form with the latter. Stahl, who had obſerved all of theſe important phenomena with great attention, thought, that in this inſtance the phlogiſton of the metal, uniting with the acid, communicated to it odour, volatility, &c. But as that great chemiſt did not carry his experiments far enough, he could not foreſee, that a ſtrong objection againſt this doctrine might be drawn from the very fact on which it was founded. M. Lavoiſier, M. Bucquet, and myſelf, have each of us examined the conſequences of this reciprocal action of mercury and the ſulphuric acid. When the mixture is white and dry, but a very ſmall quantity of the ſulphereous acid gas is formed, if this mercurial ſulphate be then ſtrongly heated, a little water, and a gas quite different in nature from the former, are diſengaged; the gas is very pure vital air. While this gas eſcapes from the mixture, the mercury is gradually *reduced*, and regains all its original properties, not ſo much as an eighth part of its quantity being loſt. From this it appears, that as the mercury has ſuffered no alteration, the two gaſes muſt belong both to the ſulphuric acid which has been decompoſed. The ſulphureous acid gas appears therefore to bear the ſame relation to this acid

which

which the nitrous bears to the nitric acid. Yet the compoſition of theſe two acids is not made up quite in the ſame manner; for we cannot inſtantly re-unite the two gaſeous principles of the ſulphuric acid into the compound body from which they were obtained; whereas we can form the nitrous acid at pleaſure, by combining the nitrous gas, and the vital air which it affords when analyzed. It is very likely that a conſiderable ſpace of time is neceſſary for the recompoſition of the ſulphuric acid; for this phænomenon actually takes place when we expoſe to the air compounds of the ſulphuric acid with different baſes, theſe being at length found to contain ſulphuric acid. Thus the combination of the ſulphureous acid with potaſh, known under the name of *Stahl's ſulphureous ſalt*, or ſulphite of potaſh, if expoſed to the air, becomes at the end of a certain time genuine ſulphate of potaſh. What, in theſe inſtances, is ſlowly effected, takes place with more rapidity in the combuſtion of ſulphur; during which that combuſtible body abſorbs the oxigene of the atmoſphere, and becomes gradually more and more acid, till it be completely ſaturated. (See the *Hiſtory of Sulphur.*)

From theſe facts it appears, 1. That the ſulphuric acid a compound of ſulphur and oxigene. 2. That when a combuſtible body having a greater affinity than ſulphur with oxigene or the baſe of vital air, is mixed with it, that body decompoſes the acid, by abſorbing the oxigene. 3. That when the combuſtible matter does not carry off all of the acidifying principle, as happens in moſt of the ſolutions of metals effected by the ſulphuric acid, what is ſeparated is not pure ſulphur, but ſulphureous acid gas. 4. That this gas is a kind of intermediate body between ſulphur and the ſulphuric acid; and is to be conſidered as differing from the acid only by containing a ſmaller proportion of oxigene; from ſulphur, only by containing ſo much oxigene as renders it faintly acid. To cauſe it to paſs into the ſtate of real ſulphur, all that we need to do is, to drive off that portion of the baſe of vital air which it contains; as happens towards the end of the proceſs in which metals are diſſolved by the ſulphuric acid when thoſe ſolutions are ſtrongly heated and made to evaporate. We now likewiſe underſtand how the ſulphureous is gradually converted into the ſulphuric acid, by abſorbing the oxigene of vital air contained in the atmoſphere.

The ſulphureous acid gas is capable of uniting in a very intimate manner with the ſulphuric acid, and it then communicates to this acid the property of exhaling in thick white vapours. Meyer, in his Chemical Eſſays, on the article of Quick-lime, mentions a *fuming oil of vitriol*, prepared at Northaauſen in Saxony, from a diſtillation of *common vitriol.* He likewiſe follows Chriſtian Bernhard, a German chemiſt, in mentioning a concrete fuming acid ſalt obtained from this acid by diſtillation. Finding an opportunity of procuring in Paris a conſiderable quantity of this ſulphuric acid of Saxony, I obſerved it to poſſeſs the properties aſcribed to it by Meyer, and obtained from it, by uſing a gentle heat, cryſtallized, concrete, volatile ſalt, fuming and deliqueſcent, under two different forms, according to Chriſtian Bernhard's account of it. I am convinced, from various experiments related in a Memoir of mine, read in the Royal Academy of Sciences in the year 1785, 1. That the property poſſeſſed by this black ſulphuric acid of Northaauſen, of fuming and affording a concrete volatile ſalt, depends on its containing a great quantity of ſulphureous gas. 2. That in proportion as it loſes this gas by being expoſed to the

the air, it ceaſes to exhale vapours, and loſes its power of affording concrete ſalt. 3. That water diſengages this gas and deprives the ſulphuric acid of Saxony of its property of fuming, &c. 4. Laſtly, That the fuming concrete acid ſalt obtained from this acid by diſtillation is a ſaturated combination of ſulphuric acid with ſulphureous gas, which when expoſed to the air, gradually paſſes into the ſtate of common ſulphuric acid. We are therefore acquainted with two concrete ſulphuric acids, one of which owes its concretion to the nitrous gas, the other to the ſulphureous acid gas. I make no doubt but the number of concrete acids may be one day increaſed, by ſome other modifications of the ſulphuric acid reduced to ſolidity by other gaſes; ſuch as the oxigenated muriatic gas, &c.

The ſulphuric acid is made uſe of in many of the arts, more eſpecially by the dyer and the hat-maker, &c. It is one of the moſt common and uſeful menſtruums in the laboratory. In medicine, it is externally applied as a very uſeful cauſtic, and internally as a refreſhing, cooling, and antiſeptic medicine; but in this caſe, it muſt be diluted in water till it have ſcarce any ſenſible acidity.

The ſulphureous acid is uſed in dyeing, for whitening ſilks, taking out ſtains, &c.

As theſe two acids are combinations of ſulphur and oxigene in different proportions, their names ought to be analogous to their nature: to us they appear to be beſt diſtinguiſhed by the names of the *ſulphuric acid*, and the *ſulphureous acid*. The termination of the word *ſulphureous*, ſerves in this, as well as in other inſtances, to ſhow that the acid to which it belongs contains an exceſs of the combuſtible baſe.

Species VI. *The Boracic Acid.*

Experiments made by a great many chemiſts have ſhown borax to be a neutral ſalt formed by the combination of ſoda with a peculiar acid: this acid was called by Homberg, its diſcoverer, *ſedative ſalt.* It has been ſince named the *acid of borax*, and the *boracine acid;* we chooſe rather to call it the *boracic acid*, in order that it its name may terminate in the ſame way with the names of the other acids.

Many chemiſts thought this acid to be merely a product of art formed by the combination of the ſalts uſed in obtaining it with ſome principle of borax: But ſince M. Hoefer, apothecary to the Grand Duke of Tuſcany, has diſcovered that the waters of ſeveral lakes in that country, for inſtance, thoſe of Caſtelnuovo and Monterotondo, maintain in ſolution a conſiderable quantity of very pure boracic acid; we can no longer entertain a doubt of its being a peculiar acid. The chemiſts of the academy of Dijon have confirmed this diſcovery; on examining a quantity of water from the lake Monterotondo ſent them out of Tuſcany, they found it to contain the ſalt which M. Hoefer had aſcribed to it. It is very likely that the ſame ſalt may be found in other mineral waters: it appears, as we ſhall hereafter mention, to be formed by the putrefaction of fat bodies.

The boracic acid, whether native or obtained from borax, by proceſſes which we ſhall have occaſion to deſcribe under the article of that neutral ſalt, is a concrete matter, cryſtallized in ſmall white ſcales, very thin, irregularly formed, figured round their edges, extremely light, and ſometimes glittering. It has a weak,

weak, yet a ſenſibly acid taſte. It communicates a faint red to tincture of violets; but has a much ſtronger effect on that of turnſol, mallows, radiſhes, &c.

When expoſed to heat, it is not volatilized; but it melts when made red-hot into a tranſparent glaſs; and the glaſs becomes opaque, and is covered with a light white duſt when expoſed to the air. This glaſs is the boracic acid unaltered; it regains its lamellated form when diſſolved in water and cauſed to cryſtallize.

The boracic acid ſuffers no ſenſible alteration from the action of the air, whether it be dry, or moiſt, or hot or cold.

It diſſolves in water, not without difficulty; for, according to the academicians of Dijon, a pound of boiling water diſſolves no more than 183 grains of this acid; when cooled and partly evaporated, it returns to its cryſtalline form. This ſolution inſtantaneouſly reddens the tincture of turnſol, and alters, though more ſlowly indeed, the colour of ſyrup of violets. When a quantity of the boracic acid, moiſtened with a little water, is heated in a cucurbite, fitted with a capital, part of the acid is ſublimated together with the vapour ariſing from the water; but as ſoon as the whole of the water is volatilized and the boracic acid left dry, the ſublimation ceaſes: from which it appears that the acid is of itſelf fixed, as may be ſhown by melting it in a crucible. By ſublimating it in this manner with water, if the proceſs be ſkilfully conducted, it is obtained under a beautiful ſparkling cryſtalline form. The boracic acid, after paſſing through this proceſs, is very pure, and is known in pharmacy by the name of *ſublimated ſedative ſalt.*

The boracic acid ſerves as a flux to ſiliceous earth;

and

and the glaſs which they form together is white or faintly coloured. With the help of heat, it diſſolves the earth precipitated from the liquor of flints. It unites with barytes, magneſia, lime, and alkalis; and forms by its union with theſe ſubſtances a claſs of peculiar ſalts, diſtinguiſhed by the general name of *borates*, of which we are well acquainted with none but one ſpecies.

The whole of theſe properties, but more eſpecially its taſte, and the red colour which it communicates to blue vegetable tinctures, ſufficiently diſtinguiſh it as an acid. But it ſaturates alkaline baſes only in part; and is known to be the weakeſt of all acids, as all of the others, not even the carbonic acid excepted, diſengage it from the ſubſtances with which it combines.

The action of the other acids on the boracic is not well known. It appears to effect a partial decompoſition of the ſulphuric acid; for when diſtilled on this ſalt, the ſulphuric paſſes into the ſtate of the ſulphureous acid. As to the nitric and the muriatic acids, we know that they diſſolve it; but the phænomena which take place on that occaſion have not yet been ſufficiently attended to, to enable us to determine whether or not a mutual decompoſition then takes place.

A diverſity of opinions prevails concerning the nature and the formation of the boracic acid. A number of chemiſts have believed it to be an intimate combination of the ſulphuric acid, and a vitrificable earth with a fat matter. Meſſrs Bourdelin and Cadet think it to be formed by the muriatic acid. The latter of theſe two gentlemen thinks that it muſt contain a ſmall quantity of earth of copper, becauſe it has the ſame pro-

property with the oxides of copper, of communicating a green colour to the flame of combuſtible bodies. Cartheuſer aſſures us, that on drying and calcining it by the action of a ſlow fire, a quantity of the boracic acid in a ſtate of great purity, he obſerved it to emit vapours of the muriatic acid; and that on diſſolving this ſalt thus dried, and filtrating the ſolution, he found a grey earth remaining after the filtration; and laſtly, that by many repetitions of this calcination and ſolution, he at length accompliſhed the entire decompoſition of the boracic acid, and found it to be a modification of the muriatic rendered fixed by an earth. This experiment has been repeated by Meſſrs Macquer and Poulletier de la Salle; they obſerved an odorous vapour to be diſengaged during the calcination of this ſalt, but they were not able to diſtinguiſh from its ſmell that it was muriatic acid. By repeated deſiccations and ſolutions, they obtained a ſmall portion of grey earth; but this earth, when united with the muriatic acid, did not form ſedative ſalt, as Cartheuſer had given out; and of conſequence this chemiſt's opinion appears to be no better ſupported than the reſt. Model thought this ſalt to be a combination of a peculiar alkali with the ſulphuric acid, which is uſed in diſengaging it. But this opinion cannot be admitted; for the boracic acid is always the ſame, whatever be the acid uſed to precipitate it. M. Baumé ſays, that he found means to produce the boracic acid by leaving a mixture of greaſe and clay to macerate for 18 months. At the end of that time, he obtained from it, by lixiviation, a ſalt in ſmall ſcales, with all the properties of *ſedative ſalt.* From this he concludes the boracic acid to be a combination of the acid of greaſe with a very fine earth, which it is impoſſible to ſeparate entirely from it. He adds, that the ſame ſalt may be produced with vegetable oils, but more ſlowly. M. Wiegleb repeated M. Baumé's experiment, but without obtaining boracic acid.

Chemiſts at preſent think this to be a peculiar acid differing from all others, and poſſeſſing certain characteriſtics of its own. Its elective attractions with alkaline baſes are arranged by Bergman in the following order; lime, barytes, magneſia, potaſh, ſoda, ammoniac. As they differ greatly from thoſe of the other acids above-examined, they afford an additional proof of the peculiarity of the nature of this acid, whoſe component principles remain ſtill unknown.

The uſe of the boracic acid in medicine was firſt introduced by Homberg, who aſcribed to it quieting narcotic qualities, and gave it the name of *ſedative ſalt*, or *volatile narcotic ſalt of vitriol*, becauſe he had obtained it by ſublimating a mixture of *nitre* and *vitriol*. But experience has ſince ſhown the medical virtues of this ſalt to be but very moderate; at leaſt it muſt be given in a much ſtronger doſe than Homberg has directed, in order to produce the effects he aſcribes to it; and it is very properly rejected, as we have many other medicines of the ſame claſs, whoſe effects are much more certain.

It is uſed in many operations of chemiſtry, and in the aſſaying of metals as a flux. We will ſpeak of its application to this purpoſe in a ſubſequent chapter.

CHAP.

[End of Vol. I. of the Original.]

CHAP. V.

ORDER II. SECONDARY, *or* NEUTRAL SALTS *.

UNDER the name of *ſecondary ſalts*, are comprehended all ſuch ſubſtances as are formed by the combination of two primary ſaline matters. They have received the name of *neutral ſalts*, becauſe they poſſeſs not the characteriſtics of primary ſalts; that is, they are neither acid nor alkaline. Yet ſeveral of them, ſuch as borax, chalk, and alkalis when united with the carbonic acid, exhibit, though in an inferior degree, ſome of the properties of primary ſalts. Theſe ſecondary ſalts have not ſo ſtrong a taſte as moſt of the primary;

The author has here the following note.

* The reader may here recollect that this work is divided into four parts. The firſt, contained in the firſt volume, explains in eight chapter the general principles of chemiſtry: The ſecond treats of the mineral kingdom, or mineralogy: The third contains the chemical hiſtory of vegetables: The fourth of animal ſubſtances.

Mineralogy was divided into three ſections. The firſt, included in the firſt volume, explains in four chapters the phyſical and chemical characteriſtics of earths and ſtones. The ſecond is appropriated to ſaline ſubſtances. This volume begins with the fifth chapter of the ſecond ſection.

primary; nor do they diſſolve, or enter into new combinations ſo readily. But, what principally diſtinguiſhes them from the primary is, their inability to communicate ſaline properties to other bodies. . Their cryſtalline form is another characteriſtic by which they are diſtinguiſhed; it merits the attention of the naturaliſt; but, though it ſometimes determines their nature, it alſo occaſions frequent miſtakes.

The term *baſe*, is commonly uſed to denote the more fixed part of the compoſition of neutral ſalts. As this baſe, which is ſometimes volatile, communicates ſeveral pretty uniform general characteriſtics to the various combinations with acids of which it admits, we ſhall uſe the name of the *baſe*, to diſtinguiſh the genera of ſecondary ſalts. Theſe ſalts may then be divided into ſo many genera as there are ſaline or alkaline baſes capable of being united with acids.

The firſt genus comprehends all ſuch as are formed by the union of the two fixed alkalis with any of the acids. Theſe we ſhall denominate *perfect neutral ſalts;* becauſe the union of their component parts is very intimate.

The ſecond genus includes thoſe ſalts which are formed by the combination of volatile alkali, or ammoniac, with acids. They have received the name of *ammoniacal ſalts* from the modern name of their baſe. They may be alſo called *imperfect ſalts*, becauſe they are much eaſier decompoſed than thoſe of the former genus.

In the third genus are ranked ſuch as have lime for their baſe. Theſe are in general more imperfect than thoſe of the ſecond genus, although lime has a ſtronger affinity than ammoniac with the acids, as ſhall be afterwards

wards particularly ſhown. They are denominated *calcareous neutral ſalts.*

The fourth genus conſiſts of combinations of magneſia with various acids. Theſe ſalts are ſtill more eaſily decompoſed than thoſe of the laſt-mentioned genus; becauſe acids have a ſtronger affinity with lime and alkalis than with magneſia. Their proper name is *magneſian neutral ſalts*, or *neutral ſalts with a baſe of magneſia.*

To the fifth genus belong thoſe of which the baſe is pure argillaceous or aluminous earth. Alum being the chief of theſe combinations, they have received the generic name of *aluminous ſalts.* Aluminous neutral ſalts are almoſt always decompoſed by the operation of alkalis, lime, and magneſia.

Laſtly, To the ſixth genus we aſſign neutral ſalts, having a baſe of barytes or ponderous earth. Both theſe and the greater part of the two preceding genera are but very little known. *Barytic ſalts* is the diſtinctive name of this genus.

It may be eaſily imagined, that theſe ſeveral baſes, when combined with the acids whoſe properties we have examined, muſt afford a very conſiderable number of neutral ſalts: and this number will be much more conſiderable, if, with Bergman, we admit as diſtinct ſalts the various combinations of theſe ſame baſes with thoſe acids which he calls *phlogiſticated;* and which, according to the modern doctrine, are deprived of a part of their pure air or oxigenous principle. But as theſe compounds are liable to alteration on coming into contact with air, which cauſes them almoſt inſtantly to aſſume the character of real neutral ſalts, it ſeems improper to add them to a liſt which is already but too numerous; we ſhall, however, point out what pecu-

peculiar properties they acquire from the ſtate of their acids. We muſt obſerve farther, that though the alkaline baſes here enumerated, when combined with aqua regia, afford a mixture of nitrous and marine ſalts, yet as theſe may be obtained ſeparate, and are perfectly the ſame with thoſe produced by the ſimple acids; we mean, therefore, only to take notice of them when ſpeaking of the combination of alkaline baſes with the ſimple acids. Having hitherto examined no more than ſix principal acids, we are to treat only of the neutral ſaline combinations into which theſe enter.

In the arrangement of the ſeveral ſpecies of the neutral ſalts, the moſt natural order ſeems to be that of the affinities of the acids: and, therefore, through all the genera, we begin with ſulphatic ſalts, proceeding from them to the nitric; after which we treat ſucceſſively of thoſe whoſe baſes are combined with the marine, the boracic, the fluoric, and the carbonic acids, the laſt of which is the weakeſt of all.

That our nomenclature may be clearly expreſſive of the nature of the ſubſtances to which it refers, the name which we affix to each of theſe ſalts is compounded of the name of its acid and that of its baſe; and the various names by which any neutral ſalt has been known at different periods are carefully ſubjoined.

Genus I. *Perfect Neutral Salts,* or *Salts with a baſe of fixed Alkali.*

Species I. *Sulphate of Potaſh.*

Sulphate of potaſh, which has been alſo called *vitriolated tartar*, *Sal de duobus, Polychreſt ſalt,* and *Arcanum duplicatum,* is a perfect neutral ſalt, reſulting, as its new name denotes, from the combination of the ſulphuric acid with potaſh. It ſeldom appears in the mineral kingdom; but a few vegetables contain a ſmall quantity of it.

This ſalt is generally in a greater or a leſs degree tranſparent and regular; its cryſtals differ in form and magnitude, according to the circumſtances in which they are obtained. When formed ſlowly in the ſmall way, they aſſume the figure of tranſparent ſix-ſided pyramids, nearly ſimilar to roſe-diamonds; and ſometimes, tho' leſs frequently, they take the form of ſix-ſided priſms, terminating in two hexahedral pyramids, much like rock cryſtal. But if the evaporation be very rapid, the cryſtals are agglutinated into one maſs, under the form of a ſolid cruſt, the ſurface of which is covered with ſmall irregular pyramidal ſpikes: of this kind is the ſalt of this name met with in commerce. Laſtly, when, in order to obtain the cryſtals as regular as poſſible, a ſolution of this ſalt is expoſed to a gentle ſpontaneous evaporation by the heat of the atmoſphere, its cryſtals are generally ſolid twelve-ſided figures, joining at the baſe, and ſometimes ſeparated by a ſhort ſix-ſided priſm. Theſe indeed are uſually foul, and at no time equal the whiteneſs and tranſparency of thoſe which are obtained

obtained by the former proceſs of evaporation. But one imperfection attending moſt of theſe neutral ſalts is, that they are either of a dark colour or an irregular figure.

Sulphate of potaſh has a very diſagreeable bitter taſte. Fire produces but little alteration upon it. When laid on burning coals, it breaks with noiſe into a number of little pieces: This phenomenon, which is called *decrepitation*, ariſes from the ſudden rarefaction of the water which entered into it when it was cryſtallized. But ſulphate of potaſh loſes none of its eſſential properties by decrepitation. It decrepitates in the ſame manner when expoſed to the action of fire in a crucible, and becomes dry, friable, and even pulverulent, by loſing the water which it contained: it becomes red before melting, and a ſtrong fire is requiſite to bring it to fuſion. If expoſed to cold when in a ſtate of fuſion, it becomes an opaque maſs, friable, and ſoluble: it appears likewiſe to have ſuffered no alteration of its principles; for it regains its tranſparent and cryſtalline form on being diſſolved in water. If kept for a while in the ſtate of fuſion in an open veſſel, it is volatilized, but without being decompoſed.

Sulphate of potaſh ſuffers no alteration from air. It remains in its cryſtalline ſtate, without ſuffering any change either of form or of tranſparency. It is ſcarce ſoluble in water; yet the difficulty of diſſolving it is greater or leſs according to the temperature of the fluid. According to Spielman, about 18 parts of cold water are required to diſſolve 1 of this ſalt. But boiling water diſſolves it nearly in the proportion of 4 to 1; for M. Baumé aſſures us, that 4 ounces of boiling water diſſolve 7 drams and 48 grains of ſulphate of potaſh. It is cryſtallized partly by cooling, but ſtill more

more by evaporation: It contains but very little water in its cryſtals, and therefore ſuffers no change of ſtate when expoſed to the air.

Sulphate of potaſh acts not at all on ſimple earths. When accidentally mixed with ſalts uſed as fluxes in making glaſs, it is found again in the ſcoriæ; and it is obtained in conſiderable quantities from glaſs gall.

According to Bergman, barytes or ponderous earth having more affinity than potaſh with the ſulphuric acid, decompoſes this neutral ſalt. If a ſolution of this earth be poured on a ſolution of ſulphate of potaſh, this proceſs forms a precipitate of barytic ſulphate or *ponderous ſpar*, which is abſolutely inſoluble; its properties we ſhall hereafter examine. The potaſh, if pure and cauſtic, remains diſſolved in the liquor.

Lime and magneſia act not on ſulphate of potaſh; but many of the acids act very forcibly upon it. Rouelle diſcovered that it is poſſible to combine with this ſalt a greater quantity of the ſulphuric acid than it naturally contains. His proceſs conſiſted in diſtilling a quantity of concentrated ſulphuric acid on ſulphate of potaſh. The neutral ſalt becomes impregnated with the acid, and acquires new properties: it now reddens the tincture of violets, is ſoluble in water, has a ſour taſte, and efferveſces with alkalis ſaturated with carbonic acid, even after being diſſolved and cryſtallized. M. Baumé has maintained, that no real combination takes place between the acid and the neutral ſalt, and that they may be ſeparated merely by placing them on bibulous paper or ſand. But Macquer remarks, that the ſulphuric acid adheres with no inconſiderable force to ſulphate of potaſh; and thinks that their mutual adheſion muſt be owing to a peculiar affinity between the two ſubſtances;

ſtances: according to him neither fire nor water is able to ſeparate them. I have ſeveral times combined the concentrated ſulphuric acid with ſulphate of potaſh, in Rouelle's way; that is, by diſtilling them in glaſs retorts, and have obſerved ſome phænomena not mentioned in his diſſertation on the ſubject. Sulphate of potaſh melts on the occaſion into a kind of glaſs or opaque white enamel of a ſtrong acid taſte: but this vitreous frit does not attract moiſture from the air; on the contrary, it rather exhibits appearances of efflorescence, when the acid makes only a fourth part of the total weight. There is, therefore, as Macquer thought, a pretty ſtrong adheſion between the neutral ſalt and the acid; and that adheſion is no doubt owing to a peculiar combination.

M. Baumé has obſerved, that ſulphate of potaſh ſuffers a very conſiderable alteration from the nitrous acid. If aquafortis be boiled on this ſalt, the nitrous acid ſeizes on part of the potaſh, and diſengages the ſulphuric acid contained in it. When this mixture is ſuffered to cool, its cryſtals are pure nitre. It was at firſt thought that this decompoſition could not take place without the help of heat; but if fuming ſpirit of nitre be poured on ſulphate of potaſh in powder, it will be found at the end of ſome hours to have depoſited cryſtals of nitre. It was likewiſe advanced, that when the mixture became cold, the ſulphuric acid, reſuming its rights, decompoſed in its turn the nitre of potaſh: but I have kept mixtures of ſulphate of potaſh with ſpirit of nitre for ſeveral years, and at the bottom of the mixture there were always ſaline cryſtals which detonized on burning coals, and ſuffered no change of nature though immerſed in the ſulphuric acid ſeparated by the nitrous. M. Cornette has obſerved,

ſerved, that the concentrated muriatic acid likewiſe decompoſes ſulphate of potaſh, even cold. From theſe two facts it would appear, that the law of affinity reſpecting the different acids does not hold ſo invariably as was imagined. Yet we muſt obſerve, with Bergman, 1. That whatever quantity of the nitrous and muriatic acids be made uſe of in theſe experiments, no more than a third part of the given quantity of ſulphate of potaſh is ever decompoſed; while the ſulphuric acid, when applied in a moderate proportion to nitrous and muriatic ſalts, effects a total decompoſition of them: 2. That ſuch a decompoſition never takes place, except when the ſulphate of potaſh contains rather more of the ſulphuric acid than is neceſſary to conſtitute it a neutral ſalt.

But of all the modes of decompoſition to which ſulphate of potaſh is liable, the moſt worthy of our attention is that which it ſuffers from many combuſtible matters, more eſpecially from charcoal and ſeveral metallic ſubſtances (See my *Memoires de Chimie*, p. 225.). If a mixture of this ſalt with coal be ſtrongly heated in a crucible, the ſulphate of potaſh will be converted into ſulphur united with the fixed alkali. Stahl thought this a very happy experiment for demonſtrating the exiſtence of phlogiſton; modern chemiſts explain it by the pneumatic theory. In the hiſtory of ſulphur, we ſhall give both theories.

A quintal of ſulphate of potaſh in cryſtals contains, according to Bergman, about 52 parts of potaſh, 40 of ſulphuric acid, and 8 of water,—which is neceſſary to make it cryſtallize.

As this ſalt is found but ſeldom in nature, and even then in ſmall quantities, the ſulphate of potaſh made uſe of in medicine is always a product of art. There are three ways of preparing it. Firſt, by a direct combination of the ſulphuric acid with potaſh. This inſtantly produces ſulphate of potaſh, which may be diſſolved in water, and cryſtallized, as we have mentioned above. The ſecond way is, decompoſing, by means of the ſulphuric acid, neutral ſalts conſiſting of potaſh united with other acids; ſuch as nitrate, muriate, and carbonate of potaſh, &c.: Sulphate of potaſh is infallibly obtained by all of theſe decompoſitions. The third way of forming this ſalt is by uſing potaſh to decompoſe earthy and metallic ſulphuric ſalts. The potaſh precipitates the ſalino-terreous ſubſtances and the metallic oxides, and ſeizes the ſulphuric acid. We will have occaſion to take farther notice of the laſt two of theſe methods of preparing ſulphate of potaſh, when we come to give an account of the neutral ſalts uſed in the preparation.

This ſalt is not much uſed except in medicine. It is a pretty efficacious purgative. It is ſometimes given by itſelf in doſes of half an ounce or an ounce. But it is moſt generally given, a dram or two at once, together with ſome other purgative medicines. It is uſed as a ſolvent in chronical diſtempers, particulary in coagulations of milk. It is then given in doſes of a few drams together in certain preparations of liquids; but its ſolvent power is much inferior to that of many other neutral ſalts, which are more ſoluble and leſs nauſeous.

The ſulphureous acid, or the ſulphuric with an overplus of ſulphur, forms, when combined with potaſh, a ſalt ſomewhat different from that which we have been conſidering. Stahl called it *ſulphureous ſalt;* we give it the name of *ſulphite of potaſh.* This ſalt cryſtallizes in polyhædrons of ten ſides, or in two tetrahedral

trahedral pyramids cut towards their baſes: it is very bitter, eaſily ſoluble, and rather deliqueſcent. Almoſt all mineral acids, and many vegetable acids, diſengage the ſulphureous acid from this ſalt with effervescence, and in a gaſeous form. Sulphite of potaſh, when expoſed to the air, gradually abſorbs the oxigenous principle, and is converted into ſulphate of potaſh.

Species II. *Sulphate of Soda.*

SULPHATE of ſoda, which has been hitherto known by the name of *Glauber ſalt,* from the name of the German chemiſt who firſt diſcovered it, is a perfect neutral ſalt, formed, as its name indicates, by the union of the ſulphuric acid with mineral alkali or ſoda. This ſalt poſſeſſes many properties in common with ſulphate of potaſh, and ſome peculiar to itſelf. It is equally diſpoſed to cryſtallize as the other; has a bitter taſte; is ſcarce fuſible; diſſolves in water; is incapable of union with earths; and, like ſulphate of potaſh, is decompoſable in part by the nitrous and muriatic acids. Many of its properties, however, are conſiderably different from thoſe of ſulphate of potaſh; as we ſhall ſee by examining them particularly.

Sulphate of ſoda is commonly a body of a regular form, and more or leſs white or tranſparent. Its cryſtals are priſms with ſix unequal and ſtriated ſides terminating in dihædral ſummits. They are ſeldom under a regular form, and the number of the ſides varies as well as their ſize, poſture, and ſtriæ; as M. Romè de Lille has ſhown very particularly in his cryſtallography.

phy. The priſms of this ſalt vary in ſize from the form of ſmall needles, very minute, to priſms half an inch in diameter and ſix or eight in length; which laſt are obtained when a great quantity is cryſtallized at once. Its taſte is at firſt freſh, but ſoon becomes very diſagreeably bitter. It produces no alteration on blue vegetable colours.

When expoſed to the action of fire, it is quickly liquefied: but it ſoon dries and becomes of an opaque white colour; in which ſtate it is no leſs difficult to melt than ſulphate of potaſh. In order to form a juſt notion of what paſſes when heat acts with this effect on ſulphate of ſoda, we muſt take notice that ſaline ſubſtances are melted two ways. 1. By means of the water which enters into their cryſtals, which is called *aqueous fuſion.* This takes place only on ſuch ſalts as are more ſoluble in warm than in cold water; which happens becauſe the portion of the fluid which enters into the conſtitution of their cryſtals, being then warmed, diſſolves the ſaline matter. This aqueous fuſion is therefore nothing more than ſolution by warm water: and therefore ſulphate of ſoda aſſumes again a ſolid form when it is ſuffered to cool. 2. But if the heat be continued after it is liquefied, it becomes dry and white: it may then be melted by means of a more intenſe heat; and this fuſion is actually the effect of fire, and is therefore called *igneous fuſion.* Sulphate of ſoda is therefore no leſs difficult of fuſion than ſulphate of potaſh; and like it is volatilized by the extreme violence of fire, but ſuffers no alteration of principles from the action of heat.

It is likewiſe on account of their containing a great quantity of water, that the cryſtals of ſulphate of ſoda, when expoſed to the air, are in a ſhort time reduced to a very fine white powder. This phænomenon is called *effloreſcence;* becauſe in fact the cryſtals are covered over with a kind of fine flour, in whiteneſs and form reſembling the ſublimated matters which are known in chemiſtry under the improper name of *flowers*. The cauſe of this ſalt's falling down in this manner, when expoſed for ſome time to the air, is its loſing the water on which the conſtitution of its cryſtals depends. It therefore effloreſces moſt readily when the air is very dry, and of conſequence eager to abſorb moiſture. This phænomenon, therefore, bears a great reſemblance to the deſiccation effected by heat: both depend on the evaporation of the water to which the cryſtalline form is owing. Yet, as the water which enters into the cryſtals of ſulphate of ſoda, and of all effloreſcent ſalts in general, is perfectly combined with the ſaline matter; effloreſcence appears to be owing to a kind of elective attraction between air and water. This phænomenon is therefore to be conſidered as a decompoſition of cryſtals, taking place in conſequence of water's having a greater affinity with air than with the ſaline matter. Such has always been my idea of effloreſcence, and I do not ſee how it can be explained otherwiſe (See my *Memoires de Chimie*). Sulphate of ſoda loſes almoſt half its weight when it undergoes this alteration: but its nature is not changed, and we may cauſe it to reſume its cryſtalline form, by reſtoring to it the water which it has loſt. Though no writer on Materia Medica has as yet made the obſervation, yet to us it ſeems an object of ſome importance, to know the exact quantity of water which ſulphate of ſoda loſes when it effloreſces, in order that the ſame quantity may be always preſcribed for a doſe, in whatever of the two ſtates the ſalt may happen to be. Rather more than one-third leſs of this ſalt ſhould be given when it is in a ſtate of efflorеſcence than when it is under the form of fine tranſparent cryſtals.

Sulphate of ſoda diſſolves very eaſily in water. No more than four parts of cold water are neceſſary to diſſolve one of this ſalt. But a ſmaller quantity of warm water will be ſufficient to diſſolve the ſalt, and a ſtill ſmaller quantity in proportion as the water is made hotter. One part of boiling water diſſolves almoſt as much of this ſalt as is equal to its own weight. The method in which we make it cryſtallize is founded on this property. As it is more ſoluble in warm than in cold water, all that we need to do is, to leave a ſtrong ſolution of this ſalt to cool; and it affords cryſtals which are more or leſs regular, and of a greater or a ſmaller ſize, in proportion as the quantity of the ſolution is greater or leſs, and as it is cooled more ſlowly or more quickly. In the laboratories of apothecaries, where this operation is performed in the great way, ſtriated priſms ſeveral inches long are often obtained, which afford ſpecimens of the regularity of the form of this ſalt.

Sulphate of ſoda acts no more on ſiliceous or aluminous earth than ſulphate of potaſh: and as it is ſo difficult of fuſion, it is no more uſed in making glaſs than the other. Barytes decompoſes it as well as ſulphate of potaſh; but the other ſalino-terreous ſubſtances produce no alteration upon it.

Pure cauſtic potaſh, mixed with a ſolution of ſulphate of ſoda, decompoſes it; becauſe it has a ſtronger affinity than ſoda with the ſulphuric acid. In order to receive full conviction of this, the reader may pour a lixiviate of cauſtic potaſh on a warm and ſtrongly ſaturated ſolution of ſulphate of ſoda. This ſolution, which, if ſuffered

ſuffered to cool, would have afforded cryſtals of the latter, gives ſulphate of potaſh by evaporation ; and the mother water contains cauſtic ſoda.

The ſulphuric acid combines with ſulphate of ſoda, and adheres to it in the ſame manner as to ſulphate of potaſh.

The nitrous and the muriatic acids decompoſe it with the ſame attendant circumſtances as when they decompoſe ſulphate of potaſh.

When ſulphate of ſoda is violently heated with charcoal and ſome metals, the ſulphuric acid aſſumes the form of ſulphur, as we ſhall have occaſion to mention under the hiſtory of that combuſtible body.

All of the properties in which ſulphate of ſoda differs from ſulphate of potaſh, ſerve as ſo many proofs that the two fixed alkalis, however ſimilar in their ſtate of purity, are nevertheleſs extremely different from each other ; becauſe they form very diſſimilar ſalts when combined with the ſame acid. Beſides, the proportion in which the principles of this ſalt are united is very different from that by which ſulphate of potaſh is formed : for, according to Bergman, a quintal of ſulphate of ſoda contains 15 parts of ſoda, 27 of ſulphuric acid, and 58 of water.

This ſalt is more copious in nature than ſulphate of potaſh. It is obtained in great abundance from ſea-water, from the water of certain ſalt ſprings, and more eſpecially from many mineral waters. Art can likewiſe procure it by the three methods of which we have given a deſcription in the hiſtory of ſulphate of potaſh. It is not more uſed in the arts than that ſalt ; but much more in medicine. It is given as a ſolvent, aperient, and purgative, in doſes of—from half a dram to an ounce and an half, according to the caſes in which it is adminiſtered. Its effects are even more ſtrong and quick than thoſe of ſulphate of potaſh; becauſe its ſapidity is greater, and it diſſolves much more readily in the humours of the human body.

We are ignorant of the properties of ſulphite of ſoda, or of that ſalt which is formed by the combination of the ſulphureous acid with alkali of ſoda.

Species III. *Nitrate of Potaſh, or Common Nitre.*

NITRATE of potaſh, common nitre, or ſaltpetre, is formed by a ſaturated combination of the nitric acid with potaſh. This ſalt has a freſh taſte, is a perfect neutral ſalt, and does not alter the colour of ſyrup of violets. Its cryſtals are ſix-ſided priſms, terminating in dihedral pyramids, or cut off with a ſlope, and often channelled from one end to the other.

There is great abundance of this ſalt in nature: it is continually forming in places inhabited by animals. It is likewiſe found in abundance on walls ſheltered from rain; and is then called *ſaltpetre de houſſage.*

There ſeem to be three circumſtances which chiefly promote its formation. The firſt of theſe is the preſence of chalk, or ſome calcareous ſubſtance: in this manner is the nitre formed which is gathered on walls covered with plaſter; and from this circumſtance, conſiderable quantities of nitre are uſually found on the demolition of old buildings. This ſalt is obtained in a ſtate of perfect purity from chalky earths. The Duke de la Rochefoucault has obtained it in the proportion of an ounce to the pound from chalk of Roche-Guyon.

The ſecond circumſtance favourable to the production of ſaltpetre is the putrefaction or ſpontaneous decompoſition of animal and vegetable matters. It is a well known fact, that places watered with animal liquors, or containing animal matters in a ſtate of putrefaction, ſuch as dunghills, ſtables, jakes, afford great quantities of nitrate of potaſh. This fact has always been gone upon as a principle, in forming beds for the artificial production of nitre. Ditches or covered ſheds are formed, and left expoſed on all ſides to the air: theſe are then filled with putreſcent ſubſtances, ſuch as dung of all kinds, and vegetable ſubſtances; water containing animal or vegetable matters is from time to time poured on the maſs; and it is ſtirred now and then to change the relative diſpoſition of the ſurfaces. When the putrefaction is conſiderably advanced, a ſmall portion of the matter is taken and lixiviated, in order that it may be known whether it contains nitre; and if it be found to contain a ſufficient quantity of the ſalt, the whole maſs is ſubjected to the ſame proceſs.

The third circumſtance apparently favourable to the production of nitre, is the contact of the air. This is one great cauſe of the formation of the ſaltpetre found on walls; and it is on this principle that the mixture depoſited for the artificial production of nitre is frequently ſtirred, in order that the air may have acceſs to every part of the maſs. Beds of chalk, which naturally contain nitre, afford it only to a certain depth, and not lower. Where theſe three circumſtances meet, nitre is produced in great abundance. Beds for the artificial production of nitre ſhould be formed on theſe principles.

It is but a very ſhort time ſince the theory of the production of nitre came to be known. Glauber, and a number of chemiſts who implicitly adopted his opinion, thought this ſalt to be entirely formed in vegetable ſubſtances, in them conveyed into the bodies of animals, and by putrefaction only diſengaged into a free ſeparate ſtate: But it was ſoon obſerved, that the vegetables uſed for its production in nitre-works could not be ſufficient to afford, of themſelves, the quantities obtained. M. Thouvenel, who by his eſſay on the formation of nitre gained a prize from the Academy, made a great many experiments with a view to diſcover its cauſe, and found that the nitric acid was formed by the combination of an elaſtic fluid diſengaged from animal matters in a ſtate of putrefaction with vital air. He has alſo ſhown that this acid, when formed, combines with calcareous earth, where nothing but animal matters is uſed for nitre beds; and that the uſe of vegetable ſubſtances is to furniſh fixed alkali or potaſh, which is the baſe of common nitre. M. Thouvenel had not determined the nature of the gas which is diſengaged from animal matters in a ſtate of putrefaction. And Mr Cavendiſh has ſince ſhown it to be the ſame with that which, under the name of phlogiſticated air, atmoſpheric mephitis, or azotic gas, conſtitutes one of the principles of the atmoſphere. By combining this gas with vital air, by means of the electric ſpark, he obtained a product of genuine nitric acid.

Nitrate of potaſh is very liable to alteration from heat. When expoſed to the action of fire in a crucible, it ſoon liquefies—by igneous fuſion; for though kept for ſome time in that ſtate, it does not become dry; and though made red hot, does not aſſume a pulverulent form. When ſuffered to cool, after being melted, it it congeals into an opaque maſs which is named *cryſtal mineral*, and is equally ponderous, fuſible, and ſoluble with nitrate of potaſh. The cryſtal mineral of the apothecaries ſhops is ſomewhat different from pure melted nitre: for it contains a little ſulfate of potaſh, produced by the combuſtion of ſulphur, which, according to the Pariſian pharmacopœia, is uſed in the proportion of a dram to the pound of nitre in the preparation of it.

If nitrate of potaſh be left expoſed to the action of fire, after being melted, it will be of itſelf decompoſed and reduced to alkali. This operation ſucceeds equally well in a retort; and when performed in this manner, is of uſe to explain the decompoſition of the nitric acid. In fact, inſtead of the nitric acid paſſing off pure, there eſcapes a large quantity of an aeriform fluid, which may be collected under water, and is found to be genuine vital air mixed with azotic gas. The reſidue of alkali uſually melts the retort very ſoon after it is ſeparated; and when we wiſh to purſue the operation to a concluſion, we muſt uſe a ſtone retort which may be proof againſt its action. Here we have the nitric acid entirely decompoſed into vital air and azotic gas by means of heat, which alone is able to ſeparate theſe two principles. If the heat be not continued ſo long, or made ſo intenſe, as to effect the entire decompoſition of the nitrate of potaſh, the alkali ſtill retains a certain quantity of the nitrous acid, or of the nitric with an exceſs of nitrous gas. This acid may be diſengaged from it by vinegar. In this ſtate, the ſalt is what we call *nitrite of potaſh*, the nitrous acid being ſuperſaturated with azotic gas; in the ſame manner we called the combination of the ſulphureous acid with potaſh, *ſulphite of potaſh*. If nitrate of potaſh be acted upon by a very intenſe heat, a reſidue of pure cauſtic alkali is obtained. Since heat decompoſes nitrate of potaſh with ſuch facility, it may be naturally inferred, that when cryſtal mineral is prepared by ſimple fuſion, the ſalt muſt not be too long expoſed to the fire. If this precaution be neglected, the medicine will contain more than a juſt proportion of potaſh, and will produce too violent effects.

The decompoſition of nitrate of potaſh is attended with other phænomena, when it is expoſed to the action of fire, together with combuſtible bodies. When laid on a coal it gives a white lively flame, attended with a kind of decrepitation: this is called the *detonation*, or *fuſion of nitre:* the ſalt is then ſaid to detonize or melt; and by this characteriſtic nitre may be at any time eaſily diſtinguiſhed. Stahl thought this phænomenon to be owing to the rapid combination of the acid of nitre with phlogiſton; and M. Baumé proceeding on the ſame theory, thought that in this operation a quantity of nitrous ſulphur was formed, which was inſtantly inflamed. In the year 1780, I read in the Academy a Memoir, in which I have ſhown that nitrate of potaſh is neither combuſtible of itſelf nor yet forms nitrous ſulphur when it detonizes; and that this phænomenon is entirely owing to the ſlower or quicker combuſtion of the combuſtible matter neceſſary to make the ſalt detonize, in conſequence of the diſengagement of the vital air, which eſcapes in great abundance from nitrate of potaſh ſtrongly heated. This theory is completely proved: 1. Becauſe the ſalt never detonizes by itſelf. 2. Becauſe after its detonation by means of an inflammable matter, that matter is found to be entirely burnt up. 3. Becauſe the greater the quantity of the nitrate of potaſh in proportion to that of the combuſtible matter, the more complete is the combuſtion of the latter ſubſtance. 4. Becauſe detonation takes place as well in cloſe veſſels as in the open air, which could not poſſibly happen if the ſalt did not furniſh vital air. This aſſertion receives the fulleſt ſupport from the phænomena attending the proceſs for making the clyſſus of nitre; which is merely a detonation of this ſalt with different combuſtible matters in cloſe veſſels. We ſhall mention here only that which is made with charcoal. Two or three large receivers fitted together are applied to a retort of earth or iron, with an orifice in the upper part, which may be cloſed with a cover or ſtopper. This veſſel is heated till its bottom be made red, and then a mixture of nitrate of potaſh with coal is put in by the orifice, which is immediately ſhut. During the detonation, the receivers are filled with vapours, part of which is condenſed into an inſipid liquor, not at all acid, but often alkaline. The reſidue is potaſh ſaturated with carbonic acid: the nitric acid is then totally decompoſed, and a large quantity of gas is produced, which I have collected by fitting to the orifice in the upper part of the receivers, either a bladder or tubes, the extremities of which entered glaſſes full of water. This gas was moſtly carbonic acid mixed with a little inflammable and azotic gas; the laſt of which is one of the principles of the nitric acd. The inflammable gas is produced in conſequence of the decompoſition of part of the water of nitre by the charcoal.

The reſidue, after the detonation of nitrate of potaſh with charcoal in a crucible, is improperly called *nitre fixed by charcoal:* it is potaſh combined with carbonic acid.

Nitrate

Nitrate of potaſh, when very pure, ſuffers no alteration from the action of the air.

It is eaſily ſoluble; for three or four parts of boiling water diſſolve one of nitre, and boiling water diſſolves a quantity of it equal to twice its own weight. It therefore cryſtallizes very readily by cooling. On its poſſeſſing theſe two properties is founded the art of extracting nitrate of potaſh from plaſter or rubbiſh containing it. The ſaltpetre makers put the pounded plaſter or rubbiſh into a veſſel with a hole at the bottom, and cover it with aſhes. Through this matter they pour water; taking care to pour pure water on rubbiſh that has been already waſhed, till it be deprived of all the nitrous matter it contains; and pouring water already impregnated with nitre upon the unwaſhed rubbiſh, in order that it may be completely ſaturated. They next evaporate the lixivium thus formed in copper veſſels. They ſkim off the firſt pellicles, which are only the muriate of ſoda or marine ſalt contained in the rubbiſh. This ſalt they call *grain;* and by their regulations, they are obliged to carry it to the refining houſes. When the water is evaporated to ſuch a degree, that the reſidue when cool muſt become ſolid, they put it into other veſſels in which the nitrate of potaſh is cryſtallized. This ſalt, which is very impure and dirty, is called *nitre of the firſt boiling*. Some chemiſts have been of opinion that the aſhes uſed in making ſaltpetre ſerved only to cleanſe the nitrate of potaſh of certain greaſy impurities; and that opinion appeared to be ſupported by the fact, that theſe matters contain almoſt no alkali, and the aſhes of tarmariſk, uſed by the ſalt-petre makers of Languedoc, contain only ſulphate of Soda. But this ſalt, as well as ſulphate of potaſh, is as uſeful as an alkali for decompoſing the calcareous nitrate, which is found in ſuch abundance

dance in plaſter or rubbiſh, by the way of double elective attraction, as M. Lavoiſier has obſerved with reſpect to the lixiviated aſhes uſed by the ſaltpetre makers of Paris. We ſhall ſay more upon this under the article of *Calcareous Nitrate.*

Nitrate of potaſh of the firſt boiling is always very impure. It contains five other kinds of ſalts beſides pure nitre; namely, muriate of ſoda, nitrate of magneſia, calcareous nitrate, muriate of magneſia, and calcareous muriate; and theſe muſt be ſeparated, if we wiſh to obtain nitrate of potaſh in a ſtate of purity. The mixture is purified of theſe ſalts, by diſſolving it again in the ſmalleſt poſſible quantity of water, and clarifying this boiling liquor by means of bullock's blood, which carries off all impurities by collecting them on the ſurface in the form of a ſcum. This lixivium is then evaporated, and by cooling the reſidue, a nitrate of potaſh is obtained, much purer than the former, which is ſaid to be *nitre of the ſecond boiling.* Still, however, it is vitiated by a certain quantity of muriate of ſoda and mother-water. It is a third time purified by the ſame proceſs, and it then becomes much purer and whiter; it is now *nitre of the third boiling.* As it is made to cryſtallize very rapidly, it is obtained in large irregular maſſes; and yet in the middle of the veſſels there is formed a layer of long regular cryſtals, which is called *nitre in ſticks.* Nitre under this laſt form is not uſed in arſenals, being not ſo fit for making good gun-powder as nitre in large irregular maſſes; becauſe the water which entered into it when it was cryſtallized would retard the combuſtion of the powder.

Chemiſts and apothecaries go on to purify nitre of the third boiling by new ſolutions and cryſtallizations.

By

By this means they are certain of at length obtaining very pure nitrate of potaſh, entirely free of every extraneous mixture, and containing no muriate with either ſoda, or lime, or magneſia for its baſe. Though theſe are ſcarce ever taken entirely away where the operation is performed in the great way *.

Nitrate of potaſh appears to be liable to ſome alteration from ſiliceous earth; for by diſtilling it with ſand the acid is ſeparated. This acid comes off colourleſs, but ſome vapours are diffuſed at the time. The reſidue is vitreous in a greater or a leſs degree, according as there was a greater or a leſs quantity of ſand employed, and as the heat was weaker or more intenſe. Sand appears to decompoſe nitrate of potaſh by its tendency to combine with its alkaline baſe: for when nitre is diſtilled without any intermediate body being uſed, there is no nitrous acid, but a mixture of vital air with azotic gas, obtained. The reaſon of this I take to be, that when nitre of potaſh is diſtilled without an intermedium, the alkali reacts on the acid, and contributes to its decompoſition; whereas, when this ſalt is heated with a mixture of ſand, the ſand, by its tendency to form glaſs by combining with the potaſh, prevents the alkali from reacting on the acid, which therefore eſcapes unaltered.

---

* There is no more extraordinary natural or chemical fact than the production of ſix ſpecies of ſalt in the rubbiſh of old houſes, each of the alkaline baſes being conſtantly united with a peculiar acid. Potaſh is always united with the nitric acid, and ſoda is always combined with the muriatic. There would ſeem to be ſome particular relations between theſe different kinds of primary ſalts, in conſequence of which they mutually ſelect each other; for why is there no muriate of potaſh or nitrate of ſoda? The ſame thing might be obſerved of the earthy ſalts: in fact, there is much more muriate of magneſia and calcareous nitrate, than nitrate of magneſia or calcareous muriate; and this ſhows magneſia to have a peculiar affinity with the muriatic, and lime with the nitric acid.

ed. Argillaceous earths likewiſe decompoſe nitre. Coloured clay is generally made uſe of for this purpoſe. The diſtillers of aquafortis in Paris make uſe of an earth of this kind. Into earthen retorts, of a peculiar form, called *cuines*, they put into each two pounds of nitre, of the ſecond boiling, with ſix pounds of coloured clay of Gentilly: the retorts are arranged one beſide another, in long furnaces known by the name of *galleries*; and the neck of each retort enters a bottle of the ſame form, ſerving as a receiver. By this means they obtain at firſt a tranſparent liquor, ſomewhat acid, which they call *phlegm of aquafortis*, and afterwards the acid gradually more and more concentrated. The reſidue is a very hard, red, earthy ſubſtance, which ſerves for making a kind of mortar. But this experiment by no means proves that clay decompoſes nitre of potaſh:—For, 1. The nitre uſed by the diſtillers is very impure, containing a great deal of earthy nitre: 2. The clay which they make uſe of is of a very compound nature, often containing a great quantity of pyrites, the vitriolic acid of which may poſſibly decompoſe the nitre. In order that this decompoſition might determine the fact in queſtion, it ſhould be made with white clay, or rather with the baſe of alum or aluminous earth. As this earth has not ſo great a tendency as ſand to unite with the alkali, and does not form glaſs by combining with this ſalt, it does not ſeem capable of effecting ſo complete a decompoſition of nitre of potaſh as ſand produces. M. Baumé, however, ſays, that he obtained the acid of nitre of potaſh by the addition of porcelain and clay baked in ſtone-ware; but he thinks the decompoſition of the ſalt was owing to the acid contained in the clays.

Barytes decompoſes nitre of potaſh, and ſeparates the alkali.

alkali. Bergman, in his table of affinities, places this ſalino-terreous ſubſtance before the alkalis, and immediately after the nitric acid.

Magneſia, lime, and the alkalis, act not upon nitre. But the acids act in a very diſtinct manner on this ſalt, particularly the ſulphuric acid, which has really a greater affinity than the nitric acid with the alkalis. When a quantity of concentrated ſulphuric acid is poured on a quantity of dry nitre of potaſh, a conſiderable effervеſcence is produced, and red vapours are ſeen to ariſe, which are actually nitrous acid. By performing this operation in a receiver with a retort fitted to it, we may collect this acid: it is known by the name of *ſpirit of nitre.* This operation is called in the laboratories, *the diſtillation of the ſpirit of nitre in Glauber's way;* becauſe Glauber was the firſt who gave a plain intelligible deſcription of it. The receiver uſed in this operation muſt be perforated with a ſmall hole, to give vent to the vapours of the nitrous acid. It was remarked, that there was much difficulty in condenſing theſe vapours, and the proceſs was liable to two accidents. The firſt was, the loſs of no ſmall portion of the ſpirit of nitre which eſcaped through the orifice of the veſſel: the ſecond, the danger to which the operator was expoſed from ſuch extremely acrid and corroſive vapours. This proceſs was therefore very defective. Mr Woulfe, an ingenious Engliſh chemiſt, has found means to obviate theſe inconveniences. Inſtead of uſing a receiver perforated with a little hole, he has adopted one with two necks. Into the extremity of this veſſel, which is fartheſt from the receiver, he puts a tube, one end of which being in an horizontal poſition, makes a right angle with the other, which is vertical and inſerted into a bottle. This bottle has in in its ſides two orifices; each of theſe receives a ſyphon which paſſes into another bottle ſtanding beſide the firſt. The two collateral bottles are joined by means of a ſyphon with two others, of which the lateral apertures remain open. The firſt bottle generally remains empty: the collateral bottles contain a quantity of water, in which the lower and longeſt extremity of the tube which communicates between the two is immerſed: the upper part of the bottles remains empty; and the acid vapour is conducted by the tubes through the bottles. By the uſe of this ingenious apparatus, the artiſt is ſecured from all danger, and nothing is loſt. The nitrous acid in vapour paſſes through the retort into the firſt bottles, and is there condenſed; and what is not condenſed in the firſt paſſes into the ſecond bottles, and there unites with the water. From the lateral apertures of the laſt bottles, there eſcapes a certain quantity of vital air, which may be received into proper glaſſes. This apparatus, as here deſcribed, poſſeſſes one advantage worthy of our notice: When the retort is left to cool at the end of the operation, a vacuum is produced in the veſſels, and the external air preſſing on the water in the outer bottles ſtanding open, forces it through the ſyphons into the inner collateral bottles; and from theſe again it paſſes into the middle bottle ſtanding neareſt to the retort. If the firſt bottle were not empty, or not large enough to contain all the water from the others, the acid liquors would paſs into the receiver: and as the ſtrongeſt nitrous acid is contained in that veſſel, it would be mixed with the liquors from the bottles, and therefore would not poſſeſs the required ſtrength. This circumſtance would be ſtill more inconvenient in other inſtances of diſtillation, of which we are hereafter to

ſpeak;

ſpeak; becauſe it would not ſimply weaken the ſtrength of the product, but would even alter its purity.

In performing this operation in a laboratory, four pounds of pure nitrate of potaſh, melted into cryſtal-mineral, are put into a tubulated ſtone retort, placed in a reverberating furnace; or tubulated glaſs retorts may be uſed in a ſand-bath. Two pounds and an half of concentrated ſulphuric acid are poured in at once through the aperture, and it is then ſhut. The apparatus above deſcribed, which we ſuppoſe to have been prepared and put together on the preceding evening, is to be inſtantly applied and luted to the retort; it is next to be gradually heated till nothing more comes over. The diſengagement of the gas, and its paſſage into the bottles, ſerve to direct the operator in conducting the proceſs. If the gas appear to be diſengaged with too much rapidity, the heat is then too violent, and muſt be diminiſhed, otherwiſe the whole maſs in the retort will ſwell up and paſs into the receiver: But again, if it paſs too ſlowly, the fire muſt be increaſed to prevent the abſorption of the gas. This apparatus is therefore happily formed to direct the artiſt in the management of his proceſs.

The reſidue, after this decompoſition, is ſulphate of potaſh, formed by the union of the ſulphuric acid with the alkaline baſe of nitre. This reſidue is known in pharmacy under the name of *ſal de duobus*, or *arcanum duplicatum*. It is uſually a white opaque maſs, half vitrified, and filled with cavities produced in it when it was ſwelled by the heat. This ſalt is ſtrongly acid, on account of the quantity of ſulphuric acid made uſe of in producing it; and it is the exceſs of the acid which cauſes the ſalt to melt, as we have ſeen under the hiſtory of ſulphate of potaſh. The nitrous acid obtained by this proceſs is very red and fuming, becauſe the intenſe heat employed in the diſtillation diſengages a portion of vital air. As it is always mixed with a certain quantity of ſulphuric acid, it is to be rectified by a new proceſs of diſtillation on a quantity of nitre equal to one-fourth of its own weight. We muſt likewiſe obſerve, that the nitre made uſe of on this occaſion muſt be very pure, in order to afford nitrous acid in ſuch a ſtate that we may depend upon its effects. That which is obtained from nitre of the ſecond boiling, contains muriatic acid, and acts with the ſolvent power of aqua regia. This acid may be purified of the muriatic acid which it contains by a diſtillation judiciouſly managed; as is ſhown by Meſſrs de Laſſone and Cornette (*Mem. Acad.* 1781, p. 653 to 656.).

The concrete boracic acid decompoſes nitre with the help of heat, diſengaging from it the nitric acid in a concentrated ſtate. It appears to effect this decompoſition by means of its fixity; which is the opinion of the academicians of Dijon. Yet it muſt be alſo aſcribed in part to the mutual attraction between the boracic acid and the potaſh baſe of nitre.

Nitre of potaſh is much uſed in the arts. It is the principal ingredient in gunpowder; of which compoſition we will have occaſion to ſpeak under the article of ſulphur. When burnt with various proportions of tartar, it forms the melting matters called *fluxes*, which are uſed in the aſſaying of metals for melting and reducing metallic ſubſtances, &c. &c.

It is often uſed in medicine as a quieting, cooling, refreſhing, diuretic, antiſeptic medicine, &c. It is given in any kind of drink, in doſes of—from ten or

twelve

twelve grains to half a dram and more. Phyſicians have daily inſtances of its good effects.

Species IV. *Nitrate of Soda.*

Nitrate of ſoda, which has been called *cubic*, *quadrangular*, and *rhomboidal nitre*, is a perfect neutral ſalt, reſulting from a ſaturated combination of the nitric acid with ſoda.

This ſalt generally appears in pretty large and very regular rhomboidal cryſtals. The name of *rhomboidal nitre* deſcribes it better than that of *cubic nitre.*

Its taſte is freſh, and rather more bitter than that of nitre of potaſh.

Fire decompoſes this as well as the preceding ſalt; but it decrepitates, and does not melt ſo eaſily as the other. It affords a mixture of vital air with azotic gas, with an alkaline reſidue like nitre of potaſh.

It is rather more ſubject than nitre of potaſh to alteration from the air, and attracts moiſture, though not with much force.

It diſſolves in cold water even more readily than the former ſalt; for two parts of water, at the ordinary temperature of 60°, are ſufficient to diſſolve one part of nitrate of ſoda. Boiling water ſcarce diſſolves it in a greater proportion: and therefore, when we wiſh to obtain it in regular cryſtals, the ſolution muſt be ſlowly evaporated. If a tolerably clear lixivium of this ſalt be ſet aſide in a dry place, at the end of ſome months it is found to contain rhomboidal cryſtals, ſix or eight lines, and ſometimes near an inch, long. This is uſually the happieſt proceſs for cryſtallizing ſalts that are as ſoluble in cold as in warm water.

Nitre

Nitre of ſoda detonizes on burning coals, and inflames any combuſtible body heated along with it,—rather more ſlowly than nitre of potaſh.

Siliceous earth diſengages the nitric acid, and unites with its baſe to form glaſs. Clay alſo ſeparates the acid, giving as a reſidue a kind of grit, which becomes porous and opaque after being expoſed to a ſtrong heat.

Barytes decompoſes it, and leaves the ſoda pure. Magneſia and lime produce no ſenſible alteration upon it.

Potaſh having more affinity than the baſe of this ſalt with the nitric acid, attracts it to itſelf, and forms with it nitre of potaſh. We obtain conviction of the truth of this fact by a very ſimple experiment. If a boiling ſaturated ſolution of nitre of ſoda be divided into two portions, and into one of theſe there be thrown a quantity of cauſtic potaſh, the portion which received this addition will depoſite, when it cools, priſmatic cryſtals of nitre of potaſh; while the other into which there was no potaſh put, will exhibit no cryſtals at all, becauſe nitre of ſoda cryſtallizes only by a very ſlow evaporation.

If concentrated ſulphuric acid be poured upon nitrate of ſoda, it will diſengage the nitrous acid with efferveſcence. Nitrous acid is obtained by a diſtillation of this mixture, as well as from nitre of potaſh. The other mineral acids act no more on this ſalt than on the foregoing.

The neutral ſalts which have been already examined, ſulphate of potaſh and ſoda, and nitrate of potaſh, produce no alteration on nitrate of ſoda. When theſe ſalts are all diſſolved in the ſame water, they cryſtallize ſeparately, each in its ordinary way: Nitrate of potaſh and ſulphate of ſoda, by cooling; ſulphate of potaſh and nitre of ſoda, by evaporation. From all of theſe properties it appears, that nitrate of ſoda differs from nitrate of potaſh only in its form, its taſte, its ſlight tendency to deliquiate, its being of eaſier ſolution, and its cryſtallizing by evaporation, and chiefly by its ſuſceptibility of decompoſition by potaſh.

Nitrate of ſoda has not been yet found in nature. It is always a product of art, and is formed in the five following ways: 1. By the direct combination of the nitric acid with ſoda. 2. By decompoſing with this alkali earthy nitrates, ammoniacal nitrate, and metallic nitrates 3. By decompoſing muriate of ſoda with the nitric acid for an intermedium. 4. By decompoſing ſulphate of ſoda by the fuming ſpirit of nitre. 5. By decompoſing ſuch nitrous ſolutions of metals as are ſuſceptible of it with muriate of ſoda: In this inſtance, in proportion as the muriatic acid combines with the metal, ſeparating from it the nitric acid, the ſeparated acid combines with the ſoda, which has alſo deſerted the acid with which it was before united. All of theſe decompoſitions will be particularly deſcribed in the reſpective hiſtories of the ſalts which are liable to them.

Nitrate of ſoda might be employed for the ſame purpoſes as nitrate of potaſh. But as it does not produce all the effects of that ſalt, doubtleſs on account of its having a greater affinity with water, it is not made uſe of in the arts. Beſides, as it is not found in nature, but is merely a product of art, no attempt has been made to apply it to any particular uſe. A ſufficient number of experiments has not yet been made on this ſalt to make us acquainted with all its properties.

Species V. *Muriate of Potaſh.*

Muriate of potaſh, which was formerly called *febrifuge ſalt of Sylvius*, is a ſaturated combination of the muriatic acid with potaſh. It has been improperly named *regenerated marine ſalt*; for the nature of its baſe renders it different from that ſalt. Its cryſtals are cubic, but always of a confuſed appearance, and rather an irregular form. Its taſte is ſalt, pungent, bitter, and diſagreeable. When expoſed to fire, it decrepitates; that is to ſay, its cryſtals break into ſmall pieces, which is occaſioned by the ſudden rarefaction of the water which enters into their compoſition. If ſuffered to remain in the fire after decrepitation, it melts and is volatilized, but not decompoſed. It may be uſed as a flux for earths and metallic ſubſtances. Its chief uſe in ſuch caſes is to cover the matters to be melted, and by that means fix the action of other fluxes employed, hindering them from becoming volatile, and preventing ſuch alterations as might be occaſioned by the acceſs of air.

Muriate of potaſh is ſubject to little alteration from the air, as it ſcarce attracts moiſture.

About three parts of cold water are neceſſary to maintain in ſolution one of this ſalt; nor has hot water any greater power of diſſolving it. For this reaſon a ſlow evaporation is uſed to give it in cryſtals. It is one of thoſe ſalts which it is very difficult to obtain in regular cryſtals of a certain ſize.

Clay ſeems to decompoſe it in part: for muriatic acid may be obtained by diſtilling this ſalt with the clays in the neighbourhood of Paris. That operation indeed

indeed affords but a ſmall quantity of the acid, and its reſult is very different from that which nitrate of potaſh affords. Sand is alſo known to act in the ſame manner as clay on muriate of potaſh.

Barytes, according to Bergman, ſeizes the acid, leaving the potaſh in a ſeparate ſtate. Magneſia and lime produce no alteration on this ſalt.

The ſulphuric and the nitric acids diſengage the muriatic with efferveſcence *. This phænomenon is the more ſtriking if the potaſh be dry. Muriate of potaſh, after decrepitating, and loſing the water of its cryſtals, gives a very conſiderable efferveſcence with the concentrated ſulphuric acid, and the mixture becomes very warm. Where theſe decompoſitions are performed in retorts, muriatic acid paſſes into the receiver, and the reſidue in the retort is found to be ſulphate of potaſh,—if the ſulphuric acid was employed to effect the decompoſition; but if the nitric acid was

---

* We have already obſerved, when ſpeaking of the decompoſition of nitre of potaſh by the concentrated ſulphuric acid, that the nitrous acid is then diſengaged with a lively efferveſcence. We find the muriatic acid exhibiting the ſame phænomenon; in a much more eminent degree indeed, becauſe this acid has a very ſtrong tendency to aſſume the gaſeous ſtate. This is the general cauſe of all efferveſcences, the nature and diſtinctions of which have, till of late, been but very imperfectly known. It was formerly thought that they were owing to the diſengagement of air: we now know them to be produced, not by air, but by all bodies which have any tendency to the ſtate of aeriform aggregation; and thus we have ſhown, that the ebullition of water may be conſidered as a ſort of efferveſcence. As this truth needs to be frequently repeated, in order that it may become generally known, we ſhall take occaſion to recur to it ſeveral times when treating of the different neutral ſalts which admit of decompoſition by acids.

was uſed, aqua regia is obtained in the receiver, and the reſidue is nitre of potaſh. The boracic acid likewiſe decompoſes muriate of potaſh by diſtillation, diſengaging the muriatic acid. As all of theſe operations are done with muriate of ſoda or marine ſalt, we ſhall give a more particular account of them under that article. Neither the fluoric nor the carbonic acid acts in any way on the muriated potaſh.

Neither ſulphate nor nitrate of potaſh or ſoda acts upon this ſalt. When all are diſſolved in the ſame water, each of them is cryſtallized ſeparately and in its own way.

Muriate of potaſh is frequently met with in nature; but never much of it together. It is found in ſea water, and in the water of ſalt ſprings; ſometimes, tho' not often indeed, it is met with in the ſame places where nitre of potaſh is found; it is alſo found in aſhes of vegetables, and in ſome animal humours. Art produces it, 1. By a direct combination of the muriatic acid with potaſh; 2. By decompoſing earthy, ammoniacal, or metallic muriates by the ſame alkali; 3. By decompoſing ſulphate or nitrate of potaſh, by means of the muriatic acid, as M. Cornette has ſhown.

This neutral ſalt was formerly adminiſtered as an excellent febrifuge. But it poſſeſſes not this property otherwiſe than in common with all bitter ſalts. Sulphate of potaſh or ſoda is now preferred to it.

Muriate of potaſh is applied to no uſe in the arts. Its diſagreeable taſte hinders it from being uſed, like muriate of ſoda, for ſeaſoning. But it has all the chemical properties of that ſalt; and the only difference between them is, that muriate of potaſh has a bitter taſte, is more difficult of ſolution, is unalterable by the air,

air, and is irregularly cryſtallized. We ſhall therefore inſiſt no more upon its hiſtory.

Species VI. *Muriate of Soda.*

Muriate of ſoda, better known under the name of *culinary* or *common ſalt*, is a perfect neutral ſalt, formed by a ſaturated combination of the muriatic acid with ſoda. The reader will perceive that the nomenclature which we have hitherto uſed, renders a definition of the nature of theſe neutral ſalts almoſt unneceſſary; as the name of each is expreſſive of its nature.

This ſalt abounds in nature more than any other ſpecies. It is found in vaſt maſſes in the interior parts of the earth, in Spain, Calabria, Hungary, and Muſcovy, but more eſpecially at Wieliczka in Poland, near the Crapack mountains. In the laſt of theſe places the mines are of vaſt extent, and the muriate of ſoda is found in prodigious maſſes. This ſalt, as it exiſts in the earth, is generally irregular, and ſeldom cryſtallized; it is uſually more or leſs white, but ſometimes coloured: in this ſtate it is called *gem-ſalt*, having often the tranſparency of the cryſtals known under that name. The waters of the ſea, as well as of ſome lakes and rivers, contain this ſalt. From theſe waters it is obtained by four general proceſſes.

The firſt is ſpontaneous evaporation by the heat of the ſun. This method is uſed in our ſouthern provinces, in Languedoc, at Peyrac, Pecais, &c. Trenches are cut on the ſea ſhore, and very compactly lined with clay: within theſe trenches little walls are built, dividing them into certain compartments, yet leaving a general communication. When the tide flows, the trenches

trenches are filled with water, which is retained in them by the walls forming a kind of ſluice-gates. Care is taken that the layer of water retained be thin enough to be readily evaporated by the rays of the ſun. As ſoon as a ſaline pellicle is formed, it is broken, and the fragments fall to the bottom; and the ſame proceſs is repeated till the water be entirely evaporated. The ſalt is then gathered with rakes, and laid in heaps to dry. This ſalt contains a mixture of all the other ſalts that exiſt in a ſtate of ſolution in ſea-water, ſuch as ſulphate of ſoda and magneſia, muriate of magneſia and lime: it is alſo contaminated with a portion of clay from the bottom of the trench: and, laſtly, ſmall globules of iron and mercury are found in it. The exiſtence of the latter in it may be eaſily ſhown by leaving a ſmall piece of gold among the ſalt for ſome time: it becomes evidently whiter. This ſalt being very impure, is known under the name of *ſel de gabelle.*

In the northern provinces of France, in Normandy and Brittany, this ſalt is prepared by an artificial evaporation by fire. In Avranches they take the quickſands among which the ſea water has depoſited ſaline cryſtals, and waſh them in the ſmalleſt quantity poſſible of ſea water, in order that no more may be uſed than what is neceſſary to diſſolve the ſalt: This ſalt water is then put into lead veſſels, and evaporated to dryneſs. This ſalt is very white, and purer than that prepared by evaporation in trenches. Guettard has given a careful deſcription of the whole proceſs in the Memoirs of the Academy for the year 1758.

In Lorraine and Franche-Comté there are a great many ſalt ſprings. The quantities of muriate of ſoda which thoſe ſprings contain in proportion to the quantity

tity of water are various. At Montmorot, in the laſt of theſe provinces, both ſpontaneous evaporation and evaporation by fire are uſed in the preparation of this ſalt. For that purpoſe, the well-water is conveyed by pumps into a large reſervoir placed at the top of a ſhed of a peculiar conſtruction. Under this ſhed are ſuſpended boards covered with little faggots of thorns. The water falling upon thoſe faggots through ſmall cocks, is divided into very minute drops: and as it thus expoſes a great deal of ſurface to the air circulating rapidly under the ſhed, nearly two-thirds of it is evaporated. What is depoſited on the faggots is ſulphate of lime or ſelenite. And when the liquor, upon trial with an inſtrument for the purpoſe, is found to be charged with ſalt to a certain degree, it is conveyed into large iron boilers ſupported by bars of the ſame metal, which croſs the bottom of the veſſels, and reſt on pieces of wood placed on each ſide. Thoſe boilers, which are called *ſtoves*, are very large and ſhallow, and hold an hundred hogſheads * of the ſalt water. They are then urged with a ſtrong fire. When the water boils up in large bubbles, it is at firſt muddy, and ſoon depoſites an ochreous earth on its ſurface in the form of a ſcum. A ſalt, which is ſcarcely ſoluble, and is called by the workmen *ſchlot*, is next ſeparated: This ſalt is nothing but ſulphate of lime mixed with a little muriate of ſoda, ſulphate of ſoda, and earthy muriates. It is conveyed by the circulation of the boiling liquor into little troughs placed round the ſides of the boilers for the purpoſe. Theſe troughs are taken out and cleared from time to time till a great quantity of ſmall

---

* *Muids*, containing each 280 French pints.

ſmall cubical cryſtals called by the workmen *pieds de mouches*, are obſerved floating on the ſurface of the liquor. They are then taken away for the laſt time. The fire is diminiſhed, and the muriate of ſoda is taken off with ladles as faſt as it is cryſtallized. The evaporation is thus continued as long as the water continues to afford cryſtals. The ſalt thus obtained is in larger or ſmaller cryſtals, according to the ſlowneſs or rapidity of the evaporation. The water which remains when cryſtals are no longer obtained, is called *mother water*, and contains earthy muriates *.

Wallerius gives an account of a fourth proceſs for obtaining ſalt from ſea water, which is practiſed in the north. The water is confined in trenches on the ſhore: as it forms but a ſmall ſtratum, the cold ſoon penetrates through and freezes it. But as that portion neceſſary for the ſolution of the ſalt contained in the whole quantity of water cannot be converted into ice, what remains fluid contains all the ſalt, and is ſo concentrated that the moſt moderate heat cauſes it to afford muriate of ſoda in cryſtals: it is then conveyed into leaden boilers, and evaporated by fire.

The cryſtals of muriate of ſoda are very regular cubes, of a larger or a ſmaller ſize, in proportion as the evaporation has been ſlower or more rapid. They ſtick together in cluſters, forming a kind of ladders, or rather hoppers. Rouelle the elder obſerved this phænomenon, and has given an accurate deſcription of it in his

---

* There is a neutral ſalt prepared at Montmorot, known under the name of *Epſom ſalt of Lorraine:* but it is only ſulphate of ſoda, or Glauber ſalt, the cryſtallization of which has been diſturbed. It is diſtinguiſhed from genuine ſulphate of magneſia and Epſom ſalt, ſuch as comes from England by its eſfloreſcing in the air, while the latter deliquiates.

his Memoirs on Cryſtallization. Bergman has given a very ingenious explanation of this fact.

Every body knows the taſte of this ſalt, which is not diſagreeable.

When expoſed to a briſk heat it burſts and flies into pieces. This phenomenon is called *decrepitation.* It is owing, as we have already obſerved when ſpeaking of ſulphate and muriate of potaſh, to the ſudden rarefaction of the water on which the cryſtallization depends. When all the water is thus evaporated, the decrepitation ceaſes, and the ſalt appears in a powder. If we continue to urge it with a ſtrong heat, it melts after becoming red-hot. If poured in this ſtate on the plane ſurface of a piece of marble, it congeals into a kind of cryſtal mineral; but it has not ſuffered the leaſt alteration, for it may be reſtored to its original form by ſolution in water. Fire therefore does not decompoſe it: if maintained for ſome time in fuſion, it is at length volatilized, but ſtill without alteration. The moſt intenſe heat is requiſite to bring it into this laſt ſtate.

Muriate of ſoda when pure ſuffers no ſenſible alteration from air; it rather becomes dry than acquires moiſture. It never indeed attracts moiſture but when it contains a mixture of muriates with earthy baſes, ſuch as *ſel de gabelle.*

It diſſolves very readily in water: three parts of the fluid are ſufficient to maintain one of this ſalt in ſolution. Three ounces and an half of water will entirely diſſolve an ounce of the ſalt. Boiling water does not diſſolve it in a greater proportion than cold water; only the ſolution is rather ſooner effected with the help of heat. A very ſlow evaporation is requiſite to give this ſalt in cryſtals. The cryſtallization begins with the for-

formation of a number of ſmall points on the ſurface of the liquor, which are gradually united in a pellicle, more or leſs thick; inſtead of being cubic, the cryſtals are ſometimes ſquare hollow pyramids, reſembling hoppers. Rouelle the elder, who paid the greateſt attention to all the phænomena of this cryſtallization, obſerved the hoppers to be formed in the following manner. When a cube is formed, the little ſolid ſinks a ſhort way beneath the ſurface of the water; a ſecond is ſoon formed, and connected with the firſt on one of its ſides; and the ſame phænomenon takes place on the three other ſides of the cube. This aggregation of cubic cryſtals naturally produces hollow inverted pyramids. When theſe are large they ſink to the bottom. If the ſalt diſſolved was very pure, what remains of the water after it has been evaporated till it would afford no more cryſtals, is entirely without any ſaline matter. The water of the ſea and of ſalt ſprings always contains ſalts with an earthy baſe. The earth may be precipitated by ſoda, as we ſhall have occaſion to mention when ſpeaking of earthy neutral ſalts. Such is the method uſed for obtaining muriate of ſoda in a ſtate of great purity.

Muriate of ſoda appears to contribute to the fuſion of glaſs. It conſtantly occupies the upper part of the pots in which this matter is melted, and conſtitutes the greateſt part of glaſs-gall.

It is uſed for vitrifying the exterior ſurface of certain pottery wares, and giving them a kind of cover, by melting down part of their ſubſtance with the force of heat communicated through the ſalt. This is eaſily effected by throwing a certain quantity of muriate of ſoda into the furnace. It is volatilized, and by that means ſpread over the ſurface of the earthen ware,

which

which, by its intenſe heat, it cauſes in part to melt. This is the Engliſh way of glazing.

Siliceous earth does not alter this ſalt though it appears to promote its fuſion.

Pure clay acts with much leſs force on muriate of ſoda than on nitres. When diſtilled with this ſalt, it affords but a very ſmall quantity of a weak phlegmatic acid. Diſtillers of aquafortis, it is true, obtain in this manner the muriatic acid called *ſpirit of ſalt:* but they make uſe of Gabel ſalt for the purpoſe; and it contains various muriates with an earthy baſe; beſides, the clay which they uſe is very impure, and of a deep colour.

According to Bergman's experiments, barytes decompoſes muriate of ſoda, as well as the other alkaline ſalts. Neither lime nor magneſia produces any alteration on muriate of ſoda. Perhaps theſe two ſalino-terreous ſubſtances, in combination with the carbonic acid, might ſeparate the component principles of muriate of ſoda by a double elective attraction.

Cauſtic potaſh decompoſes muriate of ſoda, having a greater affinity than ſoda with its acid. A ſolution of muriate of ſoda mixed with potaſh gives by evaporation muriate of potaſh, and the mother water contains pure inſulated ſoda.

Acids act in a very diſtinct manner on muriate of ſoda. When concentrated ſulphuric acid is poured on this ſalt, it cauſes a very conſiderable motion and a very lively heat. A violent effervеſcence is obſerved on the occaſion *, which ariſes from the diſengagement

---

* Effervеſcence is as obſervable in this operation as in the union of the ſame acid with lime and alkalis ſaturated with carbonic acid. It takes place, therefore, whenever any body ſeparated from a ſtate of

gagement of the muriatic acid under the form of gas. This aeriform acid may be diſtinguiſhed after it has eſcaped into the atmoſphere, as it forms a white vapour with the water in the air, and has, when the vapour is very much diluted, a pungent ſmell not unlike that of ſaffron. A conſiderable quantity of muriatic acid gas may be obtained by performing the operation with a pneumato-chemical machine provided with mercury. Glauber was the firſt who obſerved that the acid of marine ſalt might be obtained by decompoſing the ſalt with ſulphuric acid, and deſcribed the proceſs for obtaining it; on which account this has received the name of *Glauber's ſpirit of ſalt.* It was in examining the reſidue of this operation that he diſcovered his admirable ſalt to which we now give the name of *ſulphate of ſoda.*

Almoſt all writers on the ſubject direct the diſtillation of this ſalt to obtain the muriatic acid, to be performed by putting a quantity of it into a tubulated ſtone-retort, and pouring in at the orifice half its weight of concentrated ſulphuric acid: A conſiderable quantity of acid vapour is immediately diſengaged, which paſſes by the extremity of the retort into two balloons prepared to receive it: One of theſe veſſels has a little hole to let the vapours eſcape ſo that they may not burſt the veſſels. In this operation, as well as in the diſtillation of the nitrous acid, a conſiderable quantity of the pureſt muriatic acid is loſt,—eſcaping in a gaſeous form through the hole of the balloon;

---

of combination is volatilized under a gaſeous form: and it may be produced by the carbonic, the muriatic, the nitric, the ſulphureous, and the fluoric acids, &c. It muſt not be aſcribed to the diſengagement of air. A.

loon; and the vapours of this acid being ſo very corroſive, are exceedingly troubleſome to the operator. To obviate in part this inconvenience, M. Baumè puts a quantity of water into the retort; and the water being volatilized in the balloon, abſorbs part of the muriatic acid gas: But as the water is much leſs volatile than the acid, there is ſtill a conſiderable quantity of the acid loſt. Mr Woulfe has found means to obviate all of theſe inconveniences, and to procure the muriatic acid in the ſtrongeſt and moſt concentrated ſtate of which it is capable, by an expedient directly contrary to M. Baumè's. Inſtead of volatilizing the water to make it abſorb the vapours of the muriatic acid, he cauſes the gas to paſs through that liquid by the apparatus which we deſcribed under the article of nitre.

For every two pounds of muriate of ſoda and one of the concentrated ſulphuric acid that are mixed in the retort, eight ounces of diſtilled water are put into the collateral bottles. The muriatic acid gas is conducted through the tubes into the water in the bottles, and there diſſolved. The water, as it combines with the gas, is heated almoſt to ebullition, and abſorbs a quantity equal to itſelf in weight. When fully ſaturated it ceaſes to abſorb the gas and becomes cold; but the gas paſſing into the ſecond collateral bottles, is again immerſed in the water which they contain, and heats and ſaturates it.

This very ingenious proceſs being perfectly conſiſtent with the known properties of the muriatic acid gas, poſſeſſes a number of advantages. 1. It ſecures the operator from the inconveniencies to which he is expoſed when the acid is diffuſed through the open air. 2. It prevents the very conſiderable loſs of the acid which was unavoidable in M. Baumè's proceſs. 3. It gives

gives the muriatic acid in a ſtronger, more concentrated, and more fuming ſtate than we could poſſibly have it otherwiſe. 4. The acid obtained this way is extremely pure, being entirely formed of gas that has been diſſolved in water. It is on this account extremely white; whereas that which was formerly obtained in the laboratory was always of a citron colour; a circumſtance which even led chemiſts into a miſtake, for they conſidered this colour as a characteriſtic property of the acid. That portion of the liquid acid which is in this proceſs condenſed in the receiver is yellow, and contaminated with extraneous matters conveyed into it by the water of the mixture, as happened to the whole of what was obtained in the old way. 5. The new method directs the operator what ſtrength of fire to uſe, and how to conduct his operation by the ſlower or quicker paſſage of the gaſeous muriatic acid through the water in the bottles. 6. Laſtly, What is of more importance than any of its other advantages, it enables us to determine the preciſe quantity of acid contained in any neutral ſalt, as not a particle of the acid ſeparated is loſt.

The nitric acid likewiſe decompoſes muriate of ſoda; but, being volatile, it aſcends and unites with the acid of this ſalt. From that union there reſults the mixed acid known by the name *nitro-muriatic acid* or *aqua regia.*

Baron has diſcovered that the boracic acid, with the help of heat, diſengages the acid from muriate of ſoda. The reſidue, after this diſtillation, is genuine borax of ſoda in a very pure ſtate.

Neither the carbonic nor the fluoric acid acts in any diſtinct manner on muriate of ſoda.

None of the neutral ſalts hitherto deſcribed by us acts upon this ſalt. When the ſulphates and the nitrates of potaſh and ſoda and muriate of potaſh are diſſolved in the ſame water with muriate of ſoda, each of theſe ſalts is cryſtallized by itſelf, and in its own way. Muriate of ſoda is among the firſt which are ſeparated in the progreſs of the evaporation, and it mixes with a little of the ſulphate and muriate of potaſh; but the ſulphate of ſoda and nitrate of potaſh remain longer in ſolution, and are cryſtallized by the cooling of the liquid. On this account, in Lorraine, the mother water, from which marine ſalt has been obtained, is put into veſſels, and ſtirred while it cools, with ſtaves for the purpoſe; which cauſes the ſulphate of ſoda to cryſtallize in a confuſed manner, in ſmall needles, reſembling thoſe of genuine Epſom ſalt, or ſulphate of magneſia.

The uſes of muriate of ſoda are extremely various: It is employed, 1. For glazing ſome kinds of earthen ware by occaſioning a ſlight fuſion of their exterior ſurfaces. 2. By glaſs-makers, for whitening and purifying glaſs. 3. In aſſaying metal ores, as a flux to the matters of which the ſcoriæ are formed, to facilitate the precipitation of the metals, and to defend them from the contact of the atmoſphere, ſo that they may ſuffer no change from the air.

At preſent we find it neceſſary to apply it to a purpoſe of ſtill more importance than any of theſe,—for the extraction of ſoda, which is becoming every day more ſcarce, and is of eſſential uſe in many of the arts. Several people in England poſſeſs the ſecret of obtaining ſoda from marine ſalt in the great way*, and practiſe it in conſiderable extent.

Some

---

* We underſtand that the extraction of ſoda from marine ſalt is not

Some chemiſts have thought litharge capable of decompoſing muriate of ſoda by ſimple maceration and cold. It would appear that, in conſequence of its containing carbonic acid capable of attracting ſoda, and forming with the muriatic acid an inſoluble ſalt, eaſily ſeparable from the alkaline lixivium, it muſt act by a double elective attraction; but the experiments which I have made on this point convince me that the proceſs is inadequate to the purpoſe. Scheele obſerved, that iron immerſed in a ſolution of muriate of ſoda is coated with ſoda ſaturated with carbonic acid. He treated ſulphate and nitrate of ſoda in the ſame manner, with the ſame ſucceſs. He diſcovered, that if quicklime were mixed with muriate of ſoda, and the mixture depoſited in a damp cellar, it afforded an efflореſcence of ſoda and calcareous muriate. This fact was firſt communicated to the public by Cohauſen in the year 1717, M. de Morveau has proved, that theſe decompoſitions are effected by means of the carbonic acid; for if a ſolution of ſulphate and muriate of potaſh be poured upon lime-water precipitated by the carbonic acid, it becomes clear and tranſparent; but when water containing carbonic acid is poured on a ſolution of thoſe ſalts mixed with lime-water, no precipitation takes place. Theſe facts are ſo many *data*, on which we muſt proceed in attempts to obtain ſoda from marine ſalt, and form extenſive eſtabliſhments for the purpoſe.

Muriate of ſoda is uſed as ſeaſoning to the articles of our food, and corrects their inſipidity. It likewiſe facilitates digeſtion, by beginning the putrid alteration of the

---

not practiſed in England to ſuch extent as M. Fourcroy ſeems to think.

the ſubſtances we uſe for aliment. Though it be fully proved by the experiments of Pringle, Macbride, &c. that when mixed in a pretty large proportion with animal ſubſtances, it retards putrefaction, and is powerfully antiſeptic, like moſt other ſaline matters; yet it acts in a very different manner when mixed with the ſame ſubſtances in a very ſmall proportion, cauſing them to paſs more readily into a ſtate of putrefaction. This is proved by the experiments of the author of the Eſſays on the Hiſtory of Putrefaction, and M. Gardane's experiments.

This ſalt is not leſs uſeful in medicine. In apoplectic and paralytic caſes, &c. it is put into the mouth, and uſed externally in baths as an excellent ſtimulant. In moſt caſes it is a powerful diſcuſſive. It is ſtrongly recommended by Ruſſel (*de Tabe Glandulari*) for lymphatic tumours, occaſioned by a ſcorbutic habit. I have myſelf preſcribed it ſucceſsfully for ſeveral diſeaſes of that kind. It is purgative when adminiſtered in doſes of ſeveral drams. As the moſt impure ſalt is commonly uſed on all of theſe occaſions, its effects are in part to be aſcribed to the calcareous and magneſian muriates which it contains.

Species VII. *Borax of Soda, or Super-ſaturated Borate of Soda* *.

Borax of ſoda, or common borax, is a neutral ſalt, formed

---

* Hitherto we have begun with examining the neutral ſalts formed by the union of the acids with potaſh. But, in ſpeaking of thoſe into which the boracic acid enters, we are obliged to begin with that which has ſoda for its baſe, for it is the only one with which we are well acquainted.

formed by the combination of the boracic acid with ſoda. We get this ſalt from the Eaſt Indies; but its hiſtory is very little known. We know not certainly whether it be a product of nature or of art *. If the diſcovery of the boracic acid exiſting in a ſtate of ſolution in the waters of ſeveral lakes in Tuſcany, a fact which we mentioned in the hiſtory of that acid, give us reaſon to think borax a product of nature, a variety of facts which we ſhall hereafter mention, concur to ſhow that this ſalt may be alſo formed by certain artificial proceſſes, as well as nitre.

Borax of ſoda appears in commerce in three different ſtates. In the firſt, it is crude borax, *tinckal* or *chryſocolle*. This we get from Perſia; it is in greeniſh maſſes which feel greaſy, or in opaque cryſtals, coloured like green leeks, which are priſmatic figures of ſix faces, terminating in irregular pyramids. There are even two kinds of theſe greeniſh cryſtals, differing from each other in ſize. This ſalt is very impure, a great many extraneous ſubſtances being intermixed in it.

The ſecond ſpecies is known by the name of *China borax*. It is rather more pure than the former: it appears in the form of ſmall plates, or in maſſes irregularly cryſtallized, and of a dirty white colour: it diſplays the beginnings as it were of priſms and pyramids confounded together without any ſymmetrical arrangement. The ſurfaces of thoſe cryſtals are covered over with

---

* Kirwan, in his mineralogy, page 206. informs us, that it is dug out of the earth in the kingdom of Thibet, in a cryſtalline form. In the Philoſophical Tranſactions for the year 1787, we are informed by a letter from Mr Blane, dated at Lucknow, that the borax of Thibet is formed in a certain valley in that country, by the cooperation of ſnow and the waters of a lake in the middle of the valley with a ſaline matter which abounds over the valley.

with a white duſt, which is thought to be of an argillaceous nature.

The third ſpecies is Dutch or refined borax. It appears in fragments of cryſtals, tranſparent and tolerably pure: pyramids with a number of faces are obſerved in it; but their cryſtallization appears to have been interrupted This form affords a certain indication of the manner in which the Dutch purify this ſalt; it is by ſolution and cryſtallization.

Laſtly, It is prepared at Paris by Meſſrs Leſguillers, druggiſts in Lombard Street: and their purified borax is no way inferior, perhaps even ſuperior, in purity to the Dutch borax.

Beſides theſe four kinds of borax, M. la Pierre apothecary in Paris has imagined it to be formed in a mixture of ſoap-ſuds with dirty kitchen-water, which a certain individual preſerves in a kind of ditch, obtaining from it at the end of a certain time genuine borax in beautiful cryſtals. But this fact, though firſt communicated to the public ten years ſince, has not received confirmation.

We are ſtill ignorant therefore in what manner borax is formed; only it appears to be produced in ſtagnant waters containing fat matters. Some authors aſſure us, that it is artificially compoſed in China, by mixing in a trench greaſe, clay, and dung, in alternate layers, watering this collection of matters at proper times, and leaving it untouched for ſeveral years. At the end of this time, by forming thoſe matters into a lixivium, and evaporating the lixivium, crude borax is obtained. Others would perſuade us, that it is got out of water filtered through copper ore. M. Baumé poſitively aſſerts that the former of theſe proceſſes

ceſſes ſucceeded very well with him. (*Chem. Eper. Tom. II. page* 132.)

Purified borax appears under the form of ſix-ſided priſms, two of them larger than the reſt, with trihædral pyramids. It diſplays a great many varieties in its cryſtallization. Its taſte is ſtiptic and urinous. It communicates a green colour to ſyrup of violets, on account of its containing an extraordinary proportion of ſoda. We leave it in poſſeſſion of the name of borax, in order to diſtinguiſh it from genuine *borate of ſoda*, which is ſaturated with the boracic acid: we likewiſe call it *borax ſuper-ſaturated with ſoda*, to indicate the nature of the combination.

When expoſed to the action of fire, the water of its cryſtallization cauſes it to melt with great rapidity; it gradually loſes that water, and ſwells to a conſiderable bulk. It is then in the form of a light, porous, and very friable maſs, known by the name of *calcined borax*. The cauſe why borax of ſoda increaſes in bulk, and aſſumes a lamellated porous form, on being calcined, is, that the water which is diſengaged into a vaporous ſtate, raiſes to the ſurface a portion of the ſaline ſubſtance half dried, and in light thin pellicles; and the bubbles in which it riſes, making their way out at the ſurface, the pellicles become entirely dry, and are arranged one above another with interſtices between them. Calcination produces no alteration on borax of ſoda, as to its component parts: it loſes, in undergoing this proceſs, nothing but the water which mixed with it in cryſtallization, nearly in the proportion of ſix ounces to the pound. We can reſtore to it its original form by diſſolving it in water, and cauſing it to cryſtallize anew. But if after it has been calcined, we expoſe it to a continued heat, it melts on becoming red-hot into

a

a very fuſible tranſparent greeniſh glaſs; which is ſullied by expoſure to the air, and melts in water. Even fuſion produces no change of nature on borax; we can cauſe it to reſume its original appearance, with all its peculiar properties, by ſolution and cryſtallization.

Air effects no alteration on this ſalt: it makes it effloreſce indeed at the ſurface by depriving it of part of the water of its cryſtallization. But this effloreſcence does not take place in the ſame manner on all the ſeveral kinds of purified borax of ſoda. The borax of China gives a much ſlighter effloreſcence than Dutch borax. Dutch borax likewiſe gives a more copious effloreſcence than the borax purified in Paris. This ſlight difference depends no doubt on the different proceſſes adopted for purifying it, on the manner in which it is cauſed to cryſtallize, the quantity of water which its cryſtals contain, according as they have been more ſlowly or quickly, and perhaps too on the different proportions of ſoda, and the boracic acid which enter into its compoſition.

Borax of ſoda diſſolves very readily in water: twelve parts of cold water are neceſſary to diſſolve one of this ſalt; half that quantity of boiling water will produce the ſame effect. It is obtained in cryſtals by cooling the ſolution, but the moſt beautiful and regular cryſtals are formed in the mother-water, when it is left to evaporate ſlowly, with the ordinary temperature of the atmoſphere.

Borax of ſoda ſerves for a flux to ſiliceous earth, and joins with it to form a very fine glaſs. It is uſed in the preparation of artificial precious ſtones.

It likewiſe cauſes clay to vitrify, but with much more difficulty, and much more imperfectly. This is the

the reaſon of its ſticking to the crucibles in which it is put to melt.

We are rather unacquainted with the action of pure barytes and magneſia on borax of ſoda. Bergman, however, ranks thoſe two ſubſtances before the alkalis in the tenth column of his table of affinities; which ſhows that he thinks them capable of decompoſing this ſalt. But in his diſſertation, he ſays, that the affinities of ponderous earth and magneſia with the boracic acid are not yet exactly known.

Lime has actually a greater affinity than ſoda with this acid. Lime-water precipitates a ſolution of this ſalt; but to make it decompoſe entirely, we muſt boil quicklime and borax of ſoda together: an almoſt inſoluble ſaline combination of lime with the boracic acid is then depoſited, and the cauſtic ſoda is left in ſolution in the water.

Potaſh appears to decompoſe borax of ſoda as well as all other neutral ſalts with a baſe of mineral alkali. Ammoniac produces no ſort of alteration on this ſalt.

The acids act on borax in a very diſtinct manner. If into a boiling ſolution of borax of ſoda you pour a quantity of concentrated ſulphuric acid, taking care to give the liquor a very ſmall exceſs of the acid, you may obtain from this mixture by filtrating and cooling it a very copious precipitate in ſmall bright ſcales. This precipitate is boracic acid, and by waſhing it in diſtilled water, and drying it in the air, it is rendered very pure. By evaporating the ſolution thus prepared and leaving it to cool, we obtain from time to time new quantities of boracic acid. At laſt, the product is ſulphate of ſoda, formed by the union

nion of the ſulphuric acid made uſe of on the occaſion with the alkaline baſe of borax.

The nitric and the muriatic acids decompoſe borax of ſoda in the ſame manner, becauſe they, as well as the ſulphuric acid, have more affinity with ſoda than the boracic acid has. The laſt evaporations of theſe mixtures afford nitrate or muriate of ſoda. The diſcovery of the boracic acid ſeems to belong to Beccher, but has been uſually aſcribed to Homberg, he having, in the Memoirs of the Academy for the year 1702, given the firſt accurate deſcription of a proceſs for obtaining it. That chemiſt obſerved this ſalt to be ſublimated in the diſtillation of a mixture of ſulphate of calcined iron with borax of ſoda and water. Imagining the firſt of theſe matters to contribute greatly to its formation, he gave it the name of *narcotic volatile ſalt of vitriol.* Lewis Lemery, eldeſt ſon to the famous Nichola Lemery, made many experiments on borax of ſoda, and diſcovered in the year 1728, that the boracic acid, then called *ſedative ſalt*, might be obtained from it by means of the pure ſulphuric acid, and that the muriatic and the nitric acids likewiſe ſeparated it; but ſublimation was the proceſs which he always uſed. We are indebted to Geoffrey the younger for the firſt complete analyſis of borax. In the year 1732, he proved that the boracic acid might be obtained by evaporation and cryſtallization; and by examining the reſidue which remained after theſe operations, found ſoda to be one of the principles of borax.

Baron's experiments on this ſalt, which were laid before the academy in the years 1745 and 1748, added two important facts to theſe diſcoveries. The firſt, that vegetable as well as mineral acids decompoſed borax of ſoda. The ſecond, that genuine borax may be be formed by uniting the boracic acid with ſoda. The laſt of theſe facts proves that the acid is entirely formed in the ſalt, and that its formation is in no degree owing to the acids employed to decompoſe the ſalt.

The fluoric, and even the carbonic acid though one of the weakeſt, appears to be capable of decompoſing borate of ſoda, and ſeparating the boracic acid. This laſt acid unites readily with borax of ſoda, its alkaline baſe requiring to be fully ſaturated with rather more of the boracic acid than a quantity equal to the whole weight of the borax. Bergman is even of opinion that this ſalt is not fully ſaturated nor properly neutral, and that alkaline properties ſtill continue to predominate in it till ſuch time as it receives this additional quantity of boracic acid. The properties of this neutral ſalt, when thus ſaturated, have not as yet been particularly examined.

None of the alkaline neutral ſalts, whether ſulphuric, nitric, or muriatic, acts in any manner on borax of ſoda.

This ſalt acquires a reddiſh colour when melted with combuſtible matters, ſuch as charcoal; but we know not yet what alteration it ſuffers from thoſe matters.

Borax is of great utility in many of the arts. In glaſs-making, and the aſſaying of metals, it is uſed as an excellent flux. It is uſed in ſoldering metals to make the mixture run, which is deſigned for the ſolder; and it at the ſame time ſoftens the ſurfaces of the metals to be united, and defends them from being calcined by the action of the air. It was formerly much uſed in medicine, but is now gone quite out of uſe.

Species VIII. *Borate of Potaſh.*

We give the name of *borate of potaſh* to the combination of the boracic acid with potaſh. It is well known that theſe two ſaline ſubſtances readily unite, and that from their union there reſults a neutral ſalt, reſembling borax of ſoda. Of this kind is the reſidue of nitre of potaſh, decompoſed by the boracic acid. M. Baumé ſays, that this reſidue appears in the form of a white half-melted maſs, which when diſſolved in water affords ſmall cryſtals. Borate of potaſh is therefore fuſible, ſoluble, and ſuſceptible of cryſtallization, and pure acids decompoſe it as well as borate of ſoda. We know nothing more certain of this ſalt; it ſhould be examined in the ſame manner as borate of ſoda. Baron knew the poſſibility of producing this ſalt by a direct combination of the boracic acid with potaſh; he has even diſtinguiſhed it accurately from common borax, or borax with a baſe of ſoda; but not a word has he ſaid concerning the peculiar properties of borax of potaſh.

Species IX. *Fluate of Soda.*

According to the ſyſtem of nomenclature to which we have conformed from the beginning of this work hitherto, the name *fluate of ſoda* denotes the combination of the fluoric acid with potaſh. This neutral ſalt has, as yet, undergone but a very ſlight examination—by Meſſrs Scheele and Boullanger. According to thoſe two chemiſts, it always appears in a gelatinous form, and is never cryſtallized. According to Scheele, it it becomes, when dried and melted, acrid, cauſtic, and gelatinous. He compares it in that ſtate to liquor of flints. It appears that fire diſengages the fluoric acid; and that the ſiliceous earth with which it is always impregnated during its preparation, then melts into a ſoluble glaſs with the help of the potaſh.

Fluate of potaſh diſſolves very readily in water. It always retains ſo large a proportion of that fluid, that it is impoſſible to make it aſſume a cryſtalline form. When it is well ſaturated, a ſolution of it produces no alteration on ſyrup of violets.

We know not in what manner either ſiliceous, argillaceous, or barytic earth or magneſia, affects this ſalt.

According to Scheele and Bergman, lime has more affinity than potaſh with the fluoric acid. Throw fluate of potaſh into lime-water it is inſtantly decompoſed: lime unites with the fluoric acid, forming an inſoluble ſalt, which takes away the purity of the liquor, and is fluate of lime. We ſhall afterwards ſee that lime likewiſe decompoſes neutral ſalts formed of the carbonic acid with fixed alkalis. We have already ſeen that lime-water precipitates borax of ſoda; therefore the fluoric is not the only acid which has a greater affinity with that ſalino-terreous ſubſtance than with the fixed alkalis.

The concentrated ſulphuric acid decompoſes fluate of potaſh by diſengaging its acid; which, according to M. Boullanger, appears in the white vaporous form, and exhales the odour peculiar to the muriatic acid. When this experiment is made in an apparatus proper for diſtillation, we obtain the fluoric acid, juſt as we obtain the acids contained in nitre of potaſh, and muriate of ſoda when we decompoſe them with the ſulphuric acid.

No inquiry has hitherto been made concerning the action of the nitric and the muriatic acids, or of the known neutral ſalts, on fluate of potaſh. This ſalt is in other reſpects little known, and is applied to no uſe.

Species X. *Fluate of Soda.*

This is a proper enough denomination for the neutral ſalt formed by the ſaturated combination of the fluoric acid with ſoda. This, like the foregoing ſalt, has been but very little examined. Nobody but Meſſrs Scheele and Boullanger has ſaid any thing about it; and they differ in their opinions, as we are juſt going to ſee.

Scheele aſſerts, that a combination of ſoda with the fluoric acid forms a jelly like the preceding ſalt. Boullanger, on the contrary, ſays, that the combination affords very ſmall, hard, brittle cryſtals, of an oblong ſquare figure, a bitter taſte, and ſomewhat ſtiptic. This ſalt decrepitates on burning coals like muriate of ſoda; it diſſolves in water, but not readily.

Lime-water decompoſes this ſalt as well as fluate of potaſh. . The ſulphuric diſengages the fluoric acid from this ſalt with effervefcence, cauſing it to riſe, like the muriatic acid, in a white vapour ofa pungent ſmell.

From this ſhort account of this ſalt, the reader may perceive that it is not better known than the laſt.

Species XI. *Carbonate of Potaſh.*

The laſt two neutral ſalts which we have to examine, are combinations of the carbonic acid with fixed alkalis.

Theſe ſubſtances were never before reckoned among the neutral ſalts: but we ſhall immediately ſee that they are true neutral ſalts.

What we call *carbonate of potaſh*, is a neutral ſalt reſulting from a ſaturated combination of carbonic acid with potaſh. Some modern chemiſts call it *mephitic tartar*, aerated *vegetable alkali, &c.* This ſaline ſubſtance was always taken for pure alkali, till Dr Black's experiments ſhowed it to be a neutral ſalt. Its old name was *fixed ſalt of tartar*, becauſe it was obtained by the incineration of tartar of wine. It was conſidered as an alkali, becauſe it poſſeſſes ſome of the properties of thoſe ſalts. It does indeed convert ſyrup of violets to a green colour; but borax and ſeveral other neutral ſalts poſſeſs the ſame property: beſides, it neither deſtroys nor weakens the colour of violets like potaſh. It has an alkaline taſte; but the ſame is diſtinguiſhable in borax: only it was diſtinguiſhed from alkali of ſoda by its power of attracting the moiſture of the air with great rapidity, and its not being ſuſceptible of cryſtallization. When thus moiſtened in the air, it received the name of *oil of tartar per deliquium**. But fixed ſalt of tartar poſſeſſes theſe two properties only becauſe it is not a perfect neutral ſalt. Containing ſtill a certain quantity of potaſh not ſaturated with carbonic acid, this exceſs of alkali renders it deliqueſcent. At preſent, this ſalt is obtained in a ſtate in which

---

* Bohnius relates, that evaporating oil of tartar ſlowly, by a moderate heat, he obtained, under a ſaline pellicle, beautiful cryſtals, which, though expoſed to various temperatures, remained ſix years unaltered (*Diſſert. Phyſico-Chem.* 1666.) M. Montet, a celebrated chemiſt of Montpelier, who was certainly unacquainted with Bohnius's diſcovery, has invented a proceſs for cryſtallizing this fixed ſalt of tartar. Academ. des, &c. 1764, p. 576.

which it is very ſuſceptible of cryſtallization, and attracts no moiſture, but rather effloreſces. The Duke de Chaulne, who has paid much attention to this object, prepares this ſalt by expoſing a ſolution of potaſh, either cauſtic or containing a little of the carbonic acid, in a place full of that gaſeous acid, as in the upper part of a barrel of beer when it is fermenting. The alkali ſeizes as much of the carbonic acid as it can abſorb, and is regularly cryſtallized. Its cryſtals are quadrangular priſms, terminating in very ſhort pyramids with four faces.

Carbonate of potaſh has an urinous taſte, but much weaker than that of the cauſtic vegetable alkali; for in medicine it is given as a diſcuſſive in doſes of ſeveral grains. This neutral ſalt is very ſubject to alteration from fire; it melts eaſily, and is pretty quickly reduced to an alkali. If it be diſtilled in a retort with a receiver, and a pneumato-chemical apparatus with mercury fitted to it, the products obtained are, the water of its cryſtallization, and its acid in an aeriform ſtate. The potaſh, after this operation, remains in an irregular maſs, ſtill retaining, however, a ſmall portion of the acid, which cannot without the greateſt difficulty be extracted from it by fire. According to Bergman's analyſis of it, carbonate of potaſh, when ſaturated with the acid, and regularly cryſtallized, to which he gives the name of *aerated vegetable alkali*, contains in the quintal twenty parts of the acid, forty-eight of pure alkali, and thirty-two of water. But it is to be obſerved, that carbonates are more liable than other neutral ſalts to vary in the quantity of the acid. Yet, as this ſalt never furniſhes regular cryſtals but when it is fully ſaturated, Bergman's calculation deſerves to be conſidered as ſufficiently accurate.

Carbonate of potaſh, when fully cryſtallized, ſuffers no alteration from air; its cryſtals neither deliquiate nor effloreſce, but remain tranſparent. This ſalt, when ſo pure as to poſſeſs this property, being of uſe in many experiments, it may be proper to let the reader know that it is prepared in the following manner: By expoſing a lixivium of common potaſh, very pure and white, and ſeparated from the ſulphate of potaſh which it uſually contains, in a ſhallow diſh, in the upper part of a beer barrel; and the proceſs is the ſooner completed, if the potaſh be continually ſtirred or poured out of one veſſel into another; and if it be thus kept in contact with the carbonic acid produced by fermentation, till ſuch time as it depoſite beautiful cryſtals of carbonate of potaſh.

This ſalt diſſolves readily in four parts of cold water, and a rather ſmaller quantity of warm water will maintain it in ſolution; it produces cold as it unites with that fluid. That property which diſtinguiſhes neutral from ſimple ſalts ſufficiently determines the difference between carbonate of potaſh and pure or cauſtic potaſh. It is cryſtallized by evaporation and cooling conjunctly. When the ſolution is too much concentrated, it takes the form of an irregular maſs,—which often happens in the laboratories.

This ſalt, as well as potaſh, ſerves as a flux to vitrifiable earths; becauſe fire reduces it to an alkali by expelling the carbonic acid. Beſides, when this ſalt, with a mixture of ſand, is violently heated in a crucible, a lively efferveſcence may be obſerved at the inſtant of vitrification; and that efferveſcence is owing to the diſengagement of the carbonic acid. This fact ſhows that ſiliceous earth cannot enter into combination with an alkali ſaturated with this acid, and that the

the acid eſcapes when the vitreous combination takes place. This effervеſcence attends ſo invariably the combination of theſe two ſubſtances, that Bergman propoſes to try ſiliceous earth by means of the blowpipe, with carbonate of potaſh, as no other earth exhibits the ſame phænomenon when heated with this ſalt.

Clay does not act at all on carbonate of potaſh; but the ſalt reduces that earth to a vitreous frit, though not quite ſo eaſily as cauſtic potaſh. Barytes deprives this ſalt of the carbonic acid.

Lime likewiſe decompoſes it, having a greater affinity than potaſh with the acid. Lime-water poured into a ſolution of carbonate of potaſh, gives a precipitate of an almoſt inſoluble ſalt, produced by the combination of lime with the carbonic acids; and the pure or cauſtic alkali remains diſſolved in the water. In pharmacy, this proceſs is made uſe of for the preparation of the *lapis cauſticus*, which is nothing but fixed vegetable alkali rendered cauſtic by lime. Modern diſcoveries have ſhown, that Lemery's proceſs for preparing the *lapis cauſticus*, though followed by many pharmacopœiæ, is very defective. It conſiſts in mixing two pounds of aſhes obtained by the combuſtion of the huſks of grapes with lees of wine *, with a pound of quicklime, immerſing the mixture into ſixteen pounds of water, filtering it, evaporating this lixivium in a copper veſſel, melting the reſidue in a crucible, and pouring it out upon a plain ſurface. The product obtained by this operation is merely a dirty alkali not very cauſtic, and containing copper.

Bucquet,

---

* Thoſe aſhes contain a great deal of vegetable alkali or carbonate and ſulphate of potaſh. A.

Bucquet, ſenſible of the diſadvantages of this proceſs, has given one, more tedious and expenſive indeed, but much more certain and advantageous, eſpecially for preparing very pure potaſh, which is ſo neceſſary in chemical experiments. Take two pounds of very ſtrong quicklime; pour a little water upon it to reduce it to powder; add a pound of fixed ſalt of tartar, and pour upon it as much water as may be ſufficient to form it into a paſte: When this mixture becomes cool, add to it water to the quantity of ſixteen pints, and put the whole into a linen cloth lined with paper; about twelve pints of a clear liquor will paſs through this ſtrainer, and the remainder is to be waſhed with four pints of boiling water to take away all the alkali. This liquor gives no effervescence with acids: but the beſt teſt for trying its cauſticity is to obſerve whether it clouds lime-water; for if it contain the ſmalleſt portion of carbonic acid, it will infallibly produce that effect. But as, after this firſt proceſs, it ſtill gives a precipitate with lime-water, when very pure alkali is wanted for nice experiments, the lixivium may be treated with two additional pounds of quicklime. It then paſſes very clear through the ſtrainer, and becomes ſo cauſtic as not to alter the tranſparency of lime-water. When the alkali is evaporated by fire in the open air, that ſalt abſorbs the carbonic acid contained in the atmoſphere; therefore, to obtain it in a dry form, and very pure, we muſt evaporate the liquor in a retort. But this very tedious proceſs is not neceſſary for producing the *lapis cauſticus;* for if alkali be of ſuch ſtrength as to corrode the ſurface of the ſkin, it is ſufficient for the purpoſes of that preparation. But as dry ſolid potaſh, in a ſtate of high purity, is neceſſary in many experiments, I muſt here obſerve, that the cauſtic alkaline lixivium muſt be evaporated in cloſe veſſels, and that the fire muſt be very cautiouſly managed, becauſe the evaporation is attended with conſiderable difficulty, in regard to the denſity which the liquor aſſumes towards the end of the proceſs. The fixed alkali is very white, and does not effervеſce with acids, nor deſtroy the purity of lime-water.

Magneſia does not act on carbonate of potaſh; for the carbonic acid has a greater affinity with fixed vegetable alkali than with that ſalino-terreous ſubſtance.

The ſulphuric, the nitric, the muriatic, and the fluoric acids, decompoſe carbonate of potaſh by combining with the fixed alkali, and ſeparating the carbonic acid with effervеſcence. The acid may be collected under water or mercury. It is diſtinguiſhable by the four following characteriſtics: it is more ponderous than air; it extinguiſhes lights; reddens tincture of turnſol; and precipitates lime water.

The boracic acid ſeems incapable of ſeparating the acid from carbonate of potaſh cold; but when hot, it effects it with great eaſe.

The neutral ſalts which we have examined neither ſuffer any alteration from carbonate of potaſh, nor produce any ſuch effect upon it.

This ſalt abounds in nature. It is often found in vegetables, completely formed, and is conſtantly obtained by the incineration of thoſe organic bodies; as we ſhall have occaſion to ſhow when we come to ſpeak of the vegetable kingdom. Burnt tartar affords it in the greateſt abundance. It is alſo prepared by the detonation of nitre of potaſh.

Carbonate of potaſh is much uſed in the arts. In medicine, it is adminiſtered as an aperient and diſcuſſive, in obſtructions of the meſentery and the urinary paſſages. It is always given in ſmall doſes, and along with ſome ſubſtance of efficacy to moderate its action.

Species XII. *Carbonate of Soda.*

This ſalt, like the foregoing, was formerly thought an alkali. It is, however, a combination of the carbonic acid with mineral alkali. This ſeems to be the ſalt which the ancients called *natrum.* It is uſually called *ſalt of ſoda,* becauſe it may be obtained pure and regularly cryſtallized by evaporating a lixivium of common ſoda. Marine alkali is likewiſe diſtinguiſhed from vegetable fixed alkali, by its being ſuſceptible of cryſtallization and efflореſcence, which is owing to its being completely ſaturated with carbonic acid in its ordinary ſtate.

Carbonate of ſoda has an alkaline taſte; it communicates a green colour to ſyrup of violets, but does not, like cauſtic ſoda, finally alter its colour. Its taſte is urinous, but not burning, and much weaker than that of pure marine alkali.

This ſalt is naturally purer than carbonate of potaſh, and has been long known to be ſuſceptible of cryſtallization; a property which may be conſidered as forming a general diſtinction between neutral and ſimple ſalts. Its cryſtallized form is owing to its containing almoſt always the quantity of carbonic acid neceſſary to its ſaturation and cryſtallization.

This ſalt, when haſtily cryſtallized, exhibits rhomboidal plates, diſpoſed obliquely one over another, like tiles on the roof of a houſe. When ſlowly cryſtallized, it aſſumes the form of rhomboidal octohædrons, with pyramids

pyramids truncated near the baſe, or ſolid decahædrons, with two acute and two obtuſe angles.

This ſalt generally melts eaſier than carbonate of potaſh; for which reaſon it is uſed in preference to it in the glaſs-houſes. It loſes moſt part of its acid by heat, but ſtill retains a little. Bergman has found, by an exact analyſis, that an hundred parts of carbonate of ſoda, which he calls *aerated mineral alkali*, contain ſixteen parts of the acid, twenty of pure alkali, and ſixty-four of water:—ſo that more of the acid is requiſite to ſaturate ſoda than to ſaturate potaſh; and the cryſtals of the former retain juſt twice as much water as thoſe of the latter. It is to this extraordinary quantity of water that carbonate of ſoda owes its cryſtallizing with ſuch facility and regularity, as well as its property of eﬄoreſcing.

Carbonate of ſoda is more ſoluble than carbonate of potaſh. It diſſolves in two parts of cold or one of boiling water. It cryſtallizes by cooling, but gives much more regular cryſtals by ſlow evaporation.

When this ſalt is expoſed to the air, it crumbles down very readily into duſt; for the air deprives it of the water of its cryſtallization: But it is not altered by this eﬄoreſcence; for we can reſtore to it its primary form by ſolution in water.

It contributes greatly to the fuſion of vitrifiable earths, and forms with them a glaſs leſs liable to alteration than that which is in part compoſed of carbonate of potaſh, to which it is for that reaſon preferred in the glaſs-houſes. It has been obſerved, that when ſand unites with this ſalt, it eſcapes with a very obſervable effervescence, agreeably to what we have remarked of carbonate of potaſh. It has no more influence on clay than the laſt ſalt.

Barytes, as well as quicklime and lime-water, decompoſes carbonate of ſoda in the ſame manner as carbonate of potaſh, and ſeparates the pure cauſtic mineral alkali. A ſolution of this ſalt poured into lime-water produces a precipitate; an effect which is never produced by cauſtic ſoda. When pure cauſtic ſoda is wanted for nice chemical experiments, recourſe muſt be had to the ſame proceſs which we deſcribed above for preparing the *lapis cauſticus*.

Carbonate of ſoda, as well as carbonate of potaſh, may be decompoſed by the ſulphuric, the nitric, and the muriatic acids, &c. The carbonic acid may be obtained from it by collecting it into a glaſs filled with water or mercury.

In Egypt, this ſalt is found entirely formed at the ſurface of the earth, as well as in ſeveral other places. It is likewiſe found in the aſhes of ſea-weeds, but not completely ſaturated with the acid. To render it more perfectly neutral, it muſt be directly combined with the cretaceous acid, either by ſhaking it over ſome liquor in a ſtate of fermentation, or by receiving into a ſolution of it a portion of the carbonic acid, ſeparated from chalk by the ſulphuric acid. It may be alſo produced by wetting the ſides of a veſſel with a ſolution of ſoda, and then pouring into the veſſel a quantity of carbonic acid: the mouth of this veſſel is then to be covered with a wet bladder; and at the end of a few hours, the combination is found to be effected,—for the bladder is emptied by the abſorption of the carbonic acid, and the ſides of the veſſel are covered with the ſalt in regular cryſtals.

Carbonate of ſoda may be applied to the ſame purpoſes with carbonate of potaſh. It is much more uſed in ſoap and glaſs manufactories, &c. &c. We ſhould therefore

therefore endeavour to procure it in greater quantities, and to extract it in the great way from muriate of ſoda. We have ſeen that litharge, which ſome chemiſts pretend to be adequate to this effect, does not properly decompoſe that ſalt. We have alſo taken notice of Scheele's having diſcovered a more entire decompoſition of muriate of ſoda, effected by quicklime and iron, with the help of atmoſpheric air, and the carbonic acid which it contains. We ſee that a greater proportion of this acid than what uſually exiſts in the atmoſphere, is requiſite to promote this decompoſition by exerting its attractive force on the ſoda.

CHAP. VI.

Genus II. *Imperfect Neutral Salts, with a Baſe of Ammoniac, or Ammoniacal Salts.*

AMMONIACAL ſalts are formed by the combination of an acid with volatile alkali, or ammoniac. Their taſte is generally urinous: all of them are more or leſs volatile, and eaſier of decompoſition than perfect neutral ſalts. We know of ſix kinds or ſpecies of ammoniacal ſalts:—ammoniacal ſulphate; ammoniacal nitrate; ammoniacal muriate, or ſal ammoniac properly ſo called; ammoniacal borate; ammoniacal fluate; and ammoniacal carbonate.

Species I. *Ammoniacal Sulphate.*

AMMONIACAL ſulphate, formerly called *ammoniacal vitriolic ſalt*, or *ammoniacal vitriol*, reſults from a ſaturated combination of the ſulphuric acid with ammoniac. It is called *ſecret ammoniacal ſalt of Glauber*, becauſe that chemiſt was the firſt who diſcovered it.

This

This ſalt, when very pure, appears under the form of needles, which when carefully examined are found to be flattened priſms of ſix faces, two of them very large, and terminating in ſix-ſided pyramids more or leſs irregular: but this form varies almoſt always either more or leſs from what we have deſcribed. Sometimes this ſalt appears in quadrangular priſms; and I have often obtained it in very thin ſquare plates. Its form, as in other inſtances of cryſtallization, ſeems to depend on the manner in which the cryſtalline laminæ are depoſited; which is either on their largeſt faces, their edges, or their angles.

The taſte of this ſalt is bitter and urinous; it is pretty light, and very friable.

As it contains, in cryſtals, a good deal of water, even a moderate fire inſtantly liquefies it; but it becomes gradually dry, in proportion as the water which it contained is evaporated. When brought to that ſtate, it melts, according to M. Bucquet, as it begins to become red-hot, without volatilizing; but M. Baumé ſays that it is partly volatile. On repeating this experiment, I obſerved that part of this ſalt is actually ſublimated, but part remains fixed in the veſſels. M. Bucquet is certainly to be underſtood as ſpeaking of this laſt part.

Ammoniacal ſulphate ſuffers ſcarce any alteration from air. It does not effloreſce like ſulphate of ſoda, but rather attracts moiſture.

It diſſolves very readily in water: two parts of cold water diſſolve one of this ſalt; and boiling water diſſolves a quantity equal to its own weight. It cryſtallizes by cooling; but the fineſt cryſtals which it affords are obtained by inſenſible and ſpontaneous evaporation. It combines alſo with ice, which it cauſes to melt with a conſiderable cold. It acts not at all on either aluminous or ſiliceous earth. Magneſia decompoſes it in part, eſpecially if time be allowed it to act, as Bergman has obſerved.

Lime, barytes, and the pure fixed alkalis diſengage the ammoniac from this ſalt; and we ſhall find the caſe to be the ſame with regard to ammoniacal muriate. When carbonate of potaſh or ſoda is diſtilled with ammoniacal ſulphate, a double decompoſition and combination take place. The ſulphuric acid combining with fixed alkali, forms ſulphate of ſoda or potaſh, according to the nature of the alkali; and the carbonic acid which is diſengaged, being volatilized at the ſame time with the alkaline gas or ammoniac, theſe two bodies unite, forming a peculiar ammoniacal ſalt, which is cryſtallized in the receiver. We will conſider this point more at large under the hiſtory of the Ammoniacal Muriate.

The nitric and the muriatic acids ſeparate part of the ſulphuric acid from ammoniacal ſulphate; acting upon it juſt as upon ſulphate of potaſh and ſoda.

This ſalt has never yet been found among the products of nature. Yet M. Romé de Lille in his Eſſay on Cryſtallography, 1772, page 57, informs us, that, in M. Sage's opinion, the ammoniac ſalt produced from volcanoes is of this kind. Art produces it by a direct combination of the ſulphuric acid with ammoniac, by decompoſing earthy or metallic ſalts with volatile alkali, or laſtly, by decompoſing nitric, muriatic, and carbonic ammoniacal ſalts with ſulphuric acid.

Ammoniacal ſulphate is applied to no uſe; though Glauber has recommended it ſtrongly for metallurgic operations.

Species II. *Ammoniacal Nitrate.*

Ammoniacal nitrate, or *nitrous ammoniacal ſalt*, is, like the foregoing ſalt, a product of art. It is prepared by a direct combination of the nitric acid with ammoniac. Its cryſtals are priſms; but the number and the diſpoſition of their faces are not well known. M. Romé de Lille ſays, that it ſometimes cryſtallizes in beautiful needles pretty ſimilar to thoſe of ſulphate of potaſh. But its needles are long and ſtriated, and reſemble thoſe of common nitre much more than ſulphate of potaſh. The taſte of this ſalt is bitter, pungent, ſomewhat freſh and urinous. It is equally friable with ammoniacal ſulphate. It liquefies when expoſed to the action of fire; exhales aqueous vapours, becomes dry, and long before being red-hot detonizes of itſelf, without being in contact with any combuſtible matter, and even in cloſe veſſels. In the firſt edition of this work it was obſerved, that this ſingular property appeared to depend on the ammoniac, becauſe the alkaline gas ſeems to have ſomething combuſtible in its nature, and increaſes before extinguiſhing the flame of a taper. M. Barthollet having expoſed a quantity of ammoniacal nitre to the action of fire in a diſtillatory and pneumato-chemical apparatus, and having obſerved the phænomena which it then exhibited with peculiar attention, diſcovered that it is not a true detonation which takes place on that occaſion, but a rapid decompoſition, by which part of the volatile alkali or ammoniac is entirely deſtroyed: the water obtained in the receiver contains a little nitric acid, proportioned to the quantity of the ammoniac decompoſed; and the latter gives out azotic gas, or atmoſpheric mephitis. On weighing the

the liquid product of this operation, the quantity of water is found to be greater than what the ammoniacal nitre was known to contain; and M. Berthollet thinks this increaſe of the water to be owing to the combination of the hydrogene of the ammoniac with the oxigene of the nitric acid. The azotic, the other principle of this ſalt, which contains ſix parts of it for one of hydrogene, eſcapes, and is collected under the glaſſes of the pneumatic-machine, in the form of azotic gas.

It is not known whether this ſalt be fuſible; for its firſt liquefaction is owing to the water of its cryſtallization, and it is diſſipated before it can undergo a ſecond.

We are equally ignorant with regard to its volatility: we can form no judgment of it; for, before it can be ſublimated, it ſwells and is decompoſed.

It feebly attracts the moiſture of the air; its cryſtals agglutinate, and form a kind of clods.

It diſſolves very readily in water; it combines with ice, and melts it, producing at the ſame time a conſiderable cold. It diſſolves more readily in warm than in cold water: no more than half a part of the former is requiſite to maintain it in ſolution, and it cryſtallizes by cooling, but irregularly. To obtain this ſalt in regular cryſtals, recourſe muſt be had to ſpontaneous or inſenſible evaporation.

Ammoniacal nitrate is decompoſed by barytes, lime, and the alkalis, in the ſame manner as ammoniacal ſulphate. As the alkaline gas ſeparated by theſe cauſtic ſubſtances is very volatile and expanſive, ammoniacal nitrate, as well as the other neutral ſalts of the ſame genus, may be decompoſed cold by trituration with lime. But when this decompoſition is attempted by fire in cloſe veſſels, the heat muſt be very cautiouſly managed, to prevent it from catching fire.

The ſulphuric diſengages the nitric acid from this ſalt with effervefcence, and combines with its baſe to form ammoniacal ſulphate.

Carbonate of potaſh or ſoda decompoſes it, and is in its turn decompoſed by it. In theſe operations, ammoniac is ſublimated in a concrete form: the ſublimate we are afterwards to examine under the name of *ammoniacal carbonate.*

Ammoniacal nitre is not applied to any uſe.

Species III. *Ammoniacal Muriate*, or *Sal Ammoniac.*

AMMONIACAL muriate, or the ſaturated combination of the muriatic acid with ammoniac, was called by the ancients *ſal ammoniac*; becauſe it was procured from Ammonia, a country in Libya, in which ſtood the temple of Jupiter Ammon.

This ſalt is found in places adjacent to volcanoes. It appears in the form of an efflorefcence, or groupes of needles, ſeparate, or compacted together, generally of a yellow or red colour, and mixed with arſenic and orpiment: but no uſe is made of that which is procured in this way. The *ſal ammoniac* employed in the arts, is prepared by a proceſs which we are juſt about to deſcribe.

The real origin of this factitious ſalt was unknown till the beginning of the preſent century, tho' it had been made uſe of in many of the arts from time immemorial. M. Lemere, conſul at Cairo, in a letter to the

the academy, dated 24th June 1719, firſt informed us how ſal ammoniac is obtained from the ſoot of camels dung, which is burnt at Cairo inſtead of wood.

This ſoot is put into large round bottles a foot and an half in diameter, and terminating in a neck two inches long. Theſe bottles are filled up with this matter till within four inches of the neck. Each bottle holds about forty pounds of ſoot, and affords nearly ſix pounds of ſalt. Theſe veſſels are put into a furnace in the form of an oven, ſo that only the necks appear above. A fire of camel's dung is kindled beneath it, and continued for three days and three nights. On the ſecond and the third day the ſalt is ſublimated. The bottles are then broken, and the ſalt taken out in cakes. Theſe cakes, which are ſent us juſt as they have been taken out of the bottles in Egypt, are convex, and unequal on the one ſide; on the middle of that ſide they exhibit, each a tubercle correſponding to the neck of the bottle in which it was prepared. The lower ſide is concave; and both are ſooty.

Pomet makes mention of a *ſal ammoniac*, procured by the way of Holland, in truncated cakes reſembling ſugar loaves. Geoffrey, who was the firſt in France that diſcovered from what materials this ſalt is obtained, and who even gueſſed ſucceſsfully at the proceſs employed in Cairo for preparing it, found out that this ſecond ſpecies of ſalt comes from the Indies, where it is prepared in much greater quantities than in Egypt by the ſame proceſs of ſublimation, but in a different form. Theſe Indian loaves conſiſt of fourteen or fifteen pounds each, are hollow at the bottom, and formed of various layers. The cone is truncated, becauſe its extremity, being impure, is always broken off.

M. Baumé has eſtabliſhed, in the neighbourhood of Paris,

Paris, a manufactory of ammoniacal ſalt; in which this ſalt is compoſed, not extracted as in Egypt. M. Baumé's ſalt is likewiſe purer than the Egyptian *.

Ammoniacal muriate has a poignant, acrid, and urinous taſte. Its cryſtals are in the form of long hexahædral pyramids: a number of them are ſometimes united together in an acute angular direction, ſo as to exhibit the form of feathers. M. Romé de Lille thinks the cryſtals of ammoniacal muriate to be octohædrons bundled together. This ſalt is ſometimes, but not frequently, found in cubic cryſtals in the middle of the concave hollow part of the ſublimated cakes.

This ſalt poſſeſſes one pretty ſingular phyſical property; a kind of ductility or elaſticity, which cauſes it to yield under the hammer, or even the fingers, and makes it difficult to reduce it to a powder.

Ammoniacal muriate is totally volatile; but a very ſtrong fire is requiſite to ſublimate it. This method is applied when it is wanted very pure and entirely free of water. It is reduced to powder, put into a matras, and the veſſel is then immerſed half way into a ſand-bath, where it is gradually heated for ſeveral hours. By this means we obtain a maſs conſiſting of ſtriated needles, joined to each other longitudinally. When this

---

* In Britain ſal ammoniac is likewiſe prepared in great quantities. The volatile alkali is obtained from ſoot, bones, and other ſubſtances known to contain it. To this the vitriolic acid is added; and this vitriolic ammoniac is decompoſed by common ſalt by a double affinity. The liquor obtained in conſequence of this decompoſition contains ſulphate of ſoda and ſal ammoniac. The firſt is cryſtallized, and the ſecond ſublimated ſo as to form cakes, which are then expoſed to ſale. Lord Dundonald, by an ingenious proceſs, extracts ammoniac from pit-coal.

this operation is properly conducted, very regular cubic-cryſtals are often found in the midſt of the loaves. But if too ſtrong a heat has been applied, the product is only a ſhapeleſs thick and ſemi-tranſparent maſs, with the appearance of having been melted.

M. Baumé has obſerved, that by repeated ſublimations of this ſalt, a ſmall quantity both of ammoniac and of the muriatic acid is at length diſengaged; ſo that, according to that chemiſt, ammoniacal muriate might perhaps be decompoſed by continued ſublimation. This fact requires confirmation.

Ammoniacal muriate is liable to no alteration from air; it may be kept for a long time without ſuffering any change.

It diſſolves very readily in water. Six parts of cold water are ſufficient to diſſolve one of this ſalt. A conſiderable cold is produced as the ſolution takes place, and that cold is ſtill keener when the ſalt is mixed with ice. This artificial cold is happily applied to produce ſeveral phænomena which could not otherwiſe take place, ſuch as the congelation of water on certain occaſions, the cryſtallization of certain ſalts, the fixation and preſervation of certain liquids, naturally very ſubject to evaporation, &c.

Boiling water diſſolves a quantity of ammoniac, nearly equal to itſelf in weight. This ſalt may be cryſtallized by cooling; but, like other ſalts, it gives the moſt regular cryſtals by ſlow or ſpontaneous evaporation. A ſtrong ſolution of this ſalt when incloſed in a flaſk, often depoſites at the end of a few days bundles of cryſtals, conſiſting of an horizontal thread, with others united to it in a perpendicular direction; and theſe again ſupporting others; ſo that the whole together diſplays a very natural imitation of vegetation. I have ſeveral times obſerved this phænomenon in my own laboratory *.

Aluminous earth does not decompoſe ammoniacal muriate. Magneſia decompoſes it, but with great difficulty, and only in part, as Bergman has obſerved. If a mixture of magneſia and a ſolution of ammoniacal muriate be put into a phial, at the end of a few hours, as the celebrated chemiſt of Upſal has obſerved, there is diſengaged a quantity of ammoniac vapours; but this phænomenon ſoon ceaſes, and but a very little of the ſalt is decompoſed.

Both lime and barytes ſeparate ammoniac from the muriatic acid even cold. The ammoniac gas is inſtantly volatilized, if this ſalt be but triturated with quick-lime; and its ſmell makes a lively impreſſion on the nerves. When this experiment is performed in cloſe veſſels, the ammoniac may be collected in water, either in a gaſeous ſtate or diſſolved. As no author has given a particular explanation of the method of performing this operation, though modern improvements have rendered it both accurate and certain, we think ourſelves obliged to give a full deſcription of it in this place.

A

---

* Every chemiſt knows of what advantage it is to examine from time to time products preſerved in a laboratory, more eſpecially ſolutions of ſalts. When chance offers any curious facts to our obſervation, we ought always to note them down, that we may not loſe what may be afterwards found of high importance. Thus have I many times ſeen cryſtals formed which I could not obtain by evaporation. It happens too, that when phials are moved or uncorked, cryſtals are ſoon after depoſited; for motion and the contact of the air are highly favourable to the production of theſe. This note, though unneceſſary to thoſe who have been long employed in chemical purſuits, may be of uſe to thoſe who are juſt beginning to engage in ſuch ſtudies.

A mixture of ſtrong quicklime and very dry ammoniacal muriate heated in a retort, with its extremity immerſed into a bell-glaſs full of mercury, affords a large quantity of alkaline gas or ammoniac. It is now known why ſcarce any product is obtained, and the operator is expoſed to danger from the breaking of the veſſels, when ſuch a mixture is diſtilled in balloons without a pneumato-chemical apparatus. Theſe circumſtances ariſe from the rarefaction of the mixture, and the quantity of the ammoniac gas diſengaged. M. Baumé, having himſelf experienced part of thoſe inconveniences, gives it as his advice to put water into the retort. This fluid abſorbs and carries off part of the gas; but as the gas is much more volatile than water, a great part of it is always loſt. Chemiſts who are now acquainted with the ſtrong affinity between ammoniac gas and water, and with the amazing volatility of the gas, employ Mr Woulfe's apparatus very ſucceſsfully in performing this operation. This ingenious proceſs conſiſts in fitting to a balloon with two necks an empty bottle, and joining to it two or four collateral bottles connected by ſyphons. Quicklime and dry powdered ammoniacal muriate are put into a ſtone retort, which is meant to be luted to the balloon: a moderate heat is then cautiouſly applied till the bottom become red-hot, and even begin to vitrify. The ammoniac gas being diſengaged by the lime, paſſes into the balloon and the bottles, unites with the water with heat, and forms in the firſt bottles what is called *volatile ſpirit of alkali*, in the ſtrongeſt and moſt cauſtic ſtate in which it can poſſibly be obtained. By this means none of the ammoniac is loſt; and beſides the product is very white and pure, and the operator is in no danger from the vapour, or the burſting of the veſſels. Bucquet and I likewiſe found by a great many experiments, that one part and an half of lime, inſtead of three parts which are uſually employed, are ſufficient to decompoſe one part of ammoniacal muriate. Lime ſlaked by expoſure to the air decompoſes this ſalt as well as quicklime. The reſidue after this operation is calcareous muriate, which ſhall be hereafter examined. This proceſs proves lime to have a greater affinity than ammoniac with the muriatic acid.

The two fixed alkalis, as well as lime, decompoſe ammoniacal muriate, and diſengage the ammoniac in a pure gaſeous form. Theſe, as well as lime, may be made uſe of to ſeparate ſpirit of alkali. But they are not uſually applied to that purpoſe in the laboratories; becauſe the uſe of them on that occaſion would render the proceſs much more expenſive, without affording any new advantage.

The ſulphuric and the nitric acids ſeparate the muriatic acid from this ſalt, and enter themſelves into combination with the ammoniac, with which they have a ſtronger affinity. The reſidues are ammoniacal ſulphate and nitrate.

Scarce any of the alkaline neutral ſalts acts upon ammoniacal muriate; none but thoſe which are formed by the combination of the carbonic acid with the two fixed alkalis decompoſe it. A double decompoſition and combination takes place on ſuch occaſions. In fact, while the muriatic acid unites with the fixed alkalis to form muriate of potaſh or of ſoda, the carbonic acid ſeparated from the alkalis meeting with the ammoniac, at the ſame time left in a ſeparate ſtate, forms ammoniacal carbonate, which is ſublimated and formed into cryſtals that are found ſcattered all over the inner ſides of the balloon. In performing this operation, one part of potaſh or ſoda, which muſt be very

dry,

dry, is mixed with another of ſublimated ammoniacal muriate in powder. This mixture is put into a ſtone retort, to which a large balloon, or rather a glaſs cucurbite, muſt be fitted; and fire is now gradually applied till the bottom of the retort be made red-hot. A white ſalt in fine cryſtals paſſes by ſublimation into the cucurbite, (which is ammoniacal carbonate). A little water paſſes at the ſame time, and the reſidue is muriate of potaſh, or of ſoda, according as the one or the other of thoſe fixed alkalis was employed. By this means we obtain a very conſiderable quantity of the ſalt, equal to no leſs than two-thirds of the ammoniacal muriate which entered into the mixture. This phænomenon induced Duhamel to think that a little fixed alkali eſcaped along with the volatile. It is eaſy to underſtand, ſince modern experiments have thrown light on this theory, that what gives on this occaſion ſo conſiderable a quantity of the ſublimated ſalt is the union of the carbonic acid ſeparated from the fixed alkali, with the ammoniac. Till of late, however, this concrete volatile alkali was always thought to be the pureſt; and to it were aſcribed the properties of cryſtallizing and effervefcing with alkalis; while that obtained by lime, which is pure volatile alkali, was thought to be a ſalt that had been altered, and in part decompoſed. From this we ſee what new light the diſcoveries of Dr Black have thrown on the nature of ſaline matters; and we cannot help ſaying that they have rendered chemiſtry quite a new ſcience.

Ammoniacal muriate is applied to various purpoſes. In medicine it is adminiſtered internally as a diſcuſſive in obſtructions and intermittent fevers, &c. in doſes of a few grains. Externally applied, it is a powerful antiſeptic in gangrenous caſes, &c. &c.

It is uſed in many of the arts, more eſpecially in dyeing and in metallurgy, when different metals are to be ſoldered together. Braziers uſe it to clear the ſurface of copper which they are going to cover with tin.

Species IV. *Ammoniacal Borate.*

Ammoniacal borate, or the ſaturated combination of the boracic acid with ammoniac, has not been yet examined by any chemiſt. I have made the following obſervations on ſome of its properties.

I diſſolved a quantity of very pure boracic acid in ammoniac, or cauſtic volatile alkali, till the ſubſtances appeared to be mutually and completely ſaturated: this ſolution I diluted in a little water, and then evaporated in a ſand-bath about one half of this liquor. When cooled, it afforded a layer of cryſtals joined together, and exhibiting on their ſurface polyhædral pyramids. This ſalt has a poignant urinous taſte; it turns ſyrup of violets green, gradually loſes its cryſtalline form, and becomes brown by the contact of the air. It diſſolves readily enough in water. Lime diſengages the ammoniac.

Theſe are chief properties which I obſerved on a firſt examination of it: but I have not yet made enough of experiments upon it to be fully acquainted with its nature.

Ammoniacal borate is not applied to any uſe.

Species V. *Ammoniacal Fluate.*

This ſalt, like the preceding, is ſcarce ſufficiently known to be diſtinguiſhed by its peculiar properties from other ammoniacal ſalts.

M. Boullanger agrees with Scheele, that the fluoric acid when combined with ammoniac does not cryſtallize, but forms a jelly; which exhales vapours like thoſe of the muriatic acid, upon the addition of a portion of the ſulphuric. Neither of thoſe chemiſts has examined the other properties of this ſalt; but they had learned enough to enable them to diſtinguiſh between the fluoric and the muriatic acids.

Species VI. *Ammoniacal Carbonate.*

We give the name of *ammoniacal carbonate* to a kind of neutral ſalt, which was formerly called *concrete volatile alkali,* but is actually a neutral ſaline combination of the carbonic acid with ammoniac.

It does not exiſt in nature in a pure inſulated ſtate; but it may be obtained from almoſt any animal ſubſtance by the action of fire. It is likewiſe formed by the direct union of ammoniac with the carbonic acid, 1. By ſhaking that alkali in the upper part of a veſſel containing fermenting liquor. 2. By cauſing the carbonic acid to paſs into volatile ſpirit of alkali. 3. By pouring this acid into a veſſel, the ſides of which are wet with ammoniac diluted in water. 4. By a direct combination of the carbonic acid gas with ammoniac gas above mercury; the two gaſeous ſubſtances inſtantly unite, a ſtrong heat is excited, and a concrete ſalt is formed on the ſides of the glaſs in which the mixture is made up. In all of theſe caſes ammoniacal carbonate is inſtantly formed in cryſtals. The ſame ſalt is likewiſe obtained by decompoſing ammoniacal muriate with carbonic neutral ſalts having a baſe of potaſh or ſoda.

Ammoniacal muriate may be cauſed to aſſume a regular form. Its cryſtals appear to be priſms with a number of ſides. Bergman calls them *octohædrons* with four of their angles truncated. M. Romé de Lille mentions his having ſeen this ſalt in groupes of ſmall tetrahædral priſms, terminating at the upper extremity in a dihædral ſummit.

Its taſte is urinous, but much weaker than that of pure cauſtic ammoniac; its ſmell, though not unlike that of ammoniac, is alſo much fainter; it communicates a green colour to ſyrup of violets. It may here be proper to obſerve with reſpect to the laſt-mentioned property, that the carbonic is not the only acid which does not abſolutely deſtroy the characters of ſuch alkalis as it is combined with; and that there is no reaſon on this account to refuſe the name of neutral ſalts to alkalis ſaturated with this weak acid; for the boracic acid is of the ſame character, as to its effects on alkalis; and no chemiſt has ever intimated a doubt whether borax be a neutral ſalt.

Ammoniacal carbonate is very volatile, the leaſt heat being ſufficient to ſublimate it entirely. If regularly cryſtallized, it begins to liquefy when heated, with the help of the water to which it owes its cryſtalline form. But it is volatilized nearly at the ſame time; which renders it almoſt impoſſible to obtain this ſalt very dry and regularly cryſtallized.

It diſſolves very readily in water, producing cold at the

the inſtant of its ſolution, like all other cryſtallizing neutral ſalts. This property alone, plainly diſtinguiſhing it from pure ammoniac, which on the contrary produces a conſiderable heat when it combines with water, might be ſufficient to claſs ammoniacal carbonate among the neutral ſalts. Two parts of cold water diſſolve rather more than one of this ſalt; warm water diſſolves more than a quantity equal to itſelf in weight. But, as the heat of boiling water diſſipates it, we cannot adopt this method of cryſtallizing it, without running the riſk of loſing a conſiderable part.

It becomes ſomewhat moiſt when expoſed to the air, and is the more liable to this when not entirely ſaturated with the carbonic acid.

Neither ſiliceous nor aluminous earth acts upon it any more than on the other neutral ammoniacal ſalts. Magneſia decompoſes it but very feebly. Lime has a ſtronger affinity than ammoniac with the acid, and decompoſes this as well as other neutral ſalts. Lime-water poured upon a ſolution of the ammoniacal carbonate, immediately gives a precipitate, and a ſtrong ſmell of cauſtic ammoniac is at the ſame time diffuſed around. The lime ſeizing the carbonic acid, forms with it chalk or calcareous carbonate, which is precipitated, and the ammoniac is ſeparated. Quicklime, triturated with ammoniacal carbonate, inſtantly diſengages the ammoniac in a gaſeous form. The cauſtic ammoniac may be obtained from this mixture by putting it into a retort accommodated with Woulfe's apparatus, juſt as the volatile alkali is obtained from ammoniacal muriate diſtilled in the ſame manner. This decompoſition proves lime to have a greater affinity than ammoniac with the carbonic acid, as well as with the other acids.

The fixed alkalis decompoſe ammoniacal carbonate as well as lime, by ſeparating the pure ammoniac, and combining with its acid.

Laſtly, the ſulphuric, the nitric, the muriatic, and the fluoric acids, have more affinity with ammoniac than the carbonic acid. When any of theſe acids is poured on ammoniacal carbonate, it produces a lively effervescence by diſengaging the carbonic acid. If this decompoſition be performed in a long ſtrait veſſel, certain evidence may be obtained of the preſence of the carbonic acid, by immerſing into it a taper, which is inſtantly extinguiſhed,—tincture of turnſol, which aſſumes a red colour,—or lime-water, which is precipitated. Theſe decompoſitions of ammoniacal carbonate by lime and the fixed alkalis,—which by ſeizing the acid, ſeparate the ammoniac, and by the acids,—which by uniting with the alkali, diſengage the carbonic acid, ſhow clearly the peculiar nature of ammoniacal carbonate. Bergman found by accurate experiments, that a quintal of this ſalt in cryſtals contains forty-five parts of carbonic acid, forty of ammoniac, and twelve of water. As this ſalt contains more of the acid than carbonate of ſoda, and carbonate of ſoda more than carbonate of potaſh, that ingenious chemiſt concludes, that the weaker the alkaline baſe, ſo much the more acid is requiſite to ſaturate it. The boracic acid does not decompoſe ammoniacal carbonate cold ; but when a hot ſolution of the boracic acid is poured on this ſalt, a very diſcernible effervefcence is produced. The carbonic acid then diſengaged may be collected by the uſual means ; and what is found at the bottom of the veſſel is genuine ammoniacal borate. This experiment, which I have often repeated, confirms Bergman's obſervation, that heat modifies or changes the laws of elective attraction.

Ammoniacal carbonate does not act on perfect neutral ſalts. But we will hereafter ſee that it decompoſes calcareous neutral ſalts by the way of double affinity, which pure cauſtic ammoniac does not. This fine diſcovery of Black's explains the reaſon of what the chemiſts had long aſſerted, that ammoniac has a greater affinity than calcareous earth with the acids.

Ammoniacal carbonate is uſed in medicine as a ſudorific, an anti-hiſteric, &c. It is mixed with ſome aromatic matters. It has been conſidered almoſt as a ſpecific in the caſe of a viper's bite; but the Abbé Fontana with good reaſon oppoſes that notion. Many have adviſed the uſe of ammoniacal carbonate or concrete volatile alkali in venereal complaints; but experience has not yet determined certainly how far it is uſeful in ſuch caſes. All that we know concerning the application of this ſalt in the medical art is, that it is purgative, inciſive, diuretic, diaphoretic, and diſcuſſive; and that it acts powerfully in all diſtempers ariſing from the thickening of the lymph, ſuch as venereal misfortunes, coagulations of milk, ſcrophulous ſwellings, &c.

It is given in doſes of a few grains in certain drinks, or in pills mixed with opium.

CHAP. VII.

Genus III. *Calcareous Neutral Salts.*

Species I. *Sulphate of Lime, Selenite, or Gypſum.*

THE combination of the ſulphuric acid with lime is properly *calcareous ſulphate*, but is commonly known by the name of *ſelenite*, *plaſter*, or *gypſum*. This ſalt abounds in nature. It is often found in vaſt banks or layers; as for inſtance at Montmartre near Paris. At that place whole mountains are filled with ſtrata of ſelenite or plaſter, covered over with a kind of argillaceous marl, which is almoſt always found with it.

As this ſalt has but very little taſte, and is ſcarce ſoluble, naturaliſts have long conſidered it as a ſtony ſubſtance; and they have diſtinguiſhed it into many varieties, according to its various degrees of purity, and the various forms under which it appears. We ſhall mention the chief of thoſe varieties.

The

The Principal Varieties of Calcareous Sulphate.

1. Calcareous ſulphate, or ſelenite in rhomboidal plates.

It is tranſparent like ice: the pieces which are ſhown in cabinets of natural hiſtory are irregular; but they always ſplit into rhomboidal plates. Such are thoſe at St Germains and Lagny, &c.

2. Cuneiform calcareous ſulphate or ſelenite; or in the form of arrow-heads.

It conſiſts of two ſcalene triangles joined in the middle, each of which, as M. de la Hire has obſerved, conſiſts of triangular plates. This ſtone is called *lapis ſpecularis*, or talc of Montmartre.

3. Calcareous ſulphate or ſelenite in decahædral rhomboids.

Of this kind is that found in the quarries of Paſſy.

4. Calcareous ſulphate or ſelenite in decahædral priſms.

This conſiſts of hexahædral priſms, terminating in dihædral pyramids, or in a concave angle. It is found in Switzerland, &c.

5. Calcareous ſulphate or ſelenite in cock's combs, from Montmartre.

Theſe are collections of ſmall lenticular cryſtals, diſpoſed obliquely one beſide another. They are formed by the union of the arrow-heads, of which we have ſpoken under the ſecond variety.

6. Silky or ſtriated calcareous ſulphate or ſelenite, ſilky gypſum of China.

It is found in Franche-Comté, Angoumois, &c. It is in the form of very fine priſms, bundled together, uſually bright and gloſſy like ſatin. It is very difficult to to diſtinguiſh in this the rhomboidal plates, which are obſerved in all the other varieties.

7. Calcareous ſulphate, common gypſum, or plaſter-ſtone.

This ſubſtance is of a greyiſh white colour, ſpangled with ſmall ſparkling cryſtals, which may be eaſily taken out with a knife. It is found in ſtrata; and moſt of the mountains about Paris conſiſt of it. We will afterwards underſtand that this is not pure ſelenite, and does not make good plaſter till after being mixed with another earthy ſalt.

8. Calcareous ſulphate in the form of alabaſter, or gypſeous alabaſter.

This is a ſort of plaſter-ſtone, harder, and apparently of an earlier formation than the laſt deſcribed; from which it differs only as being half tranſparent, and conſiſting of ſmall layers, as is obſerved of ſtalactites. There is a great deal of it found at Langry near Paris. This is one of the whiteſt kinds, and is ſometimes veined or ſpotted with yellow, grey, violet, or black ſpots.

9. Calcareous ſulphate, ſelenite, common gypſum, or gypſeous alabaſter, coloured, veined, ſpotted, clouded, and punctuated.

This mixture of colours ſhows the ſelenite to be contaminated with ſome extraneous colouring matter. The colours of this earthy ſalt are almoſt always occaſioned by iron in various ſtates.

Calcareous ſulphate is likewiſe found diſſolved in water, as for inſtance in the wells of Paris; but never pure, and always combined with ſome other earthy ſalt, having lime or magneſia for its baſe.

We have already mentioned that calcareous ſulphate was long taken by naturaliſts for a ſtony ſubſtance. They thought

thought it could not be a ſalt, as being apparently inſipid and inſoluble: but it actually communicates a peculiar ſapidity to water,—which is very ſenſible in the ſtomach. Crude water, or water impregnated with ſelenite, affects the ſtomach with a certain cold and heavineſs. As to its ſolubility; the form, ſize, tranſparency, quantity, and ſtrata, of the cryſtals of calcareous ſulphate, in many places, and particularly all around Paris, ſhow plainly that it muſt have been once diſſolved in water, and afterwards depoſited by that fluid.

Calcareous ſulphate, when expoſed to the action of fire, loſes the water of its cryſtals, and when ſuddenly expoſed to a ſtrong heat decrepitates: it then aſſumes a rough white appearance, and becomes very friable. Under this form it is called *fine plaſter.* When mixed with water, it admits of being wrought into a paſte, of which very white and beautiful ſtatues are caſt in moulds. But as this plaſter ſoon dries, retaining but very little water, the ſtatues are apt to break under the ſlighteſt blow. If the fire be continued after calcareous ſulphate is reduced to a white powder, it melts at length into a kind of glaſs. But to produce this effect, the moſt intenſe heat is requiſite, ſuch as that of porcelain furnaces, or the focus of a burning-glaſs. Meſſrs d'Arcet and Macquer accompliſhed the melting of calcareous ſulphate. M. Macquer has obſerved, that when cuneiform ſelenite is expoſed to the focus of a burning-glaſs, ſo as that the light may fall on its poliſhed ſurfaces, it only becomes white; but when its edges are expoſed, it inſtantly melts and boils. Bergman's blow-pipe, or a ſtream of vital air poured on a burning coal, likewiſe melts it.

Calcareous ſulphate becomes phoſphoric when laid on hot iron; and this property is common to all calcareous ſalts. We have ſeen that lime likewiſe diſplays it, when ſlaked.

Calcareous ſulphate ſuffers no very obſervable alteration from the action of air; yet when expoſed to the open atmoſphere, the ſparkling and poliſhed plates of this earthy neutral ſalt loſe their luſtre, aſſume the variegated colours of the rainbow, ſplit into laminæ, and at length waſte away. But theſe phænomena are owing to the joint influence of heat, water, and air.

Calcareous ſulphate diſſolves in water, though ſlowly and inſenſibly. According to the chemiſts of Dijon, about 500 parts of water are requiſite to diſſolve one of this earthy ſalt. Warm water diſſolves it not in a greater proportion. We cannot obtain by evaporating this ſalt cryſtals reſembling thoſe of nature; on ſuch occaſions, as the boiling liquor is gradually evaporated, ſmall ſcales or needles are precipitated. The ſcales or plates obtained by evaporating a ſolution of calcareous ſulphate are uſually ſparkling, and when narrowly examined appear to be formed of very fine needles joined longitudinally.

Barytes, having a greater affinity than lime with the ſulphuric acid, decompoſes calcareous ſulphate. If a ſolution of barytes be poured into water containing a portion of this ſalt, ſtriæ of barytic ſulphate are inſtantaneouſly formed.

The fixed alkalis likewiſe decompoſe this neutral ſalt. When cauſtic fixed alkali is poured into a ſolution of calcareous ſulphate, a white precipitate is produced in mucilaginous flakes, which are ſoon accumulated at the bottom of the veſſels, and eaſily diſtinguiſhed to be quicklime by various means; and among others, becauſe much water is requiſite to diſſolve them.

If

If the incumbent liquor be evaporated, the reſidue after evaporation is ſulphate of potaſh or of ſoda, according as vegetable or mineral alkali was made uſe of on the occaſion.

As ammoniac has not ſo ſtrong an affinity with any of the acids as lime, it is unable to decompoſe calcareous ſulphate when that ſalt is very pure, and the ammoniac made uſe of very cauſtic: but if water in which calcareous ſulphate is diſſolved, contain ſome other ſalt with a baſe of magneſia or aluminous earth, ſuch as, for inſtance, the wells at Paris, ammoniac effects a precipitation of it. To ſucceed in this experiment, we muſt diſſolve calcareous ſpar in pure ſulphuric acid, and dilute that ſulphate of lime in diſtilled water. Cauſtic ammoniac poured into ſuch a ſolution, or, what is ſtill better, ammoniac gas cauſed to paſs through it, produces no precipitate.

Carbonate of potaſh and calcareous ſulphate mutually decompoſe each other. When theſe ſubſtances are mixed, a double decompoſition and combination take place. The ſulphuric acid forſakes the lime, in order to form ſulphate of potaſh by uniting with the fixed alkali; and the carbonic acid being ſeparated from the potaſh combines with the lime to form calcareous carbonate, which is well known under the name of *chalk.*

Carbonate of ſoda likewiſe decompoſes calcareous ſulphate, and is decompoſed in its turn. Sulphate of ſoda is formed on this occaſion by the combination of the ſulphuric acid with mineral alkali; and calcareous carbonate or chalk by the combination of lime with the carbonic acid.

Ammoniacal carbonate decompoſes calcareous ſulphate by a double affinity. The ſulphuric acid tends to unite with the ammoniac; while the lime is attracted by the carbonic acid, with which it has a great affinity, and by combining with it forms a precipitate of chalk.

This decompoſition is very diſcernible; and Dr Black's diſcoveries have given a very ſatisfactory explanation of the cauſe by which it is produced. And if a mixture of the ſolution of calcareous ſulphate and cauſtic ammoniac be for ſome time expoſed to the air, though it were at firſt perfectly tranſparent, its ſurface ſoon appears clouded, in conſequence of the carbonic acid being precipitated from the atmoſphere, and giving riſe to a double affinity. The ſame phænomenon may be produced by cauſing a few bubbles of this gazeous acid to paſs into the liquid. As concrete volatile alkali, or ammoniacal carbonate, was formerly thought to be pure volatile alkali,—Geoffroy, believing that this alkali actually gave a precipitate from calcareous ſulphate, concluded it to have a greater affinity than lime with the ſulphuric acid.

Many combuſtible matters, with the help of heat, decompoſe calcareous ſulphate. Coal from vegetable ſubſtances, having a greater affinity than ſulphur with the oxigenous principle, robs the ſulphuric acid of that part of its compoſition. The carbonic acid is diſengaged on this occaſion; and the ſulphur ſeparated from the ſulphuric acid uniting with the lime, forms what is called *calcareous hepar* or *liver of lime*, to which we will, in future, give the name of *ſulphure of lime*.

The varieties of cryſtallized calcareous ſulphate are carefully preſerved in natural hiſtory collections. When calcined and wrought in water, it is uſed in caſting ſtatues, &c. Various handſome pieces of ornamental furniture are formed of gypſeous alabaſter, cut and poliſhed,

poliſhed. Lagny affords fine blocks for that purpoſe.

Plaſter-ſtone is one of the moſt uſeful matters in nature. It is a mixture of calcareous ſulphate and calcareous carbonate or chalk. When expoſed to the action of fire, the calcareous ſulphate loſes the water of its cryſtallization and the chalk its acid. Burnt plaſter is therefore a mixture of quicklime and calcareous ſulphate without water. If water be poured on this ſubſtance, the lime eagerly abſorbs it, giving out heat. The fetid odour which is felt when burning plaſter is extinguiſhed, is occaſioned by the ſulphur produced by the decompoſition of the ſulphuric acid by the animal or vegetable carbonaceous matters which are always found to exiſt in plaſter-ſtone. The ſulphur then ſeparated forms a kind of *ſulphure*, or liver of ſulphur, from which the diſagreeable ſmell proceeds. When the lime has abſorbed enough of water to make it paſte, it includes a portion of calcareous ſulphate, which, attracting part of the water, cryſtallizes in the midſt of the paſte. The lime becoming gradually dry, acquires a ſolid conſiſtency, with the help of the cryſtals of calcareous ſulphate, and forms a kind of mortar which is called *plaſter*. From what has been here ſaid, it may be underſtood why plaſter muſt be burnt to a certain degree and no farther. When not ſufficiently burnt, it does not unite with the water, becauſe the lime is not quick enough: when too much burnt, the lime unites with the calcareous ſulphate to form an indifferent ſpecies of vitreous frit which cannot combine with the water; this is called *burnt plaſter*. It may be likewiſe underſtood, that the reaſon why plaſter loſes its qualities when expoſed to the air, is the gradual ſlaking of the lime. When calcined anew, it regains its original properties. Laſtly, it is eaſy to ſee why plaſter is preſerved unchanged in dry hot places, and why in damp ſituations it waſtes gradually away in ſcales or plates. In the laſt of theſe caſes, calcareous ſulphate, which is ſoluble in water, gradually loſes its conſiſtency and cryſtalline form. It is this ſolubility that diſtinguiſhes plaſter from mortar, the ſandy baſe of which is proof againſt the attacks of water. Plaſter is on this account unfit for uſe in places containing water, ſuch as reſervoirs, and other works of a ſimilar kind; nor does it retain its hardneſs in low or ſubterraneous places.

Species II. *Calcareous Nitrate.*

Calcareous nitrate, or the ſalt reſulting from the combination of the nitric acid with lime, is far from being ſo copious in nature as calcareous ſulphate or ſelenite. It is found only in ſuch places as afford alkaline nitre. It is formed on the ſides of walls, in places inhabited by animals; it is found likewiſe in putrefying animal matters, and in ſome mineral waters. But as it diſſolves very readily, and even deliquiates, it is diſſolved as faſt as formed; and from this circumſtance, it exiſts in large quantities in mother-water of ſaltpetre.

When regularly cryſtallized by a proceſs which we are hereafter to deſcribe, it exhibits ſolid priſms of ſix faces, pretty much like nitrate of potaſh, and terminating in diedral pyramids. It is but ſeldom obtained in ſo regular a ſhape, but uſually in ſmall needles, adhering together, and of an indeterminate form.

The taſte of this ſalt is bitter and diſagreeable, very different

different from that of calcareous ſulphate. It even taſtes ſomewhat freſh, like nitrate of potaſh.

It eaſily liquefies in the fire, and becomes ſolid by cooling. If taken into a dark place, after being thus heated, it becomes luminous; and in this ſtate it is called Baldwin's phoſphorus, *Balduinus.* It exhibits the ſame phænomenon when put on a red iron. When thrown on burning coals, it liquefies and detonizes ſlowly, in proportion as it becomes dry. Calcareous nitrate, when long heated, loſes its acid, which is decompoſed by the action of heat. When this operation is performed in a retort, the extremity of which enters a bell-glaſs full of water, a product of vital air is obtained, and towards the end of the operation azotic gas. The reſidue is lime, in combination with a certain quantity of nitrous acid, if only a moderate fire has been employed, and that for a ſhort time. But ſtrong quicklime may be obtained by this proceſs, if extreme violence of fire be applied and continued long enough to effect a total decompoſition of the nitrous acid. This decompoſition of the acid is preciſely the ſame with that which is effected by the diſtillation of nitre of potaſh, as we have ſhown in the hiſtory of that neutral ſalt.

Calcareous nitrate attracts very rapidly the moiſture of the atmoſphere. And it muſt therefore be kept in very cloſe veſſels when we wiſh to preſerve it in cryſtals; it even waſtes away very quickly if the mouths of the veſſels be too often unſtopped.

This ſalt diſſolves very readily in water. No more than two parts of that fluid, even cold, are requiſite to diſſolve one of calcareous nitrate: boiling water diſſolves a quantity more than equal to itſelf in weight. To obtain this ſalt in cryſtals, we muſt evaporate the ſolution, and when it acquires nearly the conſiſtency of of ſyrup ſet it aſide in a cool place: it then forms very long priſmatic cryſtals, which are uſually bundled together in needles diverging from a common centre. When a ſolution of calcareous nitrate, not juſt ſo much evaporated as the laſt, is expoſed to a dry warm temperature, it at length forms more regular priſms, like thoſe which were deſcribed at the beginning of this article.

Sand and clay decompoſe calcareous nitrate, and ſeparate the acid.

Barytes, according to Bergman, decompoſes this ſalt, as well as calcareous ſulphate: magneſia produces no ſenſible alteration on it. M. de Morveau has obſerved, that lime-water poured on a ſolution of calcareous nitrate produces a precipitate. He aſcribes this effect to the phlogiſton of quicklime, which, in his opinion, has a greater affinity with the nitrous acid than with lime. Unluckily that chemiſt did not examine the nature of the precipitate, otherwiſe he muſt certainly have obtained ſome farther knowledge concerning the phænomena of this curious experiment. M. Baumé had before obſerved, that lime water precipitates a ſolution of calcareous ſpar in nitrous acid, but aſcribed that phænomenon to a ſmall portion of argillaceous earth contained in the ſpar. This effect muſt depend either on a little magneſia, or on the avidity with which calcareous nitre abſorbs the water from the lime.

The fixed alkalis attract the nitric acid from calcareous nitre, and by that means precipitate the lime. Pure ammoniac does not decompoſe this ſalt any more than ſulphate of lime and the other calcareous ſalts in general.

The ſulphuric diſengages the nitric acid from this ſalt

ſalt with effervеſcence. The acid thus diſengaged may be obtained in a receiver in the ſame way as common nitre. The ſulphuric acid, when poured into a ſolution of calcareous nitrate, gives immediately a precipitate of ſulphate of lime, leaving the nitric acid free and ſeparate in the liquor. We are as yet ignorant in what manner the other acids act upon this ſalt.

Calcareous nitrate decompoſes ſulphuric alkaline neutral ſalts. The reſult of this decompoſition is ſulphate of lime and nitre of potaſh or ſoda. Ammoniacal ſulphate, too, when mixed with a ſolution of calcareous nitrate, gives ammoniacal nitrate and ſulphate of lime. The laſt of theſe ſalts being ſcarce ſoluble, is precipitated at the inſtant of the mixture; which eſtabliſhes the certainty of this double decompoſition beyond a doubt.

Carbonate of potaſh likewiſe diſſolves, and is in its turn diſſolved by, calcareous nitrate. This double decompoſition gives nitrate of potaſh, which remains diſſolved in the liquor; and chalk or calcareous carbonate, which is precipitated.

Carbonate of ſoda acts in the ſame manner on calcareous nitrate, giving nitrate of ſoda, which remains diſſolved in the water,—and calcareous carbonate or chalk, which is precipitated.

Ammoniacal carbonate likewiſe decompoſes this ſalt by double affinity. Ammoniacal nitrate and carbonate of lime are formed on this occaſion.

Sulphate of lime produces no alteration on calcareous nitrate; but when theſe two ſalts are found diſſolved in the ſame water, as the firſt is ſcarce ſoluble, and the ſecond diſſolves very readily, they may be ſeparated by cryſtallization. The ſulphate of lime is precipitated at the firſt, and the calcareous nitrate does not cryſtallize till the liquor be greatly condenſed by cooling.

Calcareous nitrate is applied to no uſe. It might be uſed in medicine as a very active diſcuſſive; and ſome medical chemiſts relate their having uſed it with ſucceſs, though they were not much acquainted with its properties.

Species III. *Calcareous Muriate.*

Calcareous muriate, the ſalt formed by the combination of the muriatic acid with lime, which was formerly known by the improper name of *fixed ſal ammoniac*, *oil of lime*, &c. abounds wherever muriate of ſoda is found, more eſpecially in ſea-water, to which it communicates its acrid bitter taſte; which was formerly aſcribed to bitumen, ſuppoſed to be contained in the water. But it is never pure in that fluid, being always mixed with muriate of magneſia. In order to procure calcareous muriate very pure, we muſt make a direct combination of the muriatic acid with lime to the point of ſaturation.

This ſalt, when dry and ſolid, appears in priſms with four ſtriated faces, terminating in very ſharp-pointed pyramids. It has a ſalt and very diſagreeable bitter taſte. When expoſed to the action of a moderate fire, it liquefies by means of the water of its cryſtals, and becomes fixed by cooling. When expoſed to a ſtronger fire, it ſuffers ſcarce any alteration. M. Baumé has obſerved, that on this occaſion it does not loſe its acid. When put on a red ſhovel, it becomes luminous; on which account it is called *Homberg's phoſphorus.*

That portion of calcareous muriate which remains in the retort after the decompoſition of ammoniacal muriate by lime, is called *fixed ſal ammoniac.* It melts into a kind of frit, of a light ſlate grey, without giving out any muriatic acid, even though expoſed to a degree of heat ſufficient to vitrify the ſurface of the retort. This frit gives fire with ſteel; and when rubbed in the dark with a piece of the ſame metal, gives out phoſphoric ſparks.

It is to be obſerved, that this ſaline reſidue uſually contains more lime than what is requiſite for the ſaturation of the muriatic acid; becauſe more than the neceſſary quantity of lime is employed to decompoſe ammoniacal muriate. This reſidue, no doubt, owes its property of affording an hard vitreous frit to its containing an extraordinary quantity of lime; for otherwiſe the frit would ſurely at length acquire moiſture and ſuffer alteration when expoſed to the air. Calcareous muriate, when it contains no extraordinary portion of lime, never aſſumes that degree of hardneſs which diſtinguiſhes this reſidue, nor diſplays any phoſphoric powers.

Pure calcareous muriate, when expoſed to the air, rapidly attracts moiſture, and waſtes entirely away by deliquium. It muſt be kept in a well ſtopped veſſel when we wiſh to preſerve it in its cryſtalline form.

This ſalt diſſolves very readily in water,—about a part and an half of the fluid being ſufficient to diſſolve one part of calcareous muriate. Warm water diſſolves a portion more than equal to itſelf in weight. If this ſolution be evaporated till it acquire the conſiſtency of ſyrup, and then left to cool ſlowly, it cryſtallizes into to tetrahædral priſms, ſeveral inches in length, and placed in the diſpoſition of radii, diverging from a common centre. We may obſerve, that this is almoſt invariably the form of all calcareous ſalts. When the liquor is too much evaporated, or too haſtily cooled, it becomes a ſhapeleſs maſs ſet with ſharp points on the ſurface.

A ſolution of calcareous muriate evaporated to 45 degrees of M. Baumé's areometer, and then expoſed to cold in a bottle, depoſites very regular, and often very large, priſmatic cryſtals. Sometimes when this ſolution is ſhaken before being cryſtallized, it is ſuddenly formed into a very ſolid maſs; at which inſtant it gives out a great deal of heat.

Barytes, according to Bergman's experiments, having a greater affinity than lime with the muriatic acid, decompoſes calcareous muriate. Lime and magneſia produce no alteration on this ſalt.

The fixed alkalis precipitate the lime. If the two liquors be concentrated, the lime, abſorbing the ſmall portion of water which they contain, forms almoſt inſtantaneouſly a jelly which ſoon becomes quite ſolid. This experiment is called a *chemical miracle*; becauſe it exhibits two fluids paſſing ſuddenly into a ſolid ſtate. But it does not ſucceed well except with a ſolution of carbonate of potaſh and ſoda; for the pure cauſtic alkalis precipitate the lime in too divided a ſtate.

Cauſtic ammoniac does not decompoſe calcareous muriate; for it has not ſo great an affinity as lime with the muriatic acid: a fact which proves that ammoniacal muriate may be completely decompoſed by this ſalino-terreous ſubſtance.

The ſulphuric and the nitric acids diſengage the muriatic acid from this ſalt with efferveſcence; and with a diſtillatory apparatus, the acid might be obtained from this ſalt in the ſame manner as from muriate of ſoda. The diſtillation of this earthy ſalt with the nitric acid gives the nitro-muriatic acid, or *aqua regia*, becauſe of the volatility of the two acids.

Calcareous muriate decompoſes ſulphate of potaſh and ſoda. The reader may obtain the fulleſt conviction of the truth of this fact by mixing ſolutions of theſe ſalts. A precipitate is immediately produced, which may be diſtinguiſhed to be ſulphate of lime. The incumbent liquor contains muriate of ſoda or potaſh, which may be obtained by evaporation; nay, even the taſte of the liquid is a proof of its exiſtence.

Carbonate of potaſh or ſoda likewiſe decompoſes calcareous muriate. Two decompoſitions and two combinations take place on ſuch occaſions. The muriatic acid contained in the latter ſalt, deſerting its baſe, combines with the potaſh or ſoda to form muriate of potaſh or ſoda, which remains diſſolved in the liquor; and the carbonic acid likewiſe forſaking the fixed alkalis and combining with the lime, forms a precipitate of chalk or calcareous carbonate. If carbonate of potaſh or of ſoda be diſſolved in a very ſmall quantity of water, and the ſolution of calcareous muriate be at the ſame time concentrated, the mixture becomes thick and gelatinous. It then aſſumes greater conſiſtency, and hardens into a kind of factitious ſtone, if the two ſubſtances be juſtly proportioned in the compoſition. The firſt chemiſts who obſerved this phænomenon called it *a chemical miracle*.

Ammoniacal carbonate decompoſes calcareous muriate by a double affinity, in the ſame manner as calcareous ſulphate and nitrate. The ammoniac combines

bines with the muriatic acid, forming ammoniacal muriate, which remains diſſolved in the liquor; while the carbonic acid combining with the lime, forms calcareous carbonate, which is precipitated.

If calcareous muriate and calcareous nitrate be diſſolved together in water, it becomes very difficult to ſeparate them, becauſe they are both cryſtallized by the ſame laws. But calcareous muriate and ſulphate may be eaſily obtained ſeparate; for the laſt cryſtallizing only by evaporation, leaves the calcareous muriate pure, and it then cryſtallizes by cooling. This obſervation is of ſome importance; for theſe two ſalts are often found in ſolution in the ſame mineral water.

Calcareous muriate has not yet been applied to many purpoſes. It exiſts in a large proportion in the gabel ſalt, recommended in ſcrophulous caſes as a purging diſcuſſive; and I have already obſerved that gabel ſalt is indebted to it for part of its properties. I likewiſe obſerved that the ſtrong taſte of calcareous muriate, and its tendency to ſolution, give us reaſon to expect very happy effects from it in all diſtempers in which an alteration of the humours is requiſite. It is greatly to be wiſhed that phyſicians were acquainted with its properties, and would preſcribe it in many of thoſe caſes in which the uſual diſcuſſives are found not to act with ſufficient efficacy, eſpecially in inſtances when mercurial preparations cannot be ſafely adminiſtered. I have already given the reſult of all my experience concerning the nature of this diſcuſſive ſalt in a memoir inſerted among thoſe of the Royal Society of Medicine for the years 1782 and 1783.

Species IV. *Calcareous Borate.*

This name may be given to the combination of the ſedative or boracic acid with lime. This ſalt has never been examined, though it be certain that the boracic acid is capable of combining with lime, as lime decompoſes borax of ſoda. The chemiſts of the academy of Dijon have obſerved, that the concrete boracic acid, when treated in fire, with ſlaked lime, affords a matter whoſe parts adhere very feebly together, and take no hold on the crucible. If this matter be caſt into water, it diſplays none of the characteriſtics of lime; and this proves that a combination muſt actually have taken place. M. Baumé mentions his having ſaturated lime-water with ſedative ſalt: the liquor when evaporated in the air afforded no cryſtals, but yellowiſh pellicles, having a faint taſte of the boracic acid. Laſtly, the academicians of Dijon digeſted on a ſand-bath a ſaturated ſolution of this acid with ſlaked lime. This ſolution, when filtered, gave a copious white precipitate on the addition of fixed alkali. Theſe ſeveral experiments ſhow nothing more than the poſſibility of diſſolving lime by the boracic acid, and give us no information concerning the properties of the neutral ſalt which reſults from the combination then effected.

Species V. *Fluor Spar, or Calcareous Fluate.*

This ſalt is a combination of the fluoric acid with lime. It abounds through nature. It is found more eſpecially in the neighbourhood of mines, the exiſtence of which it always indicates. Hitherto it has been conſidered as a ſtone, on account of its inſipidity, hardneſs, and inſolubility. It is called *ſpar*, as being of a ſpathoſe form and fracture; *fluor or fuſible*, becauſe it melts very readily, and is even employed advantageouſly as a flux in the working of mineral ores; *vitreous*, becauſe it has the appearance of glaſs, and may even be formed by fuſion into a very fine ſpecies of glaſs; *cubic*, becauſe it appears always under a cubic form; and *phoſphoric*, becauſe when heated and taken into a dark place it has a luminous appearance. Before Scheele's diſcovery of it, vitreous ſpar, though ſufficiently diſtinguiſhed by the miners from all other mineral matters, in conſequence of its fuſibility, had been always confounded by naturaliſts with gypſeous ſubſtances, calcareous and ponderous ſpars, which have been alſo called *fuſible*. The celebrated Margraaf, however, had eſtabliſhed a diſtinction between this ſalt and ponderous ſpar; appropriating to the former the name of *vitreous fuſible ſpar*, and calling the latter *phoſphoric fuſible ſpar;* and our acknowledgments are due to that chemiſt for the firſt diſcoveries of the properties of calcareous fluate.

This ſalt appears uſually under the form of very regular cubic cryſtals, of various colours, and of an icy and vitreous tranſparency. Its fracture is ſpathoſe, and exhibits cubical plates ſeemingly cracked at the ſurface. It breaks when ſtruck againſt ſteel: it is always found in mineral ores, to which it often ſerves as a bed or matrix. Sometimes it is opaque, and in irregular maſſes. It is weightier than any of the other ſaline matters which we have examined. It is ſometimes

times clouded, veined, ſpotted, and oftener green, red, roſe, or violet coloured, &c.

We may take notice of ten leading varieties of this ſalt as it is found in nature.

Varieties.

1. Cubic calcareous fluate, or vitreous ſpar; white and tranſparent.
2. Cubic calcareous fluate, or vitreous ſpar, white and opaque.
3. Cubic calcareous fluate, or vitreous ſpar, yellow; falſe topaz.
4. Cubic calcareous fluate, or vitreous ſpar, reddiſh; falſe ruby.
5. Cubic calcareous fluate, or vitreous ſpar, pale green; falſe aqua marine.
6. Cubic calcareous fluate, or vitreous ſpar, green; falſe emerald.
7. Cubic calcareous fluate, or vitreous ſpar, violet; falſe amethyſt.
8. Octohædral calcareous fluate, or vitreous ſpar, with truncated pyramids.

   I have in my poſſeſſion a cryſtal of this kind, which is ſemi-tranſparent and ſomewhat blackiſh.
9. Calcareous fluate, or vitreous ſpar, in an irregular lamellated maſs.

   It is almoſt always of a clear green or violet colour. It forms the *gangue* of ſeveral ores, and is ſometimes in rolls.
10. Calcareous fluate, or vitreous ſpar, in layers of various degrees of thickneſs and of various colours.

Almoſt all of theſe varieties of calcareous fluate are ſtill but one ſaline ſubſtance, namely a combination of the fluoric acid with lime. They are uſually found, however, when carefully analyſed, to contain various extraneous matters, ſuch as ſiliceous earth, clay, and iron. This is the character of all natural products in general. England is very rich in calcareous fluate.

When this earthy ſalt is expoſed to a moderate fire, it acquires a phoſphoric quality in a pretty eminent degree; but if made red hot, it is entirely diveſted of this quality. It at the ſame time loſes its green or violet colour, and becomes grey and friable. When ſuddenly expoſed to a ſtrong heat, it decrepitates almoſt in as lively a manner as muriate of ſoda. When powdered fluate of lime is thrown on an hot iron, it gives a bluiſh or violet light, which in an inſtant diſappears. If expoſed a ſecond time to heat, it no longer exhibits the ſame phænomenon.

A ſtrong heat melts this ſalt into a tranſparent uniform glaſs, which adheres to the crucibles. It melts one fourth of its weight of fine quartz, and is therefore uſed as a flux in ſmelting.

Calcareous fluate is neither alterable by air nor ſoluble in water. It ſerves as a flux for earthy and ſalino-terreous matters. Pure fixed alkali, whether mineral or vegetable, does not decompoſe it; becauſe, according to Bergman, lime has a greater affinity than either of theſe ſalts with its acid.

The concentrated ſulphuric acid diſengages the fluoric acid from this ſalt, and is commonly employed for that purpoſe. One part of calcareous fluate in powder, together with three parts of ſulphuric acid, are put into a glaſs retort. This mixture becomes gradually hot, an efferveſcence is produced, and the fluoric acid is diſengaged in

a

a vaporous form. This diſtillation is effected without the application of external heat; and a white ſubſtance, reſembling an eſſloreſcence, is ſublimed and depoſited in the receiver by the acid gas. Heat being then applied, the fluoric acid is obtained in a concentrated ſtate, covered with a thick earthy pellicle, reſembling the white eſfloreſcence above mentioned, when it drops into water in the receiver. This acid may be obtained in a gazeous form by inſerting the extremity of the retort into a bell-glaſs filled with mercury. This aeriform acid is tranſparent, and never ſuffers the earth combined with it to be precipitated but when it comes into contact with water. From this we underſtand why the liquid fluoric acid depoſites ſtony incruſtations in the bottom of the receiver: for whenever it is combined with water it becomes incapable of maintaining them in ſolution. We have already taken notice that this earth, being of a ſiliceous nature, ſeems to have originally belonged to the glaſs veſſels which have been corroded by the fluoric acid, and is not produced by the combination of the acid with water, as Scheele at firſt imagined. At the end of the diſtillation, the reſidue is obſerved to be hard, of a white or reddiſh colour, and diſpoſed in plates, while the retort is corroded in a very diſcernible manner. This did not eſcape Margraaf's obſervation: and by examining the reſidue, we find it to conſiſt of calcareous ſulphate mixed with ſiliceous, or often even with aluminous earth, and a little magneſia. The two laſt of theſe ſubſtances, as well as iron, appear to exiſt only accidentally in calcareous fluate. The incruſtation depoſited by the fluoric acid is of a ſiliceous nature; for it is neither fuſible nor ſoluble in acids, and the fixed alkalis melt it into a white durable glaſs. It appears from the hiſtory

ſtory of this experiment, that it is impoſſible to diſtil a great quantity of this acid. I have ſeveral times tried it with a pound of calcareous fluate, with a view to obtain a good quantity of the fluoric acid; but finding the retort always incapable of reſiſting ſo corroſive an agent, I was at length obliged to give up the hope of diſtilling ſo large a quantity.

The nitric acid decompoſes calcareous fluate; but, according to M. Boullanger, the phænomena which appear on the occaſion are very different from thoſe which we have juſt been deſcribing. No incruſtation is formed, as when the ſulphuric acid is employed to decompoſe this ſalt. But the circumſtances of this operation have not yet been examined with ſufficient attention.

According to Scheele, the muriatic acid likewiſe ſeparates the fluoric; but he gives no particular account of the phænomena attending this decompoſition.

We are as yet ignorant of the manner in which moſt of the neutral ſalts act on calcareous fluate. We know only that carbonate of potaſh or ſoda decompoſes it by a double affinity, whereas the cauſtic fixed alkalis never decompoſe it. When one part of this ſalt is melted with four parts of carbonate of potaſh, if the mixture be thrown, when melted, into water, it gives a precipitate of carbonate of lime, which is formed by the union of the carbonic acid with the lime of the calcareous fluate; and the liquor contains fluate of potaſh, which may be obtained by evaporation in a gelatinous form. When carbonate of ſoda is employed, the products are carbonate of lime and fluate of ſoda; and the laſt is obtained in cryſtals by evaporating the liquor.

Calcareous fluate is not employed for any other purpoſe

poſe but in ſmelting mineral ores; and it is an excellent flux. It might be uſed for the ſame purpoſe in aſſaying metals.

Species VI. *Carbonate of Lime or Chalk; Calcareous matters in general.*

Calcareous ſpar, marble, chalk, and all calcareous matters in general, are ſaline ſubſtances formed by the combination of the carbonic acid with lime: the proper denomination to be given them is therefore *carbonate of lime*, or *calcareous carbonate.* This ſubſtance has been ranked by naturaliſts among ſtones; becauſe they have not diſtinguiſhed it to poſſeſs any ſaline properties. We ſhall ſee, however, that it has a kind of ſapidity, is ſoluble in water, admits of decompoſition, and affords when analyſed a great quantity of the carbonic acid, and of the ſalino-terreous ſubſtance known by the name of *lime.* As calcareous ſpar is the laſt modification of a matter which exiſts under a vaſt variety of forms, and has paſſed through many different ſtates, before being regularly cryſtallized; it will therefore be proper to take a general view of calcareous or cretaceous ſubſtances *.

---

* I am of opinion, that all thoſe ſubſtances which are uſually known in natural hiſtory by the name of *calcareous*, might, with more propriety, be denominated *cretaceous* ſubſtances. The latter term indicates the neutral ſaline combination formed by lime and the carbonic acid, namely, chalk, *creta*; the former belongs properly to lime calx, which is the baſe of that ſalt. The expreſſion *calcareous earth*, or *matter*, ſhould be appropriated to quicklime; *chalky*, or *cretaceous matter*, ſhould be applied to the combination of quicklime with the acid of

No department of natural hiſtory diſplays a wider field, or a fuller ſeries of well eſtabliſhed facts, than that of calcareous matters. Long and uniform obſervation, with proper opportunities of obſerving the gradual progreſs of nature in forming theſe bodies, has determined that the bottom of the ſea is the great laboratory in which the proceſſes neceſſary for their production are conſtantly carried on. Among the numerous tribes of animals inhabiting that immenſe body of water there are ſeveral claſſes, the numberleſs individuals of which appear to be deſtined to increaſe the ſolid maſs of our globe. Such are ſhell-fiſhes, madrepores, and lithophites; the ſolid parts of which when examined by the chemiſt ſome time after the death of the animal, exhibit all the characteriſtics of calcareous matters. Calcareous mountains are formed by the ſucceſſive accumulation of thoſe marine ſkeletons. Tho' there be a mighty difference between theſe animated beings in their natural ſtate and cryſtallized calcareous ſpar; though it be difficult to diſtinguiſh on a firſt view the amazing difference between the ſoft pulpy ſubſtance of the animal and the hard ſtony maſs which its carcaſe afterwards contributes to form, and which is deſtined to cement and conſolidate our buildings; yet it is not impoſſible to form an idea of the ſucceſſive alterations which they muſt undergo before they can arrive at the ſtate of mineral bodies. The following appear to be the gradations through which this animated organized matter muſt paſs, before it can become

---

of chalk. But it is not to be expected that theſe two expreſſions which have always been ſynonimous, ſhould be all at once adopted into our language, and applied to diſtinct ſubſtances, whatever might be the advantage ariſing from this uſe of them. A.

come tranſparent, cryſtalline, carbonate of lime, or calcareous ſpar.

The waters of the ocean, agitated by laws of motion, which are ſtill unknown to us, gradually change their ſituation, and come to occupy a new bed. They deſert one ſhore, and encroach upon another. M. Buffon, in his theory of the earth, gives full evidence of this fact. When the waters retire from a part of the bed which they have occupied, they leave uncovered the ſtrata which their various motions (of which this celebrated philoſopher has given ſo ingenious an account) have formed by the ſucceſſive accumulation of the ſolid parts or ſkeletons of marine animals. Theſe layers are almoſt entirely compoſed of ſhells; which loſing by putrefaction the animal gluten, and with it their colours, the poliſh of their interior ſurface, and more eſpecially their conſiſtency, become friable and earthy, and paſs into the ſtate of foſſils. Hence the production of earths and ſtones containing ſhells.

Theſe ſtones are worn by the waters till they gradually loſe the organic form, become more and more friable, and are at length converted into that ſubſtance known by the name of *chalk*. When a ſhell-ſtone is ſo hard as to be ſuſceptible of poliſh, and the ſhells of which it conſiſts have retained their organization, ſo far as ſtill to diſplay different colours, it is called a *lumachello*. When the marks of organization are totally deſtroyed, if the ſtone be hard and ſuſceptible of poliſh, it is known by the name of *marble*. Water impregnated with chalk, depoſites it on all bodies over which it flows, ſo as to form *incruſtations*. When it filtrates through the arches of ſubterraneous cavities, it depoſites a white opaque matter formed into conical figures, conſiſting of concentric layers; which reſemble the bottoms of lamps, and are called *ſtalactites.* When theſe are accumulated in large maſſes, ſo as to fill up the caverns, and remain long under ground, they acquire a conſiderable degree of hardneſs, and obtain the name of *alabaſter.* Laſtly, When water impregnated with chalk, extremely fine and very much attenuated, penetrates ſlowly into ſtony cavities, and depoſites that ſubſtance as it were particle by particle; theſe minute bodies gradually unite their correſponding ſurfaces in a ſymmetrical and regular manner, forming hard tranſparent cryſtals, reſembling thoſe of ſaline matters; which receive the name of *calcareous ſpars.* This is the laſt degree of attenuation to which chalk is liable, the ſtate in which it differs moſt from its original character as part of an animal body, and bears the greateſt reſemblance to a real ſalt.

Theſe tranſitions of cretaceous matters, through ſo many different ſtates, the conſideration of which opens to the naturaliſt ſuch extenſive views of the antiquity of this globe, the alterations which it has undergone, and the range of the animal kingdom, out of which ſo conſiderable a part of its ſurface and exterior ſtrata is formed; theſe diſplay to the eyes of the chemiſt nothing more than one matter, a neutral ſalt, formed by the combination of lime with the carbonic acid. We ſhall proceed to conſider it under both theſe points of view.

3

§ I.

§ 1. *Natural Hiſtory of Calcareous Subſtances* *.

BEFORE entering into a particular detail of calcareous matters, it may be proper to take a general view of their diſpoſition in the terreſtrial globe. Theſe ſubſtances are diſpoſed in layers of a larger or a narrower extent, in an horizontal or an inclined direction, and impreſſed with the moſt unequivocal marks of their having been expoſed to the action of a maſs of water. Theſe ſtrata compoſe whole mountains and hills, &c. and form a conſiderable part of the cruſt or ſhell of our globe. They afford demonſtration that our earth was once covered by the waters of the ocean, as they conſiſt of the exuviæ of its inhabitants. The waters, filtrating through thoſe calcareous maſſes, carry off part of their ſubſtance, and convey it deeper into ſubterraneous cavities, under the different forms which we are going to examine. The general characteriſtics which have been aſſigned them by naturaliſts, and which ſufficiently diſtinguiſh them, are taken from two remarkable properties which they poſſeſs; they never ſcintillate with ſteel, and they effervеſce with acids. As theſe calcareous matters appear under ſo many varieties of form, it becomes abſolutely neceſſary to arrange them

---

* Although we have already, in the hiſtory of earths and ſtones, given methodical diviſions of calcareous matters, which have been uſually ranked by naturaliſts under that claſs of natural bodies; yet we think it proper to give here a new arrangement of them, founded on other conſiderations than thoſe which have directed naturaliſts in their labours on this ſubject. A.

them under ſeveral genera. We admit ſix genera of calcareous matters *.

Genus I. *Earths and Stones, compoſed of Shells.*

These ſubſtances have been ranked among ſtones, as being apparently inſipid and inſoluble. But when analyzed, they are found to be actually ſaline, as well as all the following genera. They are known by their organic form; ſhells are often found in them unbroken: the ſtone is indeed nothing but an accumulation of thoſe organized forms; and even the original colours of the ſhells ſometimes appear in it. Sometimes too they are found to contain animals belonging to ſpecies which are no longer known to exiſt in the ſeas; ſuch are ſeveral ſpecimens of the *cornu-ammonis*, and all the nautili. Again, in Europe, and even in France, we find foſſil ſhells belonging to ſpecies of animals which are not now known to exiſt any where but in America. Several naturaliſts have formed very extenſive arrangements of foſſil ſhells; but as they are the ſame with thoſe of the living animals, we will treat of them elſewhere. There are likewiſe foſſil remains of marine animal bodies, which cannot be referred to any known ſpecies of the preſent inhabitants of the ocean. Tho' we have no complete work on animal foſſils, and this department of natural hiſtory have not yet been examined with ſo much care and accuracy as mineralogy;

---

* The reader may perhaps be ſurpriſed to meet with new generic diviſions in the hiſtory of a ſpecies of ſalt: but theſe genera relate only to natural hiſtory, and are to be referred to the particular neutral ſalt which we are examining. A.

logy; yet we have deſcriptions of a great many of thoſe bodies, which ſufficiently prove that the ſeas have been once inhabited by ſpecies of animals which no longer exiſt.

When calcareous foſſil bodies appear to have belonged to animals of a known ſpecies, they are then diſtinguiſhed by a name referring to their origin, and uſually compounded of the name of the claſs of the animals to which they belong, with the addition of a word or ſyllable denoting their ſtate as ſtones; ſuch as *madreporites*, &c. But it is to be obſerved that human bones, and the bones of quadrupeds, birds, and fiſhes, which have been buried under ground, though they be likewiſe known by the name of *foſſils*, are not of a cretaceous nature; they retain their character of calcareous phoſphate. And therefore ornitholithes, ichthyolithes, &c. are not to be ranked among cretaceous ſubſtances.

In deſcribing organic ſubſtances, the origin of which is unknown, names have been aſſigned them, derived from their particular forms: of this kind are the *lapides judaici*, thought by ſome to be the ſpeculæ of ſea-hedge hogs; the *lapides numiſmales*, or *St Peter's pence*, reſembling pieces of money, which appear to be ſmall cornua Ammonis, arranged one over another: *foſſil bezoar*, a kind of round maſs or concretion in concentric layers; *ludus Helmontii*, the ſpaces of which appear to have been formed by the drying and ſhrinkling of a ſoft earthy matter, and afterwards filled with calcareous earth; the *trochites*, *entrochi*, and *aſtroites*, which are produced from a zoophyte named *ſea-palm;* and *the piſolites*, *oolites*, or *meconites*, which are thought to be petrified eggs of fiſhes or inſects, but of which the true origin is unknown.

To this genus of true calcareous ſtones, we likewiſe refer all petrified ſubſtances, to whatever animals they may have belonged; and natural hiſtory therefore enumerates here *gammarolites*, *cancrites*, *entomolites*, *amphibiolites*, *zoolites*, and *anthropolites*. But from the new diſcoveries concerning the nature of bones it appears, as we have already mentioned, that theſe matters are not to be conſidered as cretaceous. The ſame may be ſaid of *gloſſopetræ*, or *petrified ſhark's teeth*; *ivory*, or *foſſil unicorn*, which is produced from elephants teeth; *turquoiſe*, or *bones of green and blue colours*; *toadſtones*, the grey or yellowiſh hollow ſtones; which, according to M. Juſſieu, are the upper parts of the grinders of the Braſilian fiſh called *grondeur*; and *ſerpent's eyes*, which according to that naturaliſt belong to the inciſive teeth of the ſame fiſh.

After this detail of particulars, we may venture to reduce this genus to two ſpecies, comprehending all its varieties.

Species.

1. Entire foſſil ſhells.

   Theſe differ in colour, luſtre, hardneſs, &c. Under this ſpecies we include madrepores, and all calcareous habitations of polypi in the foſſil ſtate.

2. Falun, or cron.

Shells broken and reduced to earth. The ſoil of a part of Tourraine, and of ſeveral of the other provinces of France, is entirely of this nature. Theſe earths are an excellent manure.

Genus

Genus II. *Calcareous Earths and Stones.*

These conſiſt of the matters of the former genus, attenuated, diſſolved, and afterwards depoſited by water. They are found in banks or ſtrata in the bowels of the earth. We follow M. Daubenton's diviſion of the ſpecies of this genus.

Species.

1. Compact calcareous earth; chalk.
   This ſubſtance varies in colour and fineneſs of grain; it is applied to a great many domeſtic uſes.
2. Spongy calcareous earth; ſtone marrow.
3. Calcareous earth in powder; foſſil meal.
4. Calcareous earth of the conſiſtence of cream; lac lunæ.
5. Soft calcareous earth; tufa. This ſubſtance, as it dries, becomes hard and white.
6. Coarſe-grained calcareous ſtone. Arcueil ſtone is a ſpecimen of this. It is found to contain half-broken ſhells.
7. Fine grained calcareous ſtone. The thunderſtone is a variety of this ſpecies.

It would be improper to enter here into a minute detail of the varieties of theſe earths and ſtones: but it may be naturally imagined that there are a great many depending upon difference of colours and hardneſs, and the various purpoſes to which they are applied; and that thoſe varieties are diſtinguiſhed by different names. Almoſt all of them may be prepared as lime for the purpoſes of building, &c, &c.

Genus III. *Marble.*

MARBLES differ from calcareous ſtones properly ſo called, as being conſiderably harder. Like thoſe, however, they do not ſcintillate with ſteel: they effervеſce with acids, and their fracture is granulated; but their grain is much finer and cloſer: their colours are more brilliant, and they take a finer poliſh. All the world knows the application of marble, in ſculpture, architecture, *&c.* It is uſed too in ſome countries for making lime.

Species.

1. Lumachello.

The Italians give this name to a ſpecies of marble formed by the agglutination of ſhells.

2. Breccia.

This is a ſpecies of marble conſiſting of ſmall round maſſes, united by a cement of the ſame nature.

3. Marble, properly ſo called.

This ſubſtance exhibits neither the ſhells of lumachello nor the round maſſes of breccias; it is irregularly ſpotted, and ſometimes round. M. Daubenton arranges marbles by the number and the combination of their colours, including under the ſame denomination both lumachellos and breccias.

1. Marble of ſix colours; ſpecimen, white, grey, green, yellow, red, and black; Wirtemberg marble.

2. Marble of two colours; ſpecimen, white and grey; marble of Carana.

3. Marble of three colours; ſpecimen, grey, yellow, and black; lumachello.

4. Marble of four colours; ſpecimen, white, grey, yellow, red; brocatello of Spain.

5. Marble of five colours; ſpecimen, white, grey, yellow, red, black; breccia of Old Caſtile.

4. Figured marble.

It repreſents ruins, as in Florence marble; or herbs, as in Heſſian marble.

It is to be obſerved, that the colours of marble depend almoſt always on the iron intermixed among its grains. This ſubſtance, though ſuſceptible of a fine poliſh, is very porous; every body knows that it is eaſily ſpotted: and this property renders it fit for receiving delineations of coloured flowers, and for being ſtained with many different colours.

Marble is often mixed with fragments of an hard ſtone, ſuch as quartz and ſilex. The part which contains ſuch fragments gives fire with ſteel. I have often obſerved this of ſeveral kinds of black marble.

Genus IV. *Concretions.*

CONCRETIONS are irregularly formed by the ſlower or quicker depoſition of calcareous matter by water on the ſurface of ſome body. They are not diſpoſed in extenſive layers, but by fragments; at firſt in inſulated maſſes, which are at length united in one uniform cruſt.

Species.

1. Incruſtations.

Waters impregnated with chalk depoſite it on the ſurfaces of all bodies over which they flow: and incruſtations may therefore be of all poſſible forms, correſponding to the forms of the bodies on which they are depoſited. Such are thoſe of the waters of Arcueil; ſuch too is the Oſteocolla, &c.

2. Stalactites.

Theſe are gradually depoſited by water in concentric layers, ſuſpended from the arches of caverns, &c. They vary in ſize, tranſparency, or opacity, grain, colour, and form. They are generally hollow and pyramidal. *Flos ferri* is the pureſt of all ſubſtances of this kind. When they adhere to the ſides of ſubterraneous cavities they receive the name of *congelations*; when depoſited on the floor, they are called *ſtalagmites*.

3. Alabaſter.

Alabaſter ſeems to be formed of the pureſt ſtalactites, after they have been long buried under ground. It is ſofter than marble; and when poliſhed, its ſurface appears fat and oily. It evidently conſiſts of layers diſpoſed in various directions. It is always more or leſs tranſparent, which diſtinguiſhes it from marbles; but there are ſome ſpars which it never equals in tranſparency. Alabaſter poſſeſſes likewiſe all the characteriſtics of calcareous ſtones. It is cut into vaſes and ſtatues. There are many varieties of it.

Varieties.

1. Oriental alabaſter. This is the hardeſt and moſt tranſparent.
2. Occidental alabaſter; not ſo fine and pure as the preceding.
3. Alabaſter ſpotted with various colours.
4. Wavy alabaſter. This is called *agate alabaſter.*
5. Flowered alabaſter; exhibiting ſpecimens of herborization.

Genus V. *Calcareous Spar.*

CALCAREOUS ſpar differs from the four preceding genera in its form, which is generally more regular, and in its fracture. It is compoſed of laminæ arranged one above another, which are very diſcernible when it is broken. It crumbles down when ſtruck with ſteel.

Species.

1. Opaque calcareous ſpar.

   This is white or variouſly coloured; and uſually appears in rhomboidal laminæ.
2. Rhomboidal tranſparent calcareous ſpar; Iceland cryſtal.

   It repreſents objects double.
3. Calcareous ſpar in priſms without pyramids.

   Theſe are truncated hexahædral priſms, with faces either equal or unequal, and having ſometimes their angles cut in ſuch a manner as to make them twelve-ſided priſms; which cir-

Varieties.

circumſtances give three varieties of this ſpecies.

4. Calcareous ſpar in priſms, terminating in two pyramids.

The varieties of this ſpar are pretty numerous. Some of them are hexahædral priſms, terminating in pyramids, which are alſo hexahædral, and either whole or truncated. Others diſplay at the extremity of the hexahædral priſms, trihædral pyramids, either whole or truncated, or with dihædral ſummits. Laſtly, There are ſome in quadrangular priſms, terminating in dihædral ſummits. All of theſe varieties exhibit ſometimes one ſometimes two pyramids, according to their diſpoſition.

5. Pyramidal calcareous ſpar.

This is formed of one, or by the union of two pyramids, without any intervening priſm. The hexahædral or triangular form of thoſe pyramids, the inequality of their ſides, and the frequent mutilation of their angles, diſtinguiſh them into a great many varieties *.

6. Calcareous ſpar in duodecahædral figures.

This ſpar, reſembling a kind of granite or marcaſite, appears to conſiſt of two truncated pentagonal pyramids joined at their baſe.

7. Cal-

---

* The reader who wiſhes to be more particularly acquainted with the varieties of ſpars, may conſult Dr Hill's work intitled, *The Hiſtory of Foſſils, containing the Hiſtory of Metals and Gems, &c. London* 1748. *Folio, with copperplates.* M. Romé de Lille gives an extract from this work in the firſt edition of his Cryſtallography, page 131. *et ſeq.* p. 191, *et ſeq.* concerning calcareous ſpar and rock-cryſtals. He ſhows Dr Hill's method to be perplexed and defective, &c. A.

Varieties.

7. Calcareous ſpar in ſtriæ.

This is a collection of long priſms, bundled up together in figures of no determinate regularity. The Swediſh *lapis ſicillus* belong to this ſpecies.

8. Lenticular calcareous ſpar.

This ſpecies conſiſts of flat cryſtals, diſpoſed obliquely, one beſide another. M. Romé de Lille thinks it a variety of hexahædral priſmatic ſpar, terminating in two obtuſe, triangular pyramids, placed in oppoſite directions. *Criſtallographie, p.* 123. *firſt edition.*

---

§ II. *Chemical Properties of Calcareous Carbonate.*

As the chemical properties of bodies refer to their principles or combination, they ſhould be diſtinguiſhed by names expreſſive of their nature. The various calcareous matters which we have enumerated, are therefore to be confounded when we ſpeak of them chemically under the general name of *Calcareous Carbonate.* Experiments for determining the properties of this earthy ſalt ſhould be made either on the moſt tranſparent calcareous ſpar, or on pure white marble.

In order to analyze calcareous carbonate, we muſt firſt deſtroy its aggregation by reducing it to powder.

In

In this form it is white and opaque. It has no very ſenſible taſte; but when kept for ſome time in the mouth, it contracts the fibres of the palate and the tongue.

When this earthy ſalt is expoſed to the action of fire, it loſes its acid and the water of its cryſtals. If ſuddenly expoſed to a ſtrong heat, it decrepitates and loſes its tranſparency. By diſtilling it in a retort we obtain water and a conſiderable quantity of carbonic acid gas: but a ſtrong heat is requiſite to diſengage the gas. After undergoing this operation, the calcareous matter is reduced to the ſtate of quicklime; the ſalt may be formed again by combining the quicklime with the acid. Chalk, which differs from calcareous ſpar in no reſpect but in being leſs coheſive and opaque, has been diſtilled by M. Jacquin. The Duke de Rochefoucauld having repeated this experiment with much care, has obſerved that part of the aeriform carbonic acid eſcapes through the ſtone retorts uſed in diſtilling this ſubſtance. Dr Prieſtley has fully eſtabliſhed this fact by a number of very accurate experiments. An iron retort, or the barrel of a gun, may be uſed on this occaſion; but a little inflammable gas or hydrogene is always obtained at the ſame time, and is produced by the action of the water in the chalk on the iron.

When calcareous carbonate is expoſed to a ſtrong fire in clay crucibles, it melts into glaſs round the ſides of the veſſel. M. d'Arcet has melted pieces of ſeveral ſpecies into a ſpotted tranſparent glaſs. But as Macquer has obſerved that this earthy ſalt does not melt in the focus of M. de Trudain's lens, the fuſion effected by M. d'Arcet was owing, doubtleſs, to the clay of the crucibles.

Calcareous carbonate ſuffers no alteration from pure air: but the rays of the ſun acting upon it in a humid atmoſphere, deſtroy its tranſparency and the coheſion of its laminæ. Its ſurface aſſumes the colours of the rainbow, becomes dark, and gradually deliquiates.

It does not appear to be ſoluble in water. Chalk, though not more ſoluble in this fluid than calcareous carbonate, is however maintained in ſolution by ſtreams of water running over beds of cretaceous matter. In ſome inſtances water contains a conſiderable quantity of it. Of this kind are the waters of Arcueil near Paris; which contain ſo much chalk, that in a few months they depoſite incruſtations on bodies immerſed in the canals through which they run. The bath waters of St Philip in Italy are ſo ſtrongly impregnated with this ſubſtance, as to depoſite layers of it half an inch thick in the ſpace of a few days. Tablets and figures of this matter are obtained from theſe waters, by immerſing into them hollow moulds, in which the cretaceous matter is accumulated.

Calcareous carbonate contributes to the vitrification of ſeveral earthy and ſtony ſubſtances: when mixed with ſiliceous earth in the proportion of two-thirds or three-fourths, it cauſes it to melt.

This ſalt, when mixed by nature with an argillaceous earth, compoſes a mixed earthy matter, to which naturaliſts and farmers give the name of *marl*. That ſubſtance of which there are very many varieties, differing from each other in colour, denſity, &c. melts, when expoſed to a ſtrong fire, into a greeniſh yellow glaſs. It is uſed with great ſucceſs to ſoften and fertilize earths.

Barytes and magneſia have no action on calcareous carbonate in the humid way: the carbonic acid has a ſtronger affinity with lime than with either of thoſe two ſubſtances. But when calcareous carbonate is expoſed to fire with theſe alkaline earths, it enters into a vitreous combination with them. M. Achard has made many experiments on all of thoſe vitreous mixtures; of which a particular account is given in the *Journal de Phyſique.*

The fixed alkalis and ammoniac produce no alteration on calcareous carbonate, becauſe the carbonic acid has a greater affinity with lime than with any of thoſe ſalts.

The ſulphuric, the nitric, the muriatic, and the fluoric acids decompoſe this ſalt by ſeizing its baſe and diſengaging the carbonic acid. When the ſulphuric acid is poured on calcareous carbonate, it excites ebullition, by diſengaging the carbonic acid in a gaſeous form. Naturaliſts have very happily aſſumed this property as a general characteriſtic of calcareous ſubſtances. With acids, an accurate analyſis of calcareous carbonate may be effected. In order to this, let the ſalt be reduced to powder, and a quantity of ſulphuric acid poured upon it. The violent effervеſcence which ariſes at the inſtant when the two ſubſtances are mixed, ſhows the carbonic acid to be then ſeparated: and it may be obtained, and its quantity meaſured in a receiver, with the help of a ſyphon and bell-glaſſes filled with mercury. The effervеſcence is attended with cold, occaſioned by the volatilization of the acid. When it ceaſes, if the new combination be examined, it is found to be calcareous ſulphate, formed by the union of the ſulphuric acid with the lime, which was the baſe of the former ſalt. Late experiments have ſhown,

ſhown, that ſeveral of theſe ſpars contain a little magneſia, and afford ſulphate of magneſia, when diſſolved by the vitriolic acid. The nitric acid commonly made uſe of by naturaliſts, in aſſaying calcareous ſtones, produces the ſame effervеſcence with calcareous carbonate as the ſulphuric acid: it diſengages the carbonic acid, and forms calcareous nitrate with its baſe.

The muriatic acid likewiſe ſeparates the acid from calcareous carbonate with a violent effervеſcence, and produces muriate of lime by combining with its baſe.

The fluoric acid likewiſe decompoſes this ſalt, forming calcareous fluate with its baſe.

The boracic acid does not decompoſe calcareous carbonate cold; but cauſes it to effervеſce when heated by being mixed with powdered chalk, and diluted with a ſufficient quantity of water.

The carbonic acid renders carbonate of lime, or calcareous matters in general, ſoluble. We have already ſeen in the hiſtory of that acid, that it cauſes lime water to give a precipitate of chalk, but diſſolves it again on the addition of more of the acid than what is neceſſary to effect the precipitation. Water impregnated with the carbonic acid, when left ſtanding above a quantity of calcareous carbonate in powder, becomes at length impregnated with a certain quantity of this earthy neutral ſalt. Various waters acquire alſo chalk by means of the acid; but none of theſe ſolutions is laſting. When expoſed to the air, they aſſume gradually a turbid appearance; and in proportion as the carbonic acid eſcapes, the chalk is precipitated. Heat cauſes this effect to take place much more rapidly. And for this reaſon, waters which are hard and crude by being

im-

impregnated with chalk, may be corrected by boiling.

As it is almoſt always owing to the carbonic acid that water maintains chalk in ſolution, we may naturally infer that this earthy ſalt muſt be precipitated when the acid evaporates. Such is the origin of the incruſtations and accumulations of calcareous matter which are formed in fountains and on the ſides of channels through which water of this character flows; as may be obſerved of the water of Arcueil and the bath-waters of St Philip in Italy. Before natural hiſtory was illuſtrated by chemiſtry, ſprings exhibiting ſuch incruſtations were called *petrifying fountains*, and ſuperſtition held them to be miraculous.

Calcareous carbonate does not act in any manner on neutral ſalts with a baſe of fixed alkali. It decompoſes ammoniacal ſalts. By this decompoſition we obtain on the one hand a calcareous ſalt, formed of the acid of the ammoniacal ſalt with lime; on the other, ammoniacal carbonate produced by the combination of the carbonic acid with ammoniac. This operation is performed by diſtilling in a ſtone retort a mixture of a pound of ſal ammoniac with two pounds of chalk, or rather calcareous ſpar in powder. Both of theſe ſubſtances muſt be very dry. A long necked balloon muſt be fitted to the retort, or, what is ſtill better, a ſtone or glaſs cucurbite. Fire is to be gradually applied till the bottom of the retort be made red-hot; and the receiver muſt be cooled with wet clothes, or with cold water kept running around it during the whole of the operation. White vapours ariſe, and are condenſed on the ſides of the receiver into very white pure cryſtals. Theſe are ammoniacal carbonate. This is the proceſs by which it is prepared in London, from which it was for-

formerly retailed over all Europe under the name of *Engliſh ſal volatile.* This ſalt is now prepared in other countries as well as in England. The reſidue after this operation is calcareous muriate with an exceſs of lime, generally in fuſion if the fire has been ſtrong towards the end of the operation.

Spar and calcareous matters in general are applied to many purpoſes, as we have already obſerved when treating of their natural hiſtory ; but one of the moſt important is the preparation by which they are reduced to lime. The lime-burner decompoſes calcareous matters, driving off their acid by the action of fire. Stones containing ſhells, marbles, and moſt calcareous ſpars, are the ſubſtances which afford the beſt lime: but the ſtone which is generally uſed for the purpoſe, more eſpecially in the neighbourhood of Paris, is a kind of hard calcareous ſtone, known by the name of *lime-ſtone.* Thoſe ſtones are built into a kind of oven or turret, forming an arch. A fire of wood is kindled under the arch, and kept up till a pure lively flame, without ſmoke, ariſe about ten feet above the oven, and the ſtones become very white. They are now beginning to uſe mineral coals and peats in the neighbourhood for burning lime.

Good lime is hard and ſonorous, and becomes very hot on being brought into contact with water, and when ſlaked exhales a thick ſmoke. When not ſufficiently calcined, it is not ſo ſonorous, nor does it become ſo ſoon hot with water, or to ſo high a degree. If too much burnt, it is half vitrified ; it then yields, when ſtruck, too clear a ſound, and does not unite readily with water. The lime-burners then call it *burnt lime*. We need not here ſpeak of the purpoſes to which lime

lime is applied, as we have taken notice of them in treating of the pure ſubſtance.

We may here add, that the calcareous carbonate, which is found mixed in very ſmall fragments with calcareous ſulphate, and exiſts in mountains, in extenſive ſtrata, moſt commonly regular, and ſeparated by clay and marl, as in the vicinity of Paris, is the beſt plaſter ſtone for building. Though we have already adverted to this in the article of calcareous ſulphate, it may be not improper to return to it in this place, and to enter into ſuch a detail of particulars as may ſupply what is wanting on this head in all works on natural hiſtory and chemiſtry.

We muſt firſt recollect that pure calcareous ſulphate gives only fine plaſter by calcination; which makes but an incoherent paſte with water, and is caſt into ſtatues. It is univerſally known, that this paſte when dry is not tenacious, and is ſo brittle that the ſmalleſt degree of reſiſting force is ſufficient to break it. The reaſon is, that when this ſaline matter regains the water which is loſt by calcination, it forms an equal homogeneous maſs. This is by no means the caſe with plaſter fit for the purpoſes of building. The ſtone which affords it at Montmartre and other places, is a kind of breccia, conſiſting of very ſmall granulated cryſtals of ſulphate of lime, with very thin plates of calcareous carbonate. The preſence of the latter ſubſtance may be determined by dropping a little of the nitric acid on the ſtone: it produces a lively effervеſcence by diſengaging the carbonic acid. If a given weight of Montmartre plaſter ſtone be diſſolved in a ſufficient quantity of aquafortis, the calcareous carbonate is entirely decompoſed, when the lime

lime unites with the nitric acid, and what remains is calcareous ſulphate, a ſubſtance inſoluble in that acid. This experiment ſhows, that the proportion of calcareous carbonate varies in different plaſter ſtones; and that in the beſt it conſtitutes rather more than a third part.

This fact concerning the mixed nature of plaſter ſtones being fully eſtabliſhed, it is eaſy to comprehend the nature of the phænomena which building plaſter exhibits when burnt, ſlaked, and hardening. When this earthy ſalt is burnt, the calcareous ſulphate which it contains loſes the water of its cryſtals, and becomes friable; while the calcareous carbonate, at the ſame time loſing its acid, becomes a calx. On this account, plaſter which has been properly burnt is acrid and alkaline, communicates a green colour to ſyrup of violets, acquires heat when brought into contact with the acids, without effervefcing, and gradually loſes its ſtrength when expoſed to the air, in proportion as the quicklime which it contains is ſlaked, by attracting water and carbonic acid from the atmoſphere. When wrought into mortar, it gives out heat, in proportion as it abſorbs water. As to its ſolidity (which it is well known to aſſume very readily), a characteriſtic property in which it is directly oppoſite to pure lime, the quicklime contained in the maſs ſoon abſorbs as much water as is requiſite to ſlake it, and the calcareous ſulphate intermixed among its particles, likewiſe attracting a certain portion, is ſuddenly cryſtallized, and acts the part of ſand or cement, by uniting and conſolidating the lime.

Laſtly, This theory explains why plaſter retains its cha-

characteriſtic properties, when kept dry, and expoſed to heat; but when expoſed to moiſture, gradually loſes them and waſtes away. Theſe phænomena are owing to its being compoſed of two ſaline principles, both ſoluble in water.

END OF VOLUME FIRST.

20
4
79

4/83

29