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A TREATISE

ON THE

CHEMICAL HISTORY

AND

MEDICAL POWERS

OF SOME OF THE MOST CELEBRATED

MINERAL WATERS;

WITH

PRACTICAL REMARKS

ON THE

AQUEOUS REGIMEN.

To which are added,

OBSERVATIONS

ON THE USE OF

COLD AND WARM BATHING.

By WILLIAM SAUNDERS, M.D. F.R.S. & S.A.
Fellow of the Royal College of Physicians, of London.

SECOND EDITION, ENLARGED.

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1805.

TO

SIR WALTER FARQUHAR, BART.

PHYSICIAN TO THE

PRINCE OF WALES.

Dear Sir,

ALTHOUGH the professional eminence you have attained, and the important trust which you have so recently, and in so distinguishing a manner, been selected to fulfil, would of themselves be sufficient motives for dedicating a medical work to you, yet I am proud to acknowledge one, as paramount to every other, and most congenial to my own feelings; it is FRIENDSHIP. Accept this, then, as a public testimony of my regard, founded on a constant intercourse and the most unreserved communication, during a period of more than thirty years; and believe me to be with great truth,

Your's sincerely,

WILLIAM SAUNDERS.

July 25, 1800.

PREFACE

TO THE

SECOND EDITION.

THE former impreſſion of this work having met with a rapid ſale, and having been favourably received by thoſe who are moſt capable of appreciating its merits, muſt be conſidered as a ſufficient reaſon for the publication of another edition. It has been frequently recommended to me by many of my friends, to ſeparate the ſcientific and chemical part of this treatiſe from that which is more immediately applicable to the cure of particular diſeaſes; to this however, I have uniformly objected, by declaring that the work was originally intended for the uſe of profeſſional men, and that to obtain their approbation was the higheſt gratification I could receive; how far I have been able to ſucceed, is beſt aſcertained from its general circulation, and from the numerous teſtimonies of men diſtinguiſhed for their knowledge both in medicine and chemiſtry. The ſubject of mineral waters brings into diſcuſſion the general principles of chemical affinities, on which all the changes in the nature and properties of bodies depend. The various objects of chemiſtry which are employed, and the various proceſſes which are conducted in the elaboratory of Nature, all conduce to the fabrication of mineral waters; and that we have ſucceeded in detecting ſuch operations clearly appears, from the certainty with which we can imitate them in the preparation of artificial mineral waters. I think, that every attempt of perſons, neither ſcientific nor profeſſional, to reaſon or to diſcriminate between the uſe and abuſe of mineral waters, either in the cure of their own diſeaſes, or thoſe of others, ought to be diſcouraged, not from any low or ſordid motives on the ſide of the profeſſion, but from a conviction of the danger which muſt ariſe from the advice of perſons not properly educated. The miſtakes which are daily committed by reſorting to one medicinal ſpring, inſtead of another, from the wrong application of popular doctrines, I have frequent opportunities of knowing; and I would particularly recommend that invalids ſhould deliberate with caution on a meaſure ſo important to health, as the choice of a mineral ſpring.

My long experience has enabled me to decide with ſome degree of certainty on the preference due to particular medicinal waters; by ſuch deciſion (however impartial and well founded) I have incurred ſometimes the cenſure of perſons much intereſted in extending the uſe of their favorite ſpring; but I have no difficulty in appealing to the candid judgment of the profeſſion at large upon this ſubject.

This Edition is much enlarged, and is likewiſe rendered more valuable by the communication of an original paper, containing a very accurate analyſis of the chalybeate Spa at Brighton, by my very ingenious friend Dr. Marcet, one of the Phyſicians of Guy's Hoſpital.

Russel Square.
April 18, 1805.

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PREFACE.

THE ſcience of Medicine comprehends ſuch a vaſt maſs of detached facts and obſervations, and extends its enquiries over ſo large a range of knowledge, that it includes a number of diſtinct departments, in any of which the medical enquirer may employ his induſtry with advantage, in collecting the valuable remarks of his predeceſſors upon the ſubject, augmenting them by his own obſervations, and uſing his judgment and diſcrimination in their ſelection and arrangement.

With ſuch views, a medical man can ſcarcely chooſe any branch of enquiry more generally uſeful than the application of natural waters, in all the variety in which they are commonly found, to the purpoſes of diet and medicine; and eſpecially that heterogeneous claſs of ſubſtances, included under the general term Mineral Waters, a term of very extenſive import, and a ſubject which abounds with valuable matter of fact to attract his attention, and concerning which a variety of opinions, often very queſtionable, have been held, whereon he may exerciſe his judgment.

The beneficial effects produced by mineral waters are obvious, and in moſt caſes unqueſtioned, but the different explanations given of the true ſource of their medical powers, are more liable to error. The medicated ſprings are given bountifully by the hand of nature, the uſe of them has been reſorted to from the earlieſt times, moſt of them have grown into notice through the common consent of popular opinion, and therefore have had a high reputation established, before their peculiar claims to merit have been fairly appretiated by the man of science; and under such circumstances, even *he* has too often considered himself in the light of a popular advocate, rather than an impartial judge. Many of these waters are at once distinguishable from common springs by very striking sensible properties, which are obvious to every one; some again have acquired a high reputation from their containing scarcely any extraneous matter, from which no common water is exempt. These in almost every country have been regarded as peculiar gifts of some favourite god or saint; and the temple or marble reservoir surrounding the source of these consecrated fountains, has contributed to their security from accidental pollution. Those who are aware on what slight foundations a popular reputation for extraordinary medical virtues is ſometimes built, will not be ſurprized at the high eſtimation which has been obtained by ſome natural ſprings, many of which are now ſunk into neglect, and ſupplanted by more fortunate rivals. If, on the other hand, we conſider how much has been done towards improving our knowledge of this claſs of ſubſtances, many of which unqueſtionably poſſeſs very important medical powers; if we ſee men of the moſt reſpectable talents and information, employing themſelves in accurate and truly ſcientifical inveſtigations of the nature of mineral waters, and thereby elucidating ſome of the moſt important facts in the ſcience of chemiſtry, we ſhall have no reaſon to ſay that theſe intereſting ſubjects have been neglected by men of ſcience: and the phyſician will feel highly gratified in poſſeſſing ſuch excellent materials, on which to ground his opinions and ſyſtem of practice.

It is proper that ſomething ſhould be ſaid on the ſubject of the preſent book, and the various reaſons which have induced me to undertake it. In a Treatiſe on the Functions and Diſeaſes of the Liver, which I publiſhed ſome years ago, and which has been honoured with a favourable reception, I hazarded ſome opinions concerning the beneficial effects ariſing from the uſe of ſome of the moſt popular of our mineral waters; and from a long experience in private practice, I thought myſelf juſtified in aſcribing much of their virtues in the cure of diſeaſes connected with the biliary organs, to the watery vehicle common to all ſprings, aſſiſted by an encreaſed temperature. This opinion (in which I have the ſatisfaction to have the concurrence of ſeveral profeſſional men, eminent for their judgment and experience) has naturally led to a more extended view of the ſubject of mineral waters, and the nature of thoſe ſubſtances that give them their peculiar ſenſible and medical properties;

and I have endeavoured to eſtimate with impartiality, how much of their powers as medicines are to be attributed to their common watery ingredient, and how much to their foreign contents, in the cure of the diſorders for which theſe ſalubrious ſprings are moſt frequently reſorted to. Well aware of the difficulty of performing ſuch a taſk with fidelity and accuracy, it has been my principal attempt to clear the path for future enquirers in this ſubject, by examining what may be the operation of ſimple water under different circumſtances of temperature, in aſſiſting the general functions of the animal economy, and in the cure of diſeaſe; that by keeping this in view we may be better able to form a juſt opinion of its powers when impregnated with various foreign ingredients of different degrees of activity. To complete that part of the ſubject in which ſimple water is concerned, I have alſo taken notice of the various kinds of common water that are daily employed in diet, or for domeſtic purpoſes.

A large part of this work is devoted to the conſideration of mineral waters, with a peculiar view to thoſe active heterogeneous ſubſtances by which theſe ſprings acquire additional ſenſible properties, and highly valuable medical powers. It is particularly in ſuch ſubjects as theſe, that the ſcience of chemiſtry may be called in to aid our enquiries, and it has been employed moſt ſucceſsfully in giving us clear and accurate information as to the nature of all the foreign matters, the preſence of which conſtitutes the difference between a common and a mineral water. There is no ſcience to which a greater acquiſition in point of real matter of fact has been gained within theſe few years; and in proportion to this improvement, has the chemiſt been able to throw much light on the ſubject of mineral waters with regard to ſome of their moſt ſubtle and active contents, a ſubject which has always attracted a very large ſhare of attention, and exerciſed the ſkill of ſome of the moſt eminent men that chemiſtry has to boaſt of. As theſe enquiries can only be conducted by actual experiments, and as only the more modern chemiſts have been in a condition to carry them on with a high degree of accuracy, it is chiefly the labours of the moderns that we ſhould conſult; and the records of the older experiments muſt, like all thoſe that have been ſuperſeded by a freſh acquiſition of knowledge, be conſigned to an honourable repoſe. We may fairly claim the privilege which they themſelves exerciſed, of extracting from the works of our predeceſſors what ſtill remains valuable, and turning it to account along with the improvements of modern diſcovery. The ſound ſenſe and learning of a Hoffman may ſtill be made uſe of, without being encumbered with thoſe parts of his writings that are now become uſeleſs, or found to be erroneous.

Impreſſed with the opinion that chemical analyſis in its preſent improved ſtate, is fully adequate to make us acquainted with all thoſe foreign contents that give their medical powers to mineral ſprings, I have been more minute on this ſubject than perhaps might be thought neceſſary by the greater number of readers; but as it appears to me probable, that under particular circumſtances of dilution and temperature, the actual quantity of foreign matter contained in any water, produces effects by no means proportionate to thoſe that might occur under different circumſtances, I have thought it ſafeſt on the whole, to admit a conſiderable degree of accuracy on the ſubject of chemical analyſis, where the authorities were ſuch as to allow of it, in order that on this head at leaſt, there ſhould be as little error as poſſible; and I have not ſcrupled occaſionally to introduce remarks which will only be intelligible to the chemical reader. The terms of the modern chemical nomenclature have likewife been moftly adhered to, as well as its principles, as they are fuch as are now the moft familiar to thofe who are converfant in this fcience. With regard to the individual mineral fprings which are particularly treated of, they are very few compared to the vaft number which, by acquiring a certain degree of local reputation, have gained a place in the catalogue of medicated waters; and I have only noticed thofe that enjoy a high degree of celebrity, that are interefting from fome peculiarity of compofition, or that ferve to diftinguifh certain claffes of thefe natural bodies, and illuftrate their medical virtues. The reader will fee, that the particulars concerning the chemical analyfis of thefe fprings are extracted from the various detached publications on the individual waters; and fome pains have been taken to reconcile or account for differences of refult, which fometimes happen where more than one authority has been confulted.

Theſe publications likewiſe generally contain remarks on the medical properties of the mineral water, and directions for its uſe, many of which, being written by excellent practitioners as well as ingenious chemiſts, who have long reſided on the ſpot, afford much matter that is highly valuable to the phyſician who preſcribes theſe remedies, and to the patient who uſes them. This part of the ſubject has been ſelected with care, and is preſented to the reader accompanied with ſuch obſervations as appeared to me to be requiſite.

Some of the more eminent modern writers, who have given the hiſtory of particular ſprings, from their induſtry, their ſcientific knowledge, and the opportunities afforded by their reſidence on the ſpot, have largely contributed to the popular eſteem with which theſe fountains of health are regarded. Among theſe authors there are many whoſe ſentiments deſerve great weight from their acknowledged reputation and undoubted abilities; but at the ſame time ſome room is afforded for a free and liberal ſtricture on ſeveral of their opinions. I am far from wiſhing to undervalue the merit of theſe writers, or the importance of the ſubjects that have engaged their attention, but I am convinced, that to form a general and comparative eſtimate on matters ſo much in detail, a looker-on has in ſome reſpects ſuperior advantages to one who from ſituation, from local circumſtances, and from the very labours by which he has acquired his reputation, can hardly avoid being attached to a particular ſpot, and inclined to ſome bias in its favour. I cannot help noticing in many even diſtinguiſhed writers, a deſire of attributing effects avowedly produced by the uſe of certain mineral waters, to ſome occult and explicable cauſe exiſting in the particular ſpring that is the ſubject of their enquiry, and of a kind not to be detected by any chemical examination. Zeal for the honour of a favourite fountain has, I think, induced them to refer to an unknown caufe effects which may be fairly deduced from the operation of fubftances already familiar to chemical analyfis. Surely an unbiaffed perfon, who is aware of the comparative accuracy to which chemifts are at prefent able to carry their enquiries, can hardly fuppofe that, whatever flight error might occur in the eftimation of minute quantities, the actual exiftence of any powerful agent on the human body in any mineral water fhould efcape the nicety of refearch. Every other fact concerning thefe bodies fhews that it is only ftrong fenfible properties which here indicate correfponding medical powers; the analyfis of mineral waters as far as regards the mere afcertaining the prefence of active contents, is by no means difficult to a perfon at all converfant in the experimental part of chemiftry; a very few articles will comprife all the materia medica of mineral ſprings; moſt of theſe articles are already familiar to every practitioner, though under a different form; and, in ſhort, it appears to me highly probable, that chemiſtry gives all the information which the phyſician can require with regard to the number and nature of the active contents of every water, a good deal with regard to their reſpective quantities, and (what is perhaps of equal conſequence) it throws much light on the particular forms of combination in which they exiſt before analyſis.

The apparent inſignificancy in the quantities of ſolid contents of ſome of the moſt celebrated mineral waters of acknowledged value, has been alledged as favouring the idea of ſome unknown agent of great activity reſiding in theſe ſprings. Here I would obſerve, in the firſt place, that at the time when this idea was firſt ſtarted, there were ſome good reaſons for the ſuppoſition; as the gaſeous contents, which are probably among the moſt powerful, were not then the objects of chemical enquiry. As theſe waters were found to loſe a great part of their virtue when carried to any diſtance from the ſpring head, this circumſtance, the cauſe of which was not at that time obvious to explanation, produced a juſt opinion of a peculiarity of compoſition, and ſtill forms the ground of a very proper local attachment to the ſpot which is enriched by poſſeſſing theſe ſalubrious fountains. It ſhould in the next place be remembered, that the effects of medicines are by no means in direct proportion to their doſe; and I am perſuaded, that much of the ſteady, gradual, permanent benefit, derived from a courſe of mineral waters, depends on the dilute and largely divided doſe of the active ſubſtances which they may contain.

Any general account of the medicinal uſe of mineral ſprings would be imperfect, without taking ſome notice of the employment of them as a bath, either generally or topically; and as the ſingle circumſtance of temperature forms the baſis of the moſt important diſtinctions on this ſubject, I have in the latter end of this work, taken into conſideration the uſe of the warm and cold bath, in various diſeaſes.

The annual viſits paid by thoſe who are able to unbend from their regular occupations, by an attendance on ſome watering-place, have become ſo general, as to be almoſt a characteriſtic of Engliſh cuſtoms. This change of habit, (for in fact it is chiefly in our own times that it is become ſo univerſal), is to be in a great meaſure attributed to the number of invalids of leiſure and opulence, who have frequented theſe ſalutary ſprings; and to them we are often indebted for bringing into public notice ſome of the moſt beautiful and favoured ſpots in our iſland; for rendering mountainous countries readily acceſſible; introducing eaſe and convenience in places before unfrequented; and decorating them with the embelliſhments of a refined and delicate taſte.

The phyſician is frequently called upon, to decide for his patient, which of the various medicated waters he ſhall uſe; whether ſea-bathing or a natural chalybeate, be the moſt eligible tonic; whether a gouty dyſpeptic habit will be better put in order by the thermal waters of Bath or Buxton, the tonic purgative water of Cheltenham, or by the ſulphureous ſprings of Harrogate. Without entering minutely into the circumſtances of different caſes, I have endeavoured to lay down ſuch general indications, and to notice ſuch diſtinctions, as will aſſiſt the practitioner, or even the invalid, who is in ſome degree acquainted with theſe ſubjects, to make his choice upon ſolid and judicious grounds; and on this head, I have often been able to add to theoretical reaſoning, the reſult of my own experience for many years.

Such is the plan of the book which is here ſubmitted to the candour of the public, and it appears to me, that the preſent time is that, in which a work of this kind may prove of confiderable fervice, by collecting under one point of view, the leading features of thofe important improvements, which chemiftry has been making for many years upon thefe fubjects, particularly with regard to their application to medicine. This object is not fulfilled in thofe excellent, but purely chemical works, from the pens of Bergman, Kirwan, and others, with which this fcience is enriched; and the chemico-medical publications of Shaw, Hoffman, and Lucas, though always valuable, are now become imperfect, from the great acquifition of new matter, and often found erroneous in effential points. It is only in a number of detached effays on individual waters, that we find all the information which we poffefs; and out of thefe I have endeavoured to felect the facts which are the moft interefting, and reduce them to general arrangement. It has been my wifh to beftow upon each part of the fubject, that degree of attention, which its importance, in a medical view, ſeemed to require, or where there appeared any peculiar difficulties, in explaining effects upon eſtabliſhed principles; and it is on this account, that the valuable waters of Bath have been treated on more at large, a conſiderable difference of opinion having taken place on the true ſource of their medicinal powers. If the following pages ſucceed in conveying a tolerably clear idea, of the preciſe degree to which chemical inveſtigation has been carried up to the preſent time, in aſcertaining the compoſition of mineral waters; and in drawing ſome line of diſtinction, between the medical powers of the various ingredients; I may flatter myſelf with fulfilling a wiſh, which every phyſician, zealous for the honour of his profeſſion muſt cheriſh, that of contributing ſomething to the improvement of the healing art.

In this improved Edition, I am deſirous more particularly of requeſting the attention of the reader to the ſubject of the Chalybeate Water at Brighton, having, agreeable to the promiſe I made in the firſt Edition of this work, procured a very accurate analyſis of it, which is extremely curious and intereſting. I have likewiſe made conſiderable additions (derived from my own experience and obſervation) on the ſubject of Cheltenham Water, as applicable to the cure of Diſeaſes. The Reader will alſo find various improvements ſuggeſted on the ſubject of artificial Mineral Waters, which have been adopted and carried into effect by Monſ. Paul, at his manufactory.

I am happy in this opportunity of expreſſing the obligations I have to my old pupil and ingenious friend, Mr. Charles Rochmont Aikin, whoſe knowledge of chemiſtry has kept pace with the rapid and modern improvements in this ſcience, for the aſſiſtance which he has given me in the chemical part of this work.

A

TREATISE

ON

MINERAL WATERS, &c.

CHAPTER I.

ON THE CHEMICAL CONSTITUTION OF WATER, AND ITS POWERS UNDER VARIOUS NATURAL COMBINATIONS.

IN taking a chemical view of the properties of Water, either pure, or combined with various ſubſtances, as preſented to us on the ſurface of the earth, I ſhall begin with ſome general remarks on the nature of pure water, and the mode of its union with the different bodies into which it enters as a conſtituent part, confining myſelf at preſent to merely chemical facts. As theſe are chiefly intended to elucidate the medical and phyſical conſiderations which will be brought forward in the courſe of this work, I ſhall endeavour to render the chemical part ſubſervient to the medical, by a particular attention to thoſe ſubſtances that affect the animal frame, and to the chemical conſtitution of the organized body that receives theſe impreſſions. With regard to the complicated and highly ingenious ſyſtem of the analyſis of mineral waters, purſued by the beſt modern chemiſts, the limits and deſign of this work will not permit me to enter into it at large, as, if fully treated of, it would alone occupy a volume; and I therefore muſt refer the reader to thoſe authors and experimental chemiſts, whoſe ſkill and accuracy bear the higheſt credit.

To begin then with the queſtion, What is water?—Water is known to be a tranſparent fluid, without colour, ſmell, or taſte; in a very ſmall degree compreſſible; when pure, not liable to ſpontaneous change; liquid in the common temperature of our atmoſphere; aſſuming the ſolid form at 32° Fahrenheit, and the gaſeous, at 212°, but returning unaltered to its liquid ſtate, on reſuming any degree of heat between theſe points; capable of diſſolving a greater number of natural bodies than any other fluid whatever, and eſpecially thoſe known by the name of the ſaline; performing the moſt important functions in the vegetable and animal kingdoms, and entering largely into their compoſition as a conſtituent part.

Water, therefore, is found throughout the earth, not only in the uncombined ſtates of ice, water, or ſteam, but permanently united to a vaſt number of bodies, both ſolid, fluid, and gaſeous. For inſtance, the common air of the atmoſphere, and water, are mutually ſoluble in each other; all natural waters containing air, and even the air which is apparently the dryeſt, holding a portion of water in true ſolution. Again, many ſolid minerals, and all cryſtallized neutral ſalts, contain water in their compoſition, ſome of the latter to full half their weight; and by all theſe combinations, water, in changing its form, loſes many of its diſtinguiſhing properties.

Chemiſts have long been occupied in the important conſideration, whether water be a ſimple elementary ſubſtance; and two or three totally different controverſies have ſucceeded each other on this queſtion. It was long ſince obſerved, even by Hippocrates, that all natural waters contain air, which is ſeparable from them by heat or by freezing;

and that, under particular circumftances, they all depofit a portion of earth. Thefe events conftantly occurring with every natural water as it fprings from the foil, feveral ingenious men have imagined, that earth and air were neceffary conftituent parts of perfect water, and have attempted to allot to each of them, their peculiar fhare in producing the various appearances of this fluid, and its effect on the human body. So Hoffman obferves, (*a*) that "water is compofed of watery moifture, or *water*, properly fo called, of a fluid expanfive ether, and of earthy and faline particles." Affuming this compofition as true, he goes on to affign the particular properties of each ingredient: "The ethereal part is the caufe of the fuperiour lightnefs, brifknefs, inteftine motion, and exemption from putrefaction; the watery part, which is by far the greateft in quantity, is compofed of very fubtile and mobile particles, which infinuate into, and penetrate every fubftance capable of folution; whilft the earthy and faline matter is fixed, and will not rife in diftillation." Hence too, the quality of different waters muft, according

(*a*) Hoffman; *De Elementis aquarum mineralium.*

to this opinion, depend on the proportion of each ingredient. " The moſt ſalubrious waters are thoſe which contain moſt of the etherial particles, and are lighter than the others. They alſo heat and cool the ſooneſt (heat being only the friction of the highly mobile etherial parts upon each other), and hence the beſt waters, when ſhaken, ſhew numerous bubbles, like pearls, on the ſides of the glaſs, and yield much etherial ſpirit under the air pump. When more highly etherial, they become acidulous, as the Seltzer and Pyrmont waters, and can with difficulty be reſtrained in bottles, and therefore are much more ſalubrious when drank at the fountain head. Hence theſe waters do not cool the body like common water, but increaſe the appetite, and quicken the circulation. This ether is the univerſal ſpirit, the *ſoul* as it were of minerals. From the abundance of the aqueous parts, the integrity of the body is preſerved, the vital juices attenuated, the extreme veſſels cleanſed, and the morbid ſaline parts carried off by the excretories." This uotation (ſelected from various paſſages in tis celebrated German writer) will give the reader ſome idea of the prevalent opinions at the time; and ſhew, that conſiderable attention was paid to the gaſeous bodies with which various waters are impregnated, but which were then thought to be too ſubtile for chemical examination, and were rather conſidered as eſſential parts of every water in the ſtate of the higheſt perfection, increaſing its general ſalubrity as a common drink, as well as adding important medical powers. We ſhall preſently ſhew the great acquiſition to our knowledge on theſe ſubjects which modern chemiſtry has made, in diſtinguiſhing accurately the gaſeous, earthy, and ſaline parts, from the purely aqueous, and explaining their nature and formation.

The ſuppoſed converſion of water into earth, effected by the proceſs of diſtillation often repeated, and independent of the acknowledged earthy reſidue of all natural waters, was another opinion much controverted at that time, which was apparently ſupported by very ſtrong facts, and employed the ſkill, attention, and eſpecially the patience of many of the ableſt chemiſts. A moſt eaggerated account of the quantity of earth produced by diſtilling ſimple water a number of times ſucceſſively, having been given to the world, ſupported by the great authority of Boyle, other chemiſts made various experiments to aſcertain the truth of this report. The moſt accurate and important in ſupport of this opinion, are thoſe of the eminent Berlin chemiſt, Margraaff. He found that water, though purified by repeated diſtillations, if evaporated to dryneſs, always left a ſmall earthy reſiduum. This amounted, after ſeventy-two diſtillations, to ten grains. But as the earth thus obtained, was moſtly ſiliceous, and was produced in greater quantity by violent boiling, than by a gentle heat, though the ſame quantity and kind of water in both caſes was operated on, it was ſuſpected, that the production of earth was entirely owing to the abraſion of the glaſs veſſels in which the diſtillation was carried on. Accordingly, Lavoiſier repeated the experiment with this view, and by weighing the veſſel before and after the proceſs, he found a loſs of weight fully equal to that of the earth produced; and this explanation is now generally acquiefced in, and has long put an end to the controverfy. (*a*)

Water had hardly been re-eftablifhed on the lift of elementary fubftances, before the important queftion of its decompofition, according to the opinion of modern chemiftry,

(*a*) The particulars of this interefting experiment are the following: a glafs alembic was provided, of the kind called a *pelican*, which conftantly returns the diftilled liquor to that which is boiling, without requiring the veffel to be deranged, or ftopping the operation. This alembic, furnifhed with a glafs ftopper clofely ground in, was found to weigh one pound, ten ounces, feven gros and a half: then three pounds, fourteen ounces, five gros and a half of diftilled water were introduced, the veffel clofed, and the junctures carefully luted. The pelican was then placed in a fand bath, heated by lamps, and the heat kept up without interruption for one hundred and one days. The experiment began Oct. 24, 1768. About Dec. 20, the boiling water began to be turbid, and a depofition was formed which gradually increafed, till the diftillation was difcontinued. After every thing was cold, the luting was carefully taken off, and the veffel, with its contents, was weighed, and no increafe or diminution of the original weight was perceived; but when the alembic was emptied and carefully dried, it had loft $17\frac{4}{10}$ grains. The earth depofited from the water, weighed $4\frac{9}{10}$ grains. The water itfelf was then evaporated to drynefs, and left a further refiduum of $15\frac{1}{2}$ grains, fo that the whole quantity of earth obtained was $20\frac{4}{10}$ grains. The excefs of 3 grains of earth over the $17\frac{4}{10}$ grains, the lofs of the alembic, was fuppofed to be owing to a further abrafion of part of the veffel in which the water was evaporated to drynefs.

began to be agitated. It would be foreign to our prefent purpofe to give any hiftory of this interefting queftion, and the gradual advances which this opinion has made to an almoft univerfal eftablifhment among chemifts of every country. Water is, according to this opinion, a compound fluid, made up of two fubftances, neither of which can be exhibited feparately, except in the gafeous form; and when aeriform, they are known, the one as *Hydrogen Gas*, or *Inflammable Air;* the other as *Oxygen Gas*, or *Vital Air*. Thefe gafes, in the proportion of about three of hydrogen to eleven of oxygen, when united chemically, and reduced from the form of an air to that of a liquid, conftitute the fluid, Water. It is to be obferved however, that this circumftance of the compofition of water, has very little concern with the chemical knowledge of mineral waters. None of the methods of examining thefe waters appear in any notable degree to reduce fimple water to its original elements, but only to feparate from it the foreign contents of every defcription, to which it combines while flowing under the furface of the earth: no procefs of obtaining the adventitious gafes of natural waters, feem to decompofe any part of this fluid, but in all chemical inquiries connected with the analyfis of mineral fprings, the aqueous principle may be generally confidered as acting merely as water, at leaft in the prefent ftate of our chemical knowledge.

The principal facts, to the explanation of which the decompofition of water has materially affifted, are, various circumftances in the folution and oxydation of metallic bodies; feveral of the moft important changes that take place in the vegetable kingdom, fuch as that of their giving out oxygen gas in funfhine; the formation of oils, refins, and other inflammable bodies, during their growth; the converfion of fugar into ardent fpirit during fermentation; and the ultimate analyfis by the procefs of fpontaneous putrefaction. It ftill remains for chemiftry to determine, whether the decompofition of water performs any material part in the changes that are going on in the living animal. It is certainly by no means an improbable conjecture, fince the materials of animal bodies are fuch as are peculiarly liable to change, and efpecially as the procefs of animal putrefaction, is fuppofed to be principally brought about by the decompofition of water, affifted by a moderate temperature, and therefore the fame materials under the fame circumftances of heat, may poffibly undergo fomewhat of a fimilar decompofition even during animal life. As this fubject, however, is entirely confined to the regions of conjecture, and not connected with our prefent inquiries, we fhall take no further notice of the ultimate decompofition of water.

Of all the claffes of natural bodies, there are none into which water enters fo largely as a conftituent part, as thofe of the vegetable and animal kingdoms. Thefe are peculiarly diftinguifhed, in a chemical view, from the mineral kingdom, by poffeffing a ftructure remarkably liable to decompofition, and in which the quiefcent affinities are never fo adjufted, that the conftituent parts of their bodies can, for a moment during life, remain at reft without forming new compounds. Moft minerals will continue for ages unaltered, when protected from external chemical agents; but an animal or vegetable is at no two periods precifely the fame. This reft-leffnefs of compofition is owing to two circumftances; the one, that of poffeffing materials highly liable to change; the other, the perpetual internal motion and re-action of parts produced by their peculiar organization. This organization, which is more or lefs complex in different parts and various claffes, confifts, in all, of a fyftem of cylindrical veffels generally ramifying into minute branches, and of a fluid which is conftantly circulating within thefe veffels. Then, as all the folids are formed by depofition from the circulating fluids, and when rendered unfit for performing their functions, or noxious to the body, are removed by means of the fluids, it is neceffary that the latter fhould be capable of holding in folution, or at leaft fufpending, all the materials of which the folids are compofed. This, therefore, leads to one important property of water, that of being the bafis of all the fluids, that are perpetually circulating through every tube, of every organized and living animal or vegetable.

It would be a moft valuable difcovery, if we were able to afcertain the precife degree of ſolubility of the various materials of the circulating fluid in the water which holds them ſuſpended, and the extent to which ſimple chemical affinities would act independently of the circumſtance of life, which appears to produce regular and important changes in a manner, and according to laws, to the explanation of which natural philoſophy is inadequate. Something, however, of the chemical conſtitution of the fluids of the animal body we are already acquainted with, and theſe facts illuſtrate the high importance of the aqueous fluid, and the large ſhare which it ſupplies of all the circulating juices. Thus we know that the blood is a very compound liquid, conſiſting of animal gluten or the coagulum; of red globules, the nature of which we are but little acquainted with; of animal albumen which is ſeparable from the ſerum by heat; of animal gelly which is eaſy of ſolution; of a number of ſalts of the muriatic and phoſphoric kinds; but laſtly and chiefly, of a very large quantity of water, which enables the other contents to aſſume the fluid ſtate, and to circulate freely through very minute canals. This quantity varies at different times, but on an average is eſtimated by Haller at nearly three-fourths, or as 90 to 128, or ſometimes 103 to 128. Not only the quantity of the reſpective contents varies, but probably the ſtate of the ingredients, and the circumſtances of ſolution. So it is found, that the proportion of *coagulum* is greater in robuſt high-fed perſons, than in the weakly and ill-fed; and greater in general in the warm, than in the cold blooded animals. The proportional quantity of ſalts has not been ſo well aſcertained; attention having been rather paid to their ſenſible or ſuppoſed qualities, ſuch as thoſe of acrimony, alcaleſcency, and the like. The circumſtances of ſolution deſerve ſome notice in a chemical point of view. Of the contents of the blood, ſome, ſuch as gelly and ſaline matter, are eaſily ſoluble in water; others, ſuch as albumen and gluten, probably with much more difficulty; and the latter is rather ſuſpended than truly diſſolved, as it coagulates when at reſt, even in the body, as Mr. Hewſon has obſerved, and without diminution of temperature, or expoſure to air. This property, the ſame ingenious phyſiologiſt found to be retarded by the violent action of circulation, and thus ſatisfactorily explained the buffy coat on inflamed blood, which had been erroneouſly imputed to inſpiſſation from a loſs of the watery parts.

Water is that part of the blood which appears to be the leaſt *animalized* whilſt performing the round of circulation, the loſs of which ſeems to be the eaſieſt to bear, and to admit of the readieſt ſupply; but as there is an ample proviſion in the excretions, for carrying off whatever portion of this fluid is ſuperfluous, we may reaſonably ſuppoſe that there is little danger, in health at leaſt, of an exceſs in this moſt innocent of all the *ingeſta*.

The two moſt abundant excretions are the perſpiration and urine, and in theſe the aqueous ingredient predominates ſtill more than in the circulating maſs. Inſenſible perſpiration is little elſe than pure water, with a very minute quantity of ſalt, and ſtill leſs of animal matter, ſo little indeed, as only to be detected by the ſmell. The liquor that moiſtens the cavities of the body is nearly of the ſame nature. The animal matter appears to increaſe when the perſpiration becomes violent and ſenſible, and the odour proportionally ſtronger, and often of a very peculiar kind. The obvious ufes of this copious excretion feem to be not only to remove a fuperabundance of water from the fyftem, but efpecially by carrying it off in a gafeous form, to conftitute the great cooling procefs, and thus keep in proper check the production of heat by the lungs. In the copious excretion of urine, the proportion of water, though lefs than in the former cafe, is ftill very great. It is calculated by Haller at about $\frac{16}{20}$ to $\frac{48}{50}$, and it appears to have regular variations according to the previous diet, the time which this fecretion requires in forming, and the frequency of difcharging it. Our chemical knowledge of the other ingredients is ftill very imperfect, but they feem to be more various and peculiar than thofe of any other natural fecretion. No other, likewife, fhews fuch a total difeafed change in chemical compofition, as that which occurs during the faccharine diabetes.

On the whole, it is probable, that the purely chemical properties which water exercifes when forming a conftituent part of the animal fluids, may depend on the proportion which it bears to the other ingredients, or the degree of temperature and force of action to which the whole has been expofed, which will increafe or diminifh the true folvent power of this liquid; and poffibly too, on the order in which the other contents have been prefented to it. This laft circumftance has been but little attended to by phyfiologifts, and yet as we muft fuppofe that the laws of chemical affinity are not entirely fuperfeded by the living powers, it is certainly probable that the order of folution of the different contents of the common animal fluid, may in fome degree affect the refpective proportion of the fubftances diffolved.

It is not only in the animal, and ftill more in the vegetable fluids, that water appears the moft abundant ingredient, but even the folids of both thefe natural productions are found, when diforganized, to have been compofed moft largely of aqueous fluid, but altered in its texture, and deprived of its property of fluidity, by the union of a very fmall portion of other matter, affifted by the gradual procefs of growth and evolution from an organized body. The experiments of Van Helmont, Tillet, and others, have abundantly proved, that by far the greater part of the nutrition of vegetables, is the water which they abſorb from the earth through the pores of their roots, and that by ſubmitting them to diſtillation, they are again reſolvable for the moſt part into water. Some plants contain much more of this fluid than others, the aquatic more than thoſe that grow on a dry ſoil, and in general all young plants more than thoſe that are advanced in growth. The ſolid wood of trees is indeed compoſed of a conſiderable quantity of carbonaceous, earthy, and ſaline matter, and this is increaſing with age; but even the drieſt and moſt compact wood, ſuch as the heart of oak, when converted into charcoal, loſes during the proceſs full three-fourths of its weight, which is almoſt entirely pure water (*a*). The willow and other aquatic trees, though their wood exhibits a pretty firm texture, contain only about a fourteenth part of their weight of ſolid matter, all the reſt being reſolvable into water. Graſs loſes in drying into hay, about two-thirds of its weight, and even the dryeſt hay, if ſubmitted to diſtil-

(*a*) Watſon's Chemical Eſſays.

lation, yields two-thirds of its weight of pure water (*b*). As the animal ſolids are all formed out of vegetable matter directly or indirectly, we might conclude *a priori*, that the aqueous fluid, the principal component part of vegetables, would alſo enter largely into the compoſition of animal ſubſtances; and this is found to be the caſe by actual experiment.

It appears to be a diſtinguiſhing mark of organic matter, that in it, a vaſt proportion of mere water is capable of being ſo intimately united with other ſubſtances as to loſe that fluidity, which, in its uncombined ſtate, it aſſumes at a temperature above the freezing point; and of giving that peculiar elaſticity, flexibility, and coheſion, which are ſo neceſſary to a body that is to poſſeſs the powers of locomotion, or at leaſt to be furniſhed with a ſyſtem of veſſels in which a conſtant re-action of parts and perpetual internal movements are going on, without deſtroying that juxtapoſition which is neceſſary to an organic ſtructure. A mineral, a ſimple ſaline body, or, in ſhort, any ſubſtance that is not an im-

(*b*) Kirwan on Manures.

mediate conſtituent part of an animal or vegetable, is ſcarcely ever ſuſceptible of any intermediate ſtate between the ſolid and the fluid texture, produced by an union with any proportion of a liquid menſtruum: a cryſtal of Glauber's ſalt, for inſtance, though it contains half its weight of water, is neither flexible nor elaſtic; and if heated, it paſſes immediately into the ſtate of ſolution, owing to the increaſed ſolvent power of its water of cryſtallization; but the glutinous part of wheat flour, though dry and pulverulent, no ſooner comes into contact with water, than it abſorbs a part, becomes thereby highly ductile and tenacious, and even refuſes to unite with an additional quantity of the ſame fluid, except by the aſſiſtance of a degree of heat, which entirely alters its original properties.

If, therefore, we conſider water either as the principal ſolvent for all the alimentary matter which the animal body perpetually receives from without, or as the baſis of all the ſecretions and excretions that perform particular functions, or as a large conſtituent part of the ſolids of every denomination; if we ſurvey its agency as diffuſed through every tube of the complicated ſyſtem of an organized body, or condenſed into firm but flexible fibres, we ſhall have no heſitation in allowing it a high place among thoſe important, but ſimple materials, out of which is formed the curious and intereſting ſtructure of every animated being.

CHAPTER II.

ON THE FOREIGN CONTENTS OF MINERAL WATERS.

ATTEMPTS to ſubject to analyſis the various mineral ſprings, muſt ſoon have followed their introduction into medicine, eſpecially thoſe that poſſeſſed any remarkable ſenſible properties; and accordingly, many very eminent chemiſts have directed their attention to this object. Here, however, a very great difficulty preſented itſelf to the chemiſts of every time, down to the period immediately preceding the introduction of the modern ſyſtem of chemiſtry, which was the great volatility of the moſt active contents in many of the moſt curious and powerful waters, which eſcaped in the ſtate of gas, during the evaporation neceſſary to exhibit in a ſolid form the ſaline and earthy particles that were held in ſolution. The eſcape of theſe gaſes could not but be noticed; and even ſome of their chemical properties, as that of acidity in fixed air, and the ſulphureous nature of hepatic air; and hence we find the terms *volatile ſpirit of vitriol*, *volatile ſulphur*, and the like; hence too the very perplexing diſputes concerning the exiſtence of ſulphur, where the odour and other properties ſtrongly indicated it, and yet where none could then be preſented, as the reſult of chemical analyſis. Modern chemiſts, by ſlow ſteps, and by improving gradually on the labours of their predeceſſors, have arrived at a much more accurate knowledge of theſe ſubtile bodies; and by improvement in chemical apparatus, have been able to procure them in a ſtate of purity, to confine them in proper veſſels, and to ſubject them to examination by means of chemical re-agents; and, to complete their information, they have re-produced them from other ſources, and combined them with water in ſuch a manner, as to imitate accurately the greater part of thoſe natural waters, that firſt led to the inquiry.

The chemical analyſis of mineral waters is therefore become a complicated ſubject, and is one that is juſtly conſidered as exerciſing, in a peculiar degree, the ſkill and induſtry of the operator. As it embraces a number of objects, it requires the knowledge of gaseous bodies, and the method of separating them, and estimating their respective proportions, as well as a familiar acquaintance with the operation of a great variety of chemical tests or *re-agents*, as they are called, and with the different appearances and habitudes of a vast number of saline substances, which are either produced in the process of analysis, or form the heterogeneous solid contents of mineral springs. The high degree of accuracy, however, which the chemist would require, is often much more than is necessary for the purpose of the physician, who is every day using indiscriminately, various saline substances in a much greater quantity than that which is sufficient to constitute a *mineral* water.

It is my intention in the chemical part of this treatise, to dwell particularly upon those substances which obviously give sensible and medical properties to the water with which they are naturally united; but as it is to accurate chemical inquiries that we are already indebted, for elucidating many facts on these subjects, I shall not entirely confine myself to those parts which are now considered as the moſt important, but give a general account of all the foreign contents of the mineral waters that are uſed medicinally, along with their habitudes with different re-agents, and other circumſtances that form the baſis of chemical diſtinctions. In this part of the ſubject, the ſcientific reader will readily diſcern the greater number of authorities that have been conſulted, for which it is not neceſſary in every place to quote the names of Bergman, Kirwan, Fourcroy, and others. On the ſubject of particular waters, however, where the authority of the analyſt is of conſequence, the reader will be referred to thoſe accurate and often very complete proceſſes of analyſis which we poſſeſs, of moſt of the beſt known mineral ſprings, (many of which we owe to men of the medical profeſſion); and which may for the moſt part be depended on, as they have been made at the fountain head, with due attention to all the collateral circumſtances of ſite, ſoil, and temperature: and certainly, though a ſelection of the principal facts may be allowed to the medical inquirer, too much accuracy of examination can hardly be beſtowed on the original experiments.

Water is found throughout the earth in every degree of purity except the higheſt, for ſuch is never procured except by artificial diſtillation, as all natural waters are conſtantly coming into contact with ſome ſubſtance, which they can either diſſolve or hold ſuſpended. Of theſe ſubſtances, which form the foreign contents of natural waters, ſeveral are gaſeous, or, more properly ſpeaking, they are ſimply liquid, when diſſolved in the water; but on expoſure to heat, or often merely to air, they readily ſeparate from this fluid, aſſume the form of a gas, and mix undiſtinguiſhably with the atmoſphere. It is to be obſerved, that all the gaſeous contents are expelled by boiling for about ten minutes, and almoſt all give very perceptible ſenſible properties to water, when in conſiderable proportion.

Of theſe the firſt to be mentioned is,

1.—*Common* or *atmoſpherical air.*

Water very readily diſſolves at a moderate temperature a ſmall portion of this air, but parts with it at either the boiling or freezing point. The ſame happens in part, when the preſſure of the atmoſphere is removed by means of the air-pump. Moſt natural waters contain a ſmall quantity of common air, but ſeldom more than $\frac{1}{28}$ of their bulk, as Bergman obſerves. This air is indeed for the moſt part compoſed of rather a large proportion of oxygen than that of the atmoſphere, and it is by means of this, that the reſpiration of fiſhes is carried on through the medium of their gills; whence theſe animals periſh from ſuffocation in water that has been freſhly boiled or diſtilled, or that is impregnated with a non-reſpirable gas. Water that has been deprived of its air, ſoon regains it by ſimple expoſure to the atmoſphere. Air gives a ſenſible taſte, or at leaſt impreſſion, on the tongue, when united with water, for it renders this liquid more freſh taſted and briſk; and when expelled, the water has a flat inſipid taſte, and has long been under diſrepute for lying heavy on the ſtomach*, and even producing ſcrophulous tumours and obſtructions.

* There can be little doubt but that this opinion aroſe from the ſuppoſed levity which air gave to water when united with it, which has been an opinion handed down from the time of Hippocrates; and therefore that water, deprived of air, was actually heavier, and hence more liable to form obſtructions. This is one of the many prejudices that have been removed by actual experiments; for of all waters, that which has the leaſt ſpecific gravity, is perfectly pure diſtilled water, which is as free from gaſeous as from ſolid contents.

The only natural water that does not contain common air, is probably ſnow or hail juſt after melting: but immediately on becoming fluid, it is of the fitteſt temperature to regain the air which it may have loſt, and hence the ſnow torrents which tumble from the hills, conſtantly agitated into foam, and gradually depoſiting their earthy ſediment, form a clear ſparkling water of great ſalubrity and excellence. No particular teſt for the preſence of common air whilſt united to the water, has been ſuggeſted, except ſulphat of iron, which is thereby decompoſed, and a brown oxyd of iron gradually depoſited; whereas the ſolution of this ſalt remains clear in diſtilled water.

2.—*Carbonic acid Gas*, or *fixed Air*.

All natural waters that ſpring from the ground contain, as Bergman obſerves, at leaſt $\frac{1}{100}$ of their bulk of this gas; and every proportion of it is found, from this quantity to an equal bulk with the water, or even more. This is one of the gaſeous ſubſtances that is of the greateſt importance to the conſtitution, and probably to the medical powers of a vaſt number of mineral waters, and the difcovery of its chemical properties has cleared up a great many difficulties that ftood in the way of former chemifts. Water, at a moderate temperature, will readily take up its own bulk of carbonic acid gas, and becomes thereby bright and fparkling to the eye, acidulous and gently pungent to the tafte, and fends off numerous bubbles when fhaken or moderately heated. Water thus acidulated, or even long before it acquires thefe fenfible properties, is capable of diffolving feveral earths, efpecially lime and magnefia, and a few metals, of which iron is the only one that is met with in the medical fprings. The adhefion of the carbonic acid to the water is very weak, fo that it may be all driven off in a gafeous form by boiling for about a quarter of an hour; and whilft the acid gas is flying off, the earths or iron which it had diffolved, are gradually precipitated in a pulverulent form; the former as a white powder, the latter as a light brown ochre. Water, ftrongly acidulated with carbonic acid, fometimes exerts a kind of intoxicating power, when largely drank. It proves fatal to fifhes and fome infects, in the same manner as an atmosphere of fixed air suffocates other animals. The tests for this acid when dissolved in water, are lime water, litmus tincture, and sometimes the stronger mineral acids. The lime is immediately precipitated out of lime water in the form of chalk, by the carbonic acid, but an excess of this acid re-dissolves the lime; and therefore to apply this test, the lime water should be in equal quantity with the acidulated water. Tincture of litmus, diluted so as to be of a faint blue, is reddened by this water as by every other acid; but to prove that the redness is produced by the carbonic acid, the water should occasion no change of colour after it has been boiled, and the carbonic acid expelled*. Lastly, any of the stronger acids, (the sulphuric for instance) will produce copious bubbles of air when dropped into water that contains much carbonic acid.

* The test by litmus is very delicate. If a very little of this colouring liquor, diluted to a faint blue, be agitated in a large phial previously filled with air from the mouth, the blue will be sensibly changed into a faint red, as will appear by comparing it with another portion of the same litmus liquor reserved for comparison: yet the air expelled from the lungs is not estimated to contain in general more than 5 or 6 per cent. of carbonic acid.

The proceſs of the diſcovery of this gaſeous acid and its remarkable properties, was very gradual. The briſk lively taſte, and ſparkling appearance of the ſtrongly acidulated waters, ſuch as the Spa or Pyrmont, were ſoon noticed, as well as the readineſs with which the gas eſcaped, and the conſequent loſs of ſenſible qualities. Then, as ſeveral ſubſtances, eſpecially oxyd of iron, were often found to be precipitated along with the expulſion of the gas, it was rightly inferred, that it was this ſubſtance which held them in ſolution; and this circumſtance, added to the ſenſible acidity of theſe natural waters, gave riſe to the opinion that the gas was a ſpecies of vitriolic acid, or a *volatile imperfect vitriol*, which term is often to be found in the numerous writers that made their experiments before the diſcovery of the true nature of the carbonic acid gas was effected. The compounds of this acid, with the ſeveral alkaline, earthy, or metallic baſes, form the claſs of *carbonats*, (carbonat of lime, for inſtance, or chalk) ſeveral of which will come under notice as ſubſtances intereſting to the chemiſt or phyſician.

3.—*Hydrogen Gas*, or *Inflammable Air.*

This gas is by itſelf ſcarcely ſoluble in water, and is never procured alone from any mineral water, but is ſometimes found united with the carbonic acid, forming the *carbonated-hydrogen*, or *heavy inflammable air*; and much more frequently holding ſulphur in ſolution, conſtituting the next gas which we ſhall mention. Hydrogen gas, has in a few caſes, been confounded with azotic gas, from which, however, it entirely differs in chemical properties.

4.—*Sulphurated Hydrogen Gas*, or *Hepatic Air.*

This gas, which conſiſts of ſulphur held in ſolution by hydrogen gas, is one of very conſiderable importance, and is found copiouſly in all thoſe natural waters which emit that peculiar offenſive odour, that has been compared to the ſmell of rotten eggs, or rather, to the ſcourings of a foul gun barrel. It is contained ſparingly in many ſtanding wells that are not much frequented, where the characteriſtic ſmell is only perceived on agitating the water, as by dipping the bucket in it. This air is produced naturally by the ſpontaneous decompoſition of pyrites, and may readily be procured by pouring any of the mineral acids on alkaline or calcareous liver of ſulphur, or, according to Scheele's method, by making an artificial pyrites by fuſing together iron and ſulphur, and adding to it dilute ſulphuric acid. This gas, when pure, burns with a blue flame at the point of contact with the atmoſphere, and when previouſly mixed with common air or oxygen, it explodes with a lighted match. In either caſe it depoſits ſulphur during combuſtion. Water, at a medium temperature, will abſorb from $\frac{2}{3}$ to $\frac{3}{4}$ of its bulk of this gas, and by long continued agitation, may be made to take up nearly twice its bulk (*a*). Water, thus imgregnated, has the following properties: it has a ſtrong offenſive ſmell, a taſte ſomewhat ſweetiſh, and generally appears rather turbid. It ſlightly rendens litmus, but does not affect lime water. It precipitates of a reddiſh brown, which afterwards turns black, the metals out of various metallic ſolutions, eſ-

(*a*) Kirwan on Mineral Waters.

pecially thofe of lead, filver, and mercury; and blackens the furface of reguline filver or mercury, when they have been immerfed for feveral hours. It forms a yellow precipitate with the folutions of arfenic. Thefe changes on metallic furfaces or folutions, are owing to the union of the fulphur with the metal, and they are ufed as the moft accurate tefts of the prefence of this gas. A few drops of ftrong nitrous acid, poured into this hepatic water, at once repreffes the offenfive fmell, renders the mixture more turbid, and caufes the fulphur to be gradually depofited. The oxygenated marine acid has the fame effect, but if added to excefs, it acidifies the fulphur, and thus, inftead of fulphur being depofited, fulphuric acid is produced. The adhefion of the fulphur to the hydrogen and water is very weak; for, hepatic water becomes turbid, lofes its fmell on expofure to air, or partly if kept clofely corked, and pure fulphur is depofited. This is the origin of the fulphureous pellicles that are found in the channels in which this water flows, or lining cafks and other veffels in which it is ufually conveyed. Water, when heated to 80° or 90°, can with difficulty be made to diffolve any of this gas; and hence, to procure it for the purpofe of afcertaining its quantity, it fhould be received over warm water. Several hot fprings contain this gas in abundance, and it is often found in conjunction with carbonic acid. When taken internally, the fulphureous particles feem to pervade the whole fyftem, and even will, in time, tarnifh any filver that is worn in the pocket.

5.—*Azotic Gas*, or *Phlogifticated Air*.

The exiftence of this fubftance, in combination with a few natural waters, has been fully afcertained by fkilful and accurate chemifts. It is always, however, found only in a fmall quantity, as water exerts but little folvent power over this gas. Its adhefion to water appears to be loofer than that of any other gafeous body, for it is readily expelled on the firft impreffion of the heat ufed to collect aeriform fubftances from mineral waters. In fome fprings that contain this gas, a large quantity of it comes up along with the water, rifes through it unmixed, and may readily be collected by any inverted veffel held over the fountain head. Azotic gas does not appear to give any fenfible properties to the water with which it may be combined, nor is there any re-agent that we are acquainted with, which will indicate its prefence when diffolved; but it is a fubftance that requires to be mentioned, as it gives a peculiarity of compofition to a few mineral waters that poffefs a high reputation.

Thefe are the gafeous fubftances that have been hitherto found in mineral waters; they all have, in common, the property of re-affuming the aeriform ftate, by the application of heat, and it is then, for the moft part, that their refpective quantities are eftimated by proceffes which belong properly to pneumatic chemiftry. Of thefe gafes, there are two, the fulphurated hydrogen, and the carbonic acid, which are by far the moft important in a medical and chemical view, as materially contributing to the peculiarity of compofition, and to the medicinal properties of the mineral water of which they are component parts. The carbonic acid likewife acts as a chemical agent, on other compound ingredients in thefe waters, and thus will o ten come into further notice in fomewhat of a different character.

CALCAREOUS SALTS.

Lime is, of all the earths, that which is moſt generally contained in mineral waters of almoſt every deſcription; for there are few ſprings which, during ſome part of their ſubterranean courſe, have not an opportunity of coming in contact with calcareous earth, and there is none which appears to be ſo readily ſoluble in a variety of menſtrua. There are three calcareous ſalts which are chiefly found in mineral waters, the carbonat, ſulphat, and muriat of lime, formed by the union of this earth with the three reſpective acids, the carbonic, ſulphuric, and muriatic, which, in fact, are the ſole acids, or nearly ſo, that are met with in natural ſprings.

6.—*Carbonat of Lime.*

The circumſtances of the ſolution of lime in the carbonic acid, deſerve ſome attention. Lime, in its pure ſtate, is readily and completely ſoluble in about 700 times its weight of water, at the temperature of 60°, forming common lime water: the ſame earth, when fully ſaturated with carbonic acid, is alſo equally ſoluble in water; but when only partially ſaturated, it remains entirely inſoluble, and, in this ſtate, it forms the ſolid *carbonat of lime*, or *chalk*. This is the ſtate to which lime ſpontaneouſly tends when expoſed to the air in either ſolution; in the one, by abſorbing carbonic acid from the atmoſphere, in the other, by giving off into the ſurrounding air its exceſs of this acid; and in either caſe the carbonat of lime is precipitated as chalk. The ſame happens when carbonic acid is added in any way to lime water, as when lime water is added to a carbonated ſolution of lime. Water, containing any quantity of carbonic acid, will diſſolve as much chalk as is equal to the weight of the acid, if the latter be in conſiderable proportion to the water, but will diſſolve about twice as much, if the water be but weakly impregnated with this acid, as Kirwan obſerves. This is one ſource of *hardneſs* in waters, but is readily got rid of by boiling, which drives off the exceſs of carbonic acid, and thus cauſes the chalk to be precipitated; hence the earthy cruſt, or *furr*, on kettles in which hard water has been boiled for a number of times. Some natural waters contain an unuſual quantity of this calcareous earth, which is rapidly depoſited as ſoon as they become expoſed to the air, and thereby give an earthy lining to every tube through which they flow, and encruſt with the ſame material every ſubſtance that accident or deſign may put in their way. Of this kind are the various petrifying ſprings, that form part of the natural curioſities of ſeveral mountainous diſtricts, and have been applied to uſe in a very ingenious manner at the baths of St. Philip, in Tuſcany, (*a*) and ſtill more extenſively at Gualecavelica, in Peru. The teſts of carbonat of lime diſſolved in water, are not quite deciſive, except recourſe be had to boiling the water, and examining the nature of the precipitate which is thereby produced. The moſt delicate re-agent for this earthy ſalt, is Brazil wood, the bright red of which is changed to a blue; but the ſame change is produced by any alkali. Syrup of violets is likewiſe rendered green by this ſalt, as well as by alkalies.

(*a*) For a very intereſting account of this manufacture, ſee the Journal de Phyſique, for 1776.

7.—*Sulphat of Lime, Gypſum,* or *Selenite.*

This is one of the commoneſt of all the earthy ſalts that are found in natural ſprings, and generally accompanies every ſaline ſubſtance except where there is an exceſs of alkali. It is almoſt invariably found in conjunction with carbonat of lime, and hence, the calcareous depoſitions, petrifactions, and the like, frequently contain a ſmall admixture of ſelenite.

Sulphat of lime is a ſalt very ſparingly ſoluble in water, requiring 500 times its weight of that fluid for its ſolution, and gives it very little taſte, but imparts that rough and harſh feel to the fingers and tongue, which characteriſes the inſipid *hard* waters. This quality of hardneſs is very inconvenient in domeſtic purpoſes, as the ſelenite decompoſes or curdles ſoap, owing to a mutual ſeparation of the ingredients of each; the oil of the ſoap uniting with the lime into curdy inſoluble flakes, and its alkali combining with the ſulphuric acid. Selenitic waters are, however, in general, clear and well taſted. When ſuch a water is evaporated, the earthy ſalt gradually falls to the bottom in the form of grey ſcales, in proportion as the water which held it in ſolution is diſſipated; but mere boiling will not produce this precipitation, as it does with carbonat of lime. Hence it is, that hard waters which have been employed for moſt culinary purpoſes, for making tea or brewing malt liquors, remain equally ſelenitic after theſe proceſſes as before. Sulphat of lime is not certainly detected by any ſingle teſt; but its component parts, lime and the ſulphuric acid, may be aſcertained ſeparately by different re-agents. Every earthy ſalt will curdle ſoap, but when an inſipid water produces this effect, we may in general infer the preſence of ſulphat of lime; almoſt all the other earthy ſalts having a very ſenſible taſte. Spirit of wine, which will precipitate every ſalt with the ſulphuric acid out of the water in which it is diſſolved, if ſufficiently concentrated, poſſeſſes this power to a remarkable extent with ſulphat of lime; for, as Kirwan obſerves, it will immediately precipitate one grain of this earthy ſalt out of 1000 grains, or about two ounces of water; and therefore this is a teſt of conſiderable delicacy.

8.—*Muriat of Lime.*

The falt produced by the union of lime with the muriatic acid, is found in a great variety of fprings, efpecially in the brine fprings, where it is a troublefome ingredient. It is bitter to the tafte, very foluble both in water and fpirit of wine, and very deliquefcent. It is almoft always accompanied with falt, from which it is with difficulty feparated in manufacturing this article. The great bitternefs of fome falt waters, fuch as thofe of the Dead Sea, is owing to the muriats of lime and of magnefia, and not to bitumen, as was erroneoufly fuppofed. Muriat of lime is not difcoverable with certainty by any fingle teft.

In all the falts with the bafis of lime, this earth is precipitable from any combination by the oxalic acid, or acid of fugar. This acid unites with the lime, and forms a compound, which, being nearly infoluble in water, falls to the bottom of the liquor, and by collecting, drying, and weighing this precipitate, the weight of the pure lime may be inferred. Lime is not precipitated from its acid folutions by pure ammonia, which is an important circumftance in analyfis, as it is thereby diftinguifhable from magnefia and aluminous earth, which are both feparated from their acids by cauftic volatile alkali. But the mild or carbonated ammonia, will decompofe all the earthy falts by double affinity, the alkali uniting with the acid of the earthy falt, and the carbonic acid with its earth; and as the cauftic ammonia is highly difpofed to attract carbonic acid from the air, when ufed as a re-agent, it fhould be mixed in a phial with the folution to be examined, and clofely corked.

MAGNESIAN SALTS.

Magnefia is an earth that is found almoft as widely diffufed in the mineral waters of different countries as lime is, but generally not in fuch quantities. We have no inftance of magnefian depofitions from ſprings, to an extent nearly equal to the calcareous. Magneſia is found in union with the ſame acids as lime, and ſome of the ſalts of the one, reſemble much in ſome properties thoſe of the other.

9.—*Carbonat of Magneſia.*

Water, ſaturated with carbonic acid, is capable of diſſolving $\frac{1}{300}$ of its weight of the pulverulent carbonated magneſia, and hence the ſolubility of this earth is greater than that of lime. Magneſia, even in the ſolid ſtate, when fully ſaturated with carbonic acid, is ſoluble in water without any exceſs of this acid. Hence it is, probably, that this earth is not ſo readily ſeparable from water by mere boiling, as lime, but continues to be depoſited in minute quantities during the whole proceſs of evaporation. It is always accompanied with carbonated lime in natural waters, and hence the firſt ebullition of this water for a few minutes, precipitates all the lime, and the greater part of the magneſia. Carbonated magneſia produces the ſame change upon Brazil wood and ſyrup of violets as carbonated lime.

10.—*Sulphat of Magnesia, Epsom Salt, or Bitter Purging Salt.*

The moſt important of the magneſian ſalts, is formed by the union of that earth with the ſulphuric acid. This ſalt is readily ſoluble in water, but not in ſpirit of wine, is cryſtallizable but ſomewhat deliqueſcent, has a ſtrongly bitter and ſaline taſte, and in a moderate doſe proves purgative. It was firſt diſcovered in a well at Epſom, whence its name; and has been found in a great variety of ſaline ſprings, almoſt always combined with Glauber's ſalt and ſelenite, often with a chalybeate, and frequently in ſuch quantities as to render the water that contains it ſenſibly purgative in a moderate doſe. Almoſt all the natural purging waters owe their property to this ſalt combined with ſulphat of ſoda. Sulphat of magneſia abounds in many parts of Spain and Bohemia, but the large quantity of this ſalt that is uſed in medicine, either as a purgative, or in the preparation of common magneſia, is prepared from the refuſe ſalt of ſea water, after the common ſalt has been extracted (*a*). There is no single test to discover this salt, and, in procuring the contents of any water which contains this salt along with sulphat of soda, or Glauber's salt, it is not possible to separate them entirely by mere crystallization, as they have nearly the same solubility in water, and form of crystals. Lime water will distinguish the one from the other, by decomposing the sulphat of magnesia, but not the sulphat of soda. For the purposes of medicine it is seldom requisite to separate them, as their effects are so much alike.

11.—*Muriat of Magnesia.*

This is a salt difficult to be crystallized, very soluble in water and in alcohol, very deliquescent, of a nauseous bitter and saline taste; is found in various brine springs, and forms a considerable part of the saline contents of sea water. It is this salt which gives the bitterness to sea water, and as it does not easily crystallize, it remains in the *mother liquor*, as it is called, or the liquid residuum, after the common salt has been sepa-

(*a*) See the note to the next article.

rated in a ſolid form, during thoſe proceſſes in which ſea water is boiled down, or otherwiſe evaporated to obtain its ſalt (*a*). In ſeparating different ſalts for the purpoſe of analyſis, advantage is occaſionally taken of the property of ſome, (ſuch as the muriated magneſia) to attract moiſture from the air, and run into a liquid ſtate, whilſt others (ſuch as common ſalt) remain permanent in the air. Muriated magneſia is not indicated by any ſingle teſt.

In all the magneſian ſalts, this earth is precipitated by cauſtic ammonia, and thus diſtinguiſhed from lime; it differs from aluminous earth, in the readineſs with which this decompoſition takes place, as well as in

(*a*) In ſome parts of the kingdom on the ſea coaſt, eſpecially at Lymington in Hampſhire, the culinary ſalt is obtained from ſea water by firſt expoſing the freſh brine to the air in ſhallow ſquare pits lined with hard clay, by which it loſes much of its ſuperfluous water, and the ſaline ſolution becomes proportionably concentrated. The brine is afterwards boiled down and clarified, till it yields the muriated ſoda in a ſtate of purity. The muriated magneſia that remains, is then decompoſed by means of green vitriol, and ſulphat of magneſia and muriat of iron are formed. The Epſom ſalt is then obtained in a cryſtallized ſtate, ſeparate from the iron, and other impurities of the reſiduum of the brine, and exported for ſale.

the eafe with which the magnefian precipitate is foluble in cold dilute fulphuric acid.

ALUMINOUS SALTS.

Salts, with the bafis of alumine, or the earth of pure clay, are but rarely found in any mineral waters. Aluminous earth has been found in folution with the three acids, that are moft commonly joined to the two preceding earths, the carbonic, fulphuric, and muriatic, but none requires particular notice except the

12.—*Sulphat of Alumine*, or *Common Alum.*

This falt is foluble in its own weight of boiling water, but requires a much larger proportion of cold water. It readily forms cryftals, permanent in the air, and has an acid and very aftringent tafte. Alum poffeffes naturally an excefs of acid, which is neceffary to the conftitution of this falt, and therefore it fhews with different re-agents the fame appearances as an uncombined acid. Alum is but rarely contained in mineral waters, and is generally found affociated with fulphat of iron. It is produced by the ſpontaneous decompoſition of aluminous pyrites (a natural union of ſulphur and aluminous earth), and as this earthy mixture is generally combined with iron pyrites, any ſpring of water that flows in the neighbourhood, will hence contain both alum and vitriolated iron. It ſhould be remarked, that the term *aluminous* has often been applied indiſcriminately to any very hard water, which has a harſh taſte, and readily curdles ſoap.

ALKALIES.

Of the three alkalies, there is but one, the mineral alkali, which is at all abundant in mineral waters, either in combination with a fixed acid, or with the carbonic. It is only in the latter caſe that it ſhews alkaline properties to the taſte, and with different re-agents.

13.—*Carbonat of Soda, Natron,* or *Mild Mineral Alkali.*

This alkaline ſalt is found very partially, but ſometimes in vaſt quantities. The moſt remarkable waters that contain this alkali are thofe of certain lakes, efpecially the natron lakes in Upper Egypt. It is here often mixed with common falt, and they both are largely diffolved in the water, and form a cruft of feveral feet in thicknefs at the edge of the lake, owing to the copious evaporation of their water of folution, effected by a tropical fun. Befides thefe large refervoirs of this valuable alkali, there are fome fprings in different countries which contain it in fmall quantities, but enough to receive thereby very fenfible properties, and it is often fuperfaturated with carbonic acid. The valuable waters of Seltzer are of this kind, and they therefore fhew at the fame time the tefts of an acid and an alkali. The alkalies, either pure or carbonated, will turn fyrup of violets green, and Brazil wood purple; in which properties they are imitated by the carbonats of lime and magnefia; but the diftinguifhing teft of an alkali is, to turn the yellow of turmeric to an orange or brick red, which the carbonated earths will not do. Carbonated foda is readily procured from its folutions by evaporation and cryftallization; or, the quantity of uncombined alkali in any water may be determined by ſaturating it with an acid of known ſtrength, and eſtimating the quantity neceſſary for that purpoſe.

14.—*Carbonat of Ammonia*, or *Mild Volatile Alkali.*

This alkali is likewiſe met with in a few ſprings, though very rarely. It is ſuſpected to originate in all theſe caſes from ſome decompoſed animal or vegetable matter; and this is very probable, as all the ammonia which is procured artificially, has its origin from the vegetable, or, more eſpecially, the animal kingdom. Carbonat of ammonia is ſeldom contained in any water ſo largely as to be immediately perceptible to the ſenſes, or even to chemical teſts; but as it is readily volatilized by a moderate heat, it may be brought into a concentrated form by boiling any water in which it is diſſolved, when the ammonia riſes along with the firſt aqueous vapour, and is entirely condenſed in the firſt portion that is diſtilled. This will then give the uſual teſts of the volatile alkali, ſuch as precipitating a ſolution of ſulphat of copper, and re-diſſolving the oxyd of copper into a blue liquor.

ALKALINE NEUTRAL SALTS.

Of all the neutral ſalts which chemiſtry is able to exhibit, by the combination of every acid with each of the alkalies, there are only two that require any notice as contents of any mineral water. The alkali of each is ſoda, and the acids, are the ſulphuric and the muriatic.

15.—*Sulphat of Soda*, or *Glauber's Salt.*

This ſalt is found very frequently in various lakes and ſprings, aſſociated with a great number of other ſaline ſubſtances, and often in ſuch a quantity as to give a very conſiderable purgative effect. Sulphat of ſoda is very ſoluble in water, and contains half its weight of water of cryſtallization, the greater part of which flies off on expoſure to dry air, leaving the ſalt in a white pulverulent ſtate, and proportionally ſtronger of its ſaline ingredients. To the taſte it is bitter, ſalt, and cooling to the tongue. It cryſtallizes with great eaſe by evaporation and ſubſequent cooling, and is a ſalt which is for the greater part readily ſeparable from water. As it is often found in conjunction with ſulphat of magneſia, and cryſtallizes at the ſame time, theſe two ſalts are not eaſily procured in a ſeparate ſtate.

16.—*Muriat of Soda*, *Common* or *culinary Salt*.

This ſalt, of all others the beſt known, and moſt extenſively employed, is alſo one that is the moſt univerſally and largely diffuſed over every part of the globe. Beſides the immenſe ſtorehouſe for this ſalt in the waters of the ocean, it is found in a more concentrated ſolution in various lakes and brine ſprings, and in vaſt ſolid maſſes on the ſhores of different lakes, or many fathoms beneath the ſurface of the earth in beds that are worked as mines. In moſt of the common ſprings however, or even in thoſe that are uſed medicinally, the muriat of ſoda is not found in nearly ſo large a proportion as in ſea water, and therefore in theſe it is only a ſalt of inferior conſequence. Common ſalt cryſtallizes in cubes, and only by evaporation of the water in which it is diſſolved: when not mixed with an earthy ſalt, it is not in the leaſt deliqueſcent, and is particularly acceptable from its poſſeſſing a ſimple ſaline taſte, unmixed with any thing nauſeous or bitter. It is never found alone, however, in any natural ſolution; but, as Kirwan obſerves, unleſs accompanied with ſoda, it always is with ſelenite. It is not ſoluble in alcohol, nor can it be detected by any ſingle teſt, but is readily aſcertained when ſolid, by its cubical form, and by various re-agents.

IRON.

As this metal is abundant in every part of the earth, we may expect to find it as a very common ingredient in the various ſprings that riſe from beneath the ſurface; and accordingly it is the metal which of all others is met with moſt frequently in mineral waters, and the moſt readily detected, even in very minute quantities. Water that holds this metal in ſolution, is called a *chalybeate* water; and is characteriſed by a peculiar inky taſte, which is very perceptible, even where the proportion of iron is fo fmall as hardly to be eftimable by any chemical procefs. There are two folutions of this metal which are met with in mineral waters, that in the carbonic and the fulphuric acids, and fometimes the fame water holds both thefe falts in folution.

17.—*Carbonat of Iron.*

Water, well faturated with carbonic acid, will diffolve about $\frac{1}{10000}$ of its weight of iron, as Bergman obferves; but, for this effect, it is neceffary that the iron fhould be in the reguline ftate, or at leaft fo little oxydated as to be ftill magnetical. Iron is feldom met with under this form, compared to the frequency with which it occurs as a perfect oxyd: otherwife, if the latter were equally foluble with the former, almoft every natural water would be a chalybeate. The carbonated chalybeates are in general perfectly clear when frefh from the fpring, but the affinity of the carbonic acid is fo fmall, that they foon grow turbid when expofed to the air, and gradually depofit a fine ochre, or carbonated oxyd of iron, which partly precipitates to the bottom of the veffel in which the water is contained, and partly fwims on the furface in the form of a fine iridefcent pellicle. The water is by this means entirely freed from every particle of iron, and will no longer indicate this metal by the moft delicate tefts. This feparation likewife occurs, if the frefh water be kept in a bottle only half full, or carelefsly corked. The walls of every chalybeate well, and the channels through which the water flows, are alfo lined with the fame oxyd, forming a very good indication of the nature of the fpring. The ochre, when analized, is found to be compofed of iron, oxygen, carbonic acid, and water. An artificial folution of iron in carbonic acid (firft noticed by Mr. Lane, and which cleared up every doubt on this fubject) may be very readily made, by agitating for a few minutes, iron wire or filings in a bottle filled with water faturated with this acid gas; and this folution is a perfect imitation of moft of the fimple natural chalybeates. Cauftic alkalies feparate the iron intirely, but the aerated alkalies re-diffolve a part of the precipitated oxyd, as Bergman obſerves, and thus the exiſtence of carbonated iron, and carbonated alkali in the ſame water, are not incompatible. The carbonated chalybeates are by far the moſt frequent, and the iron is readily diſcovered by the teſts of gall-nuts in any form, and the pruſſiated lime or alkalies.

18.—*Sulphat of Iron*, or *Green Vitriol.*

This ſalt which is not very unfrequent in mineral waters, though much leſs common than the laſt mentioned chalybeate, is the natural product of the ſpontaneous decompoſition of martial pyrites, and is procured largely from this ore for the purpoſes of manufacture. Sulphat of iron, when cryſtallized, has a fine emerald green colour, a ſtrong chalybeate aſtringent taſte, rather effloreſces in the air, and is eaſily ſoluble in water. There is one circumſtance regarding this ſalt which deſerves notice, as it explains the nature of this ſpecies of chalybeates. Iron when in ſolution with different acids exiſts in two degrees of oxygenation, but when in the loweſt degree, it has a ſtrong tendency to attract oxygen from every ſurrounding body that will yield it, and thus to reach the higheſt degree. Pure ſulphat of iron contains the metal only in the loweſt ſtate of oxygenation; but when it is diſſolved in water that contains common air, or has acceſs to the atmoſphere, an additional quantity of oxygen is abſorbed by the oxyd, it thereby becomes inſoluble, and precipitates in the form of a brown ochre. Hence it is, that theſe chalybeates depoſit an ochery ſediment as well as thoſe with carbonated iron, but from a different cauſe; as in the former caſe it is owing to mere abſorption of oxygen, in the latter, to a loſs of carbonic acid. A ſolution of ſulphat of iron is therefore in ſome degree a pretty good teſt for ſhewing the preſence of oxygen or common air diſſolved in waters (*a*).

(*a*) This is ſhewn in a ſtriking manner by putting in ſeparate bottles, cloſely corked, a ſolution of ſulphat of iron in diſtilled water newly boiled, and alſo in the ſame water after it has been violently agitated for a few minutes in a bottle half full, by which it will be made to abſorb air. In a few hours the latter ſolution will depoſit a fine flocculent precipitate, while the former will remain clear.

The presence of the sulphat of iron in any kind of chalybeate water, is detected by its affording a purple or black precipitate with any solution either watery or spirituous, of the gall-nut, or any vegetable astringent. The colour of the precipitate, and the time that it requires to be formed, are likewise in some degree tests of the quantity of iron; for if it is but small, the colour is only a light purple, is some minutes before it appears, and never reaches a full black by long standing. Where the proportion of this metal is very small, it is often necessary to use a piece of the gall-nut, or what is better, of the concrete acid of galls, instead of any solution. Alkalies or lime, united with the acid of Prussian blue, are likewise very delicate tests of iron, by affording a blue precipitate when any ascertainable quantity of this metal is present. But little iron is contained even in the strongest of the chalybeate waters, and yet there is no proportion, however small, which is not perceptible to the taste, when there is sufficient to be indicated by any of the chemical re-agents.

COPPER.

This metal hardly comes under notice in a medical view as an ingredient in mineral ſprings, as it is never uſed medicinally in this ſtate, and only requires to be detected to be avoided. There are, indeed, ſeveral natural waters that contain ſulphat of copper, formed, probably like ſulphat of iron, by the decompoſition of copper pyrites, and conſequently are found in the neighbourhood of copper mines, often conſtituting a very valuable part of their riches.

The copper is indicated by forming a cupreous cruſt on a piece of bright poliſhed iron, that has been immerſed for ſome time in the water, or by receiving a beautiful blue purple colour from the addition of ammonia.

BITUMEN.

For want of accurate definitions of this term, ſeveral ſubſtances have been miſtaken for bitumen, in various mineral waters, where modern analyſis has otherwiſe accounted for the ſenſible properties which were aſcribed to it. So, the bitumen of ſome chemiſts was a vegetable extractive matter, which was imagined to give the ſulphureous odour to thoſe waters in which ſulphur in ſubſtance was not to be detected, and which effect is now known to be produced by ſulphurated hydrogenous gas, as has been already mentioned. The bitumen of other chemiſts, was that which gives the bitter nauſeous taſte to ſea water and many brine ſprings, which is in fact owing to the muriats of lime and magneſia. The proper bituminous ſubſtances are mineral inflammables, which are in no way ſoluble in water by themſelves, and which, by combuſtion, are chiefly reſolved into carbonated hydrogenous gas. Petroleum, amber, pit-coal, and the like, are of this ſpecies. A few natural ſprings of petroleum are known, and along with theſe, ſprings of water ſometimes riſe, but theſe two ſubſtances do not apparently mix, the former being found floating on the latter. If ever bitumen enters into the compoſition of a mineral water, it is probably through the medium of an alkali, forming a kind of ſoap.

21.—*Siliceous Earth.*

When very minutely divided, this earth is readily ſuſpended in a ſmall proportion by running waters, and is depoſited gradually on their remaining at reſt. But very little, however, is taken up in this way, for the pureſt of all ſprings are thoſe that flow from ſiliceous rocks, where they are expoſed to conſtant agitation, a circumſtance which would much favour the ſuſpenſion of any earth. Silex, however, has been found apparently in a ſtate of true ſolution in ſome hot and tepid ſprings, eſpecially in the neighbourhood of volcanoes. It is in theſe ſubterranean laboratories that water, probably expoſed to great preſſure, as well as heat, becomes ſuper-ſaturated with ſiliceous earth, which it depoſits in a ſemi-cryſtalline form as ſoon as it obtains acceſs to the external atmoſphere. The fact of a natural water containing this earth in true ſolution, was firſt aſcertained by the late eminent profeſſor at Edinburgh, Dr. Black; and the chalcedony which encruſts the margin of the boiling ſprings near Hecla in Iceland, appears to be a ſpontaneous depoſition from this ſingular ſpecies of mineral water. In theſe waters, the ſilex is accompanied by a ſmall exceſs of ſoda, but not enough to be at all equal by itſelf to the ſolution of this earth. Siliceous earth has alſo been found in other waters, though in much leſs quantity; but its ſolution in water is a natural proceſs, which is one that art cannot imitate with any ſucceſs. The preſence of ſilex is only aſcertained by evaporating the water to dryneſs, and treating the reſiduum with water, and different acids, till every thing is taken up that is ſoluble in theſe menſtrua. What remains is ſilex, which is diſtinguiſhed by fuſing on the blow pipe with carbonated ſoda into a perfect glaſs.

22.—*Alumine,* or *Pure Clayey Earth.*

This earth is entirely inſoluble in pure water by any artificial means, and appears to be equally ſo, by any natural proceſs. Owing, however, to the great fineneſs of its particles, and the quantity of water with which it combines, it remains very long ſuſpended, gives a milkineſs and opacity to water, and a ſmooth unctuous feel, and requires a long filtration to be entirely separated. Clay, when baked, loses its diffusibility in water, becomes harsh to the feel, and materially altered in its properties.

The various earths, metals, alkalies, and acids, along with their several combinations which have been enumerated, form the most important of what may be considered as the proper foreign contents of mineral waters, or those with which the water becomes impregnated when flowing beneath the surface of the earth. When they flow within a channel over the surface of the ground, they often become much changed in their chemical composition, losing some of their contents by evaporation, others by slow deposition, or by being decomposed through the influence of the light and air. At the same time they often acquire new contents, which are furnished by the soil over which they flow. Thus the streams which pass over a country covered with vegetable matter, or which water large towns, will contain a ſenſible quantity of mixed alluvial contents, a heterogeneous compound of animal and vegetable extract, of mucilage, of carbonaceous matter, held partly in a ſtate of ſolution; occaſionally will contain nitrous, phoſphoric, and ammoniacal ſalts, and beſides are contaminated with an infinite number of living animals, which are perpetually growing, multiplying, and periſhing in the element that affords them habitation and ſubſiſtence.

CHAP. III.

ON THE PARTICULAR WATERS IN COMMON USE.

There is a great variety of waters employed in the preparation of food, in manufactures, and domeſtic purpoſes, where the object is to uſe a ſimple pure water; and all the foreign matter which the liquid may contain, is conſidered as detrimental, or, at beſt, uſeleſs. Some notice of theſe is requiſite, on account of the abundant daily uſe which we make of them, and the various ſubſtances which they contain ſhould be noticed, as they here conſtitute mere impurities, ſome of which are innocent, others prejudicial; ſome may be got rid of by ſimple methods, others can only be removed by chemical proceſſes, which can ſeldom be adopted for common uſe. As the ſtandard of perfectly pure water, we muſt have recourſe to that which is artificially purified by diſtillation, for every natural water contains ſome foreign ingredients; and the excellence of theſe waters is directly in proportion as it approaches in properties to that which is diſtilled.

1.—*Diſtilled Water.*

This is the lighteſt of all others, containing neither ſolid nor gaſeous ſubſtances in ſolution; is perfectly void of taſte and ſmell; colourleſs, and beautifully tranſparent; has a ſoft feel, and wets the fingers more readily than any other. It mixes uniformly with ſoap into a ſmooth opaline mixture, but may be added to a ſolution of ſoap in ſpirit of wine without injuring its tranſparency. The clearneſs of diſtilled water is not impaired by the moſt delicate chemical re-agents, ſuch as lime water, a ſolution of barytes in any acid, nitrated ſilver, or acid of ſugar. When evaporated in a ſilver veſſel, it leaves no reſiduum; if preſerved from acceſs of foreign matter floating in the air, it may be kept for ages unaltered, in veſſels upon which it has no action, as it does not poſſeſs within itſelf a power of decompoſition. As it freezes exactly at 32° of Fahrenheit, and boils at 212°. under the atmoſpherical preſſure of 29. 8°.

inches, thefe points are made ufe of as the ftandard ones for thermometrical divifion; and its fpecific weight being always the fame under like preffure and temperature, it is employed for the comparative ftandard of fpecific gravity.

Pure diftilled water can only be procured from a water which contains no volatile matters that will rife in diftillation, and continue ftill in union with the vapour when condenfed. Many fubftances are volatile during diftillation; but moft of the gafes, fuch as common air, carbonic acid, and the like, are incapable of uniting with water at a high temperature: other bodies, however, fuch as vegetable effential oil, and in general much of that which gives the peculiar odour to vegetable and animal matter, will remain in water after diftillation. So, the fteam of many animal and vegetable decoctions has a certain flavour which diftinguifhes it from pure water, and the aqueous exhalation from living bodies, which is a kind of diftillation, has a fimilar impregnation.

To obtain diftilled water perfectly pure, much ftrefs was laid by former chemifts on repeating the procefs a great number of times; but it was found by Lavoifier, that rain water once diftilled, rejecting the firft and laft products, was as pure a water as could be procured by any fubfequent diftillations.

Diftilled water appears to poffefs a higher power than any other, as a folvent of all animal and vegetable matter, and thefe it holds in folution, as little as poffible altered from the ftate in which they exifted in the body that yielded them. Hence the great practical utility of that kind of chemical analyfis which prefents the proximate conftituent parts of thefe bodies, and which is effected particularly by the affiftance of pure water. On the other hand, a faline, earthy, or otherwife impure water, will alter the texture of fome of the parts, impair their folubility, produce material changes on the colouring matter, and become a lefs accurate analyfer, on account of the admixture of foreign contents.

Diftilled water is feldom employed to any extent in the preparation of food, or in manufactures, on account of the trouble of procuring it in large quantities; but for preparing a great number of medicines, and in almoſt every one of the nicer chemical proceſſes that are carried on in the liquid way, this water is an eſſential requiſite.

The only caſes in which it has been uſed largely as an article of drink, have been in thoſe important trials made of the practicability of procuring it by condenſing the ſteam of ſea water, by means of a ſimple apparatus adapted to a ſhip's boiler; and theſe have fully ſhown the eaſe with which a large quantity of freſh water, of the pureſt kind, may be had at ſea, at a moderate expence; whereby one of the moſt diſtreſſing of all wants may be relieved. There are one or two circumſtances which ſeem to ſhew that water, when not already loaded with foreign matter, may become a ſolvent for concretions in the urinary paſſages. At leaſt we know that very material advantage has been derived, in theſe caſes, from very pure natural ſprings, and hence a courſe of diſtilled water has been recommended as a fair ſubject of experiment *(a)*.

(a) See Heberden in the Medical Tranſactions, vol. I.

2.—*Rain Water*.

The next in purity to diſtilled water, is that which has undergone a natural diſtillation from the earth, and is condenſed in the form of rain. This is a water ſo nearly approaching to abſolute purity, as probably to be equal to diſtilled water, for every purpoſe except in the nicer chemical experiments. The foreign contents of rain water appear to vary according to the ſtate of the air through which it falls. The heterogeneous atmoſphere of a ſmoaky town will give ſome impregnation to rain as it paſſes through, and this, though it may not be at once perceptible on chemical examination, will yet render it liable to ſpontaneous change; and hence, rain water, if long kept, eſpecially in hot climates, acquires a ſtrong ſmell, becomes full of animalcula, and in ſome degree putrid. According to Margraaff, the conſtant foreign contents of rain water appear to be ſome traces of the muriatic and nitric acids; but as this water is always very ſoft, it is admirably adapted for diſſolving ſoap, or for the ſolution of alimentary or colouring matter, and it is accordingly uſed largely for theſe purpoſes. The ſpecific gravity of rain water is ſo nearly the ſame as that of diſtilled water, that it requires the moſt delicate inſtruments to aſcertain the difference. Rain that falls in towns, acquires a ſmall quantity of ſulphat of lime and calcareous matter from the mortar and plaſter of the houſes (*b*).

Ice and Snow Water.

This equals rain water in purity, and when freſh melted, contains no air, which is expelled during freezing. In cold climates and

(*b*) This water, however, as *M. Guyton* ſays, may be rendered pure enough for all chemical purpoſes by the addition of a ſmall quantity of a ſolution of pure barytes, or *barytic lime water*, as it has been called. The barytes here precipitates along with the acid of the ſelenite; the lime is then left uncombined, and by abſorbing carbonic acid from the air, alſo falls to the bottom, and the water remains pure. The barytic ſolution is made from barytes procured by evaporating to dryneſs the nitrat of barytes, and driving off its acid by fire. *See the Annales de Chimie.*

in high latitudes, thawed ſnow forms the conſtant drink of the inhabitants during winter; and the vaſt maſſes of ice which float on the polar ſeas, afford an abundant ſupply of freſh water to the mariner. It is well known that in a weak brine, expoſed to a moderate freezing cold, it is only the watery part that congeals, leaving the unfrozen liquor proportionably ſtronger of the ſalt. The ſame happens with a dilute ſolution of vegetable acids, with fermented liquors and the like, and advantage is taken of this property to reduce the ſaline part to a more concentrated form.

Snow water has long lain under the imputation of occaſioning thoſe ſtrumous ſwellings in the neck, which deform the inhabitants of many of the Alpine vallies; but this opinion is not ſupported by any well authenticated indiſputable facts, and is rendered ſtill more improbable, if not entirely overturned, by the frequency of the diſeaſe in Sumatra, where ice and ſnow are never ſeen (*Marſden's Hiſt. of Sumatra*); and its being quite unknown in Chili. (*Eſſai ſur l'Hiſtoire Naturelle de Chili. Par l'Abbe Molini*); and in Thibet (*See an Account of the ſoil, climate, and natural pro-*

ductions of Boutan and Thibet, by R. Saunders, Esq. Phil. Trans. vol. 79) though the rivers of theſe countries are chiefly ſupplied by the melting of the ſnow, with which the mountains are always covered.

4.—*Spring Water.*

Under this comprehenſive claſs, are included all waters that ſpring from ſome depth beneath the ſoil, and are uſed at the fountain head, or at leaſt before they have run any conſiderable diſtance, expoſed to the air. It is obvious, that ſpring water will be as various in its contents as the ſubſtances that compoſe the ſoil through which it flows. When the ingredients are not ſuch as to give any peculiar medical or ſenſible properties, and the water is uſed for common purpoſes, it is diſtinguiſhed as a hard or ſoft ſpring, ſweet or brackiſh, clear or turbid, and the like. Ordinary ſprings inſenſibly paſs into mineral ſprings, as their foreign contents become more notable and uncommon; though ſometimes waters have acquired great medical reputation for mere purity. By far the greater number of ſprings are cold; but as they take their origin at ſome depth from the ſurface, and below the influence of the external atmoſphere, their temperature is in general pretty uniform during every viciſſitude of ſeaſon, and always ſeveral degrees higher than the freezing point. Others again ariſe conſtantly hot, or with a temperature always exceeding the ſummer heat; and the warmth poſſeſſed by the water is entirely independent of that of the atmoſphere, and varies little, winter or ſummer.

One of the principal inconveniencies in almoſt every ſpring water, is its hardneſs, owing to the preſence of earthy ſalts, which in by far the greater number of caſes, are only the inſipid ſubſtances, chalk and ſelenite, which do not impair the taſte of the water; whilſt the air which it contains, and its grateful coolneſs, render it a moſt agreeable, and generally a perfectly innocent drink; though ſometimes in weak ſtomachs it is apt to occaſion an uneaſy ſenſe of weight in that organ, followed by a degree of dyſpepſia. The quantity of earthy ſalts varies conſiderably; but in general it appears, that the proportion of five grains of theſe in the pint, will conſtitute a hard water, unfit for waſhing with ſoap, and for many other purpoſes of houſehold uſe or manufactures. The water of deep wells is always, *ceteris paribus*, much harder than that of ſprings which overflow their channel; for much agitation and expoſure to air produce a gradual depoſition of the calcareous earth, and hence ſpring water often incruſts to a conſiderable thickneſs the inſide of any kind of tube through which it flows, as it ariſes from the earth. The ſpecific gravity of theſe waters is alſo, in general, greater than that of any other kind of water, that of the ſea excepted. Springs that overflow their channel, and form to themſelves a limited bed, paſs inſenſibly into the ſtate of ſtream or river-water, and become thereby altered in ſome of their chemical properties.

5.—*River Water.*

This is in general much ſofter and more free from earthy ſalts than the laſt, but contains leſs air of any kind; for by the agitation of a long current, and in moſt caſes a great increafe of temperature, it lofes common air and carbonic acid, and with this laft, much of the lime which it held in folution. The fpecific grâvity thereby becomes lefs, the tafte not fo harfh, but lefs frefh and agreeable; and out of a hard fpring is often made a ftream of fufficient purity for moft of the purpofes where a foft water is required. Some ftreams, however, that arife from a clean filiceous rock, and flow in a fandy or ftony bed, are from the outfet remarkably pure. Such are the mountain lakes and rivulets in the rocky diftricts of Wales, the fource of the beautiful waters of the Dee, and numberlefs other rivers that flow through the hollow of every valley.—Switzerland has long been celebrated for the purity and excellence of its waters, which pour in copious ftreams from the mountains, and give rife to fome of the fineft rivers in Europe. An excellent obferver and naturalift, the illuftrious Haller, thus fpeaks of the Swifs waters:—"Vulgaribus aquis Helvetia fuper omnes fere Europæ regiones excellit. Nufquam liquidas illas aquas, & cryftalli fimillimas, fe mihi obtuliffe memini poftquam ex Helvetia exceffi. Ex fcopulis enim noftræ per puros ſilices percolatæ nullâ terrâ vitiantur.' Some of them never freeze in the ſevereſt winter, the cauſe of which is probably, as Haller conjectures, that they ſpring at once out of a ſubterraneous reſervoir ſo deep as to be out of the reach of froſt, and during their ſhort courſe when expoſed to day, they have not time to be cooled down from 53°, their original temperature, to below the freezing point*.

Some river waters however, that do not take their riſe from a rocky ſoil, and are indeed at firſt conſiderably charged with foreign matter, during a long courſe even over a rich cultivated plain, become remarkably pure as to ſaline contents, but often fouled with mud, and vegetable or animal exuviæ, which are rather ſuſpended than held in true ſolution. Such is that of the Thames, which, taken up at London at low water, is a very ſoft and good water, and after reſt and filtration, it holds but a very ſmall portion of any thing that could prove noxious, or impede any manu-

* See Haller's *Hiſtoria Stirpium Indigenarum Helvetiæ*, in the author's Introductory Preface.

facture. It is alſo excellently fitted for ſea ſtore; but it here undergoes a remarkable ſpontaneous change. No water carried to ſea becomes putrid ſooner than that of the Thames. When a caſk is opened after being kept a month or two, a quantity of inflammable air eſcapes, and the water is ſo black and offenſive as ſcarcely to be borne. Upon racking it off, however, into large earthen veſſels (oil jars are commonly uſed for the purpoſe), and expoſing it to the air, it gradually depoſits a quantity of black ſlimy mud, becomes clear as cryſtal, and remarkable ſweet and palatable.

The Seine has as high a reputation in France, and appears from accurate experiment to be a river of great purity (*a*). It

(*a*) See *Parmentier ſur les eaux de la Seine*, a paper inſerted in the *Journal de Phyſique* for 1775. Some doubts having been thrown on the ſalubrity of this water, the Faculty of medicine appointed a committee of eminent chemiſts to examine it. By their report it would appear, that the Seine water is purer even than Briſtol water, and more ſo than the different ſtreams around Paris, its tributaries. It contains only 5 grains in the pint, of foreign contents, which are chiefly ſelenite, calcareous earth, nitre, and common ſalt. Rain water was found to be purer than might be expected that a river which has paffed by a large town, and received all its impurities, and been ufed by numerous dyers, tanners, hatters, and the like, that croud to its banks for the convenience of plenty of water, fhould thereby acquire fuch a foulnefs, as to be very perceptible to chemical examination for a confiderable diftance below the town; but it appears from the moft accurate examination that where the ftream is at all confiderable, thefe kinds of impurity have but little influence in permanently altering the quality of the water, efpecially as they are for the moft part only fufpended and not truly diffolved; and therefore mere reft, and efpecially filtration, will reftore the water to its original purity. Probably therefore, the moft accurate chemift would find it difficult to diftinguifh water taken up at London, from that procured at Hampton-

Seine water frefh from the river, but lefs fo than Seine water once diftilled. There was no perceptible difference between the water taken up at Paris, and fome miles higher up, after the former had been filtered. Mr. Parmentier obtained nearly the fame refults with thofe of the committee.

court, after each had been purified by ſim-ple filtration.

6.—*Stagnant Waters.*

The waters that preſent the greateſt impurities to the ſenſes, are thoſe of ſtagnant pools and low marſhy countries. They are filled with the remains of animal and vegetable matter undergoing decompoſition, and during that proceſs becoming in part ſoluble in water, thereby affording a rich nutriment to the ſucceſſion of living plants and inſects which is ſupplying the place of thoſe that periſh. From the want of ſufficient agitation in theſe waters, vegetation goes on undiſturbed, and the ſurface becomes covered with conferva and other aquatic plants; and as theſe ſtanding waters are in general ſhallow, they receive the full influence of the ſun, which further promotes all the changes that are going on within them. The taſte is generally vapid, and deſtitute of that freſhneſs and agreeable coolneſs which diſtinguiſh ſpring water. However, it ſhould be remarked, that ſtagnant waters are generally ſoft, and many of the impurities are only ſuſpended, and therefore ſeparable by filtration; and perhaps the unpalatableneſs of this drink has cauſed it to be in worſe credit than it deſerves on the ſcore of ſalubrity. The decidedly noxious effects produced by the *air* of marſhes and ſtagnant pools, have been often ſuppoſed to extend to the internal uſe of theſe waters; and often, eſpecially in hot climates, a reſidence near theſe places has been as much condemned on one account as on the other, and in like manner an improvement in health has been as much attributed to a change of water as of air.

The quality of water is highly important in a number of arts and manufactures, in medicine and in domeſtic uſe; and the effects produced by ſome of the foreign contents, are more than might at firſt be imagined, conſidering the ſmallneſs of their actual quantity. Several manufactures have acquired a ſuperiority in particular places from an excellence in the water employed in them; and, in general, this is in proportion to its purity, but ſometimes proceeds from an exceſs in ſome one of the foreign contents. It is eſpecially where water is uſed to extract the ſoluble parts of vegetable or animal matter, that its degree of purity, in large manufactures, is of conſequence. The admixture of earthy neutral or metallic ſalts, will in many caſes not only alter the power of water as a ſolvent, but will produce eſſential changes on ſome of the ſubſtances when diſſolved. Water, as M. Berthollet obſerves, affects the colouring matter of vegetables by the ſalts which it contains. All ſalts with an earthy baſis oppoſe the ſolution of colouring matter; cauſe various kinds to precipitate in conſequence of combining with the earth, and render the colour deeper and more full. Beſides, the carbonats of lime and magneſia precipitate their earth upon the ſtuff, during boiling, and prevent the acceſs of the colouring particles. Therefore the dyer ſhould chooſe ſoft water which is clear, without ſmell, and which does not curdle ſoft ſoap. Some of the earthy ſalts are indeed uſed in dying, but that is with the intent of altering and heightening particular colours. Hard water is alſo improper for bleaching, as it curdles the ſoap employed in that proceſs, and the oily earth adheres to the ſtuff, leaving a yellow ſtain difficult to be got out (*a*).

In the preparation of animal ſkins, and in ſome other arts, water is uſed to extract all that is ſoluble in this liquid, and to leave the remaining ſubſtance proportionally clearer, or in ſome caſes to bring on a certain degree of fermentation or putrefaction, and thereby to alter the texture of bodies: in all theſe, it is evident that a ſoft water is preferable to one whoſe ſalts render it ſomewhat antiſeptic, and diminiſh its ſolvent powers. On the other hand, there are ſeveral ſaline ſubſtances which are very readily ſoluble in any kind of water, and here a hard water may be employed where the object is only to procure theſe particular ſalts. For culinary purpoſes, water is uſed either to ſoften the texture of animal or vegetable matter, or to extract from it, and preſent in a liquid form, ſome of its ſoluble parts. Soft pure water will fulfil both theſe objects better than hard water, and at the ſame time the colour of the ſubſtance em-

(*a*) See Bertholleu's admirable work *L'Art de la Teinture*.

ployed will vary, as well as its ſolution. Green vegetables and pulſe are rendered quite pale, as well as tender, by boiling in ſoft water, whereas in a hard water the colour is more preſerved and the texture leſs altered, becauſe in the former caſe the colouring matter of the vegetable is readily extracted by the menſtruum, whilſt in the latter, more of it remains, and is likewiſe altered by the chemical action of the earthy or neutral ſalts. The following ſimple experiments will illuſtrate theſe facts.

Experiment.—To half a pint of *cold* ſelenitic water, and to the ſame quantity of *cold* diſtilled water, were added, in ſeparate veſſels, half a dram of green tea. After ſtanding twelve hours, the infuſion in diſtilled water was higher coloured, more bitter than the other, and ſtruck a deeper black with muriated iron. The ſelenitic infuſion retained its earthy ſalt, and gave a copious precipitate with muriated barytes and oxalic acid; and the leaves that had been macerated in this water, had a harſh feel, and were ſtill corrugated and not opened by the infuſion, whereas thoſe in the diſtilled water were ſoft, open, and yellow, like tea leaves from which common tea has been made.

Experiment.——The ſame experiment was repeated as before, only that the tea was powdered, and the different waters added *boiling hot.* The ſelenitic infuſion was now rather higher coloured than the other, and equally ſtrong of the acid of galls, for in each ſolution the blackneſs produced by muriated iron appeared preciſely the ſame; it was taken away by the ſame number of drops of ſulphuric acid, and reſtored by the ſame quantity of carbonat of potaſh.

We ſee therefore by theſe experiments, that hard water is leſs powerful in ſoftening the texture of vegetable leaves than ſoft water, and that it is not able to exert its full effect in heightening their colour till aſſiſted by heat: and alſo, that the gallic acid is equally well extracted by hard as by ſoft water, when, by raiſing the temperature, the power of the former as a ſolvent is fully exerciſed.

Various methods have been ſuggeſted of correcting certain defects of particular waters, and making them approach more nearly in their properties to pure ſoft water.

Both chemical and mechanical means have been uſed with this intention; but it is very ſeldom that the former can be employed in an adequate degree, without altering the taſte; and thereby rendering the water unfit for drinking, though it may be uſeful for other purpoſes. All the earthy ſalts which would oppoſe the ſolution of ſoap, may be decompoſed by a mild alkali, which will cauſe the earth to precipitate, and the addition of ſo much alkali, and the converſion of an earthy into a neutral alkaline ſalt, will not injure the ſolvent powers of the water (*a*). Simple boiling will likewiſe ſoften thoſe waters whoſe hardneſs conſiſts in mere carbonated earths, eſpecially the calcareous. As this expels the carbonic acid, the earth ſubſides. This however will not remove ſelenite; and as moſt hard waters contain both theſe calcareous ſalts, boiling is only partially uſeful. Another and more extenſively applicable method is that of filtra-

(*a*) The aſhes of fern or wormwood, which contain a good deal of carbonat of potaſh, are often uſed in various parts of the country for ſoftening hard water for the purpoſe of waſhing.

tion. The principle of this procefs is, to caufe water that is foul, to pafs through the very minute pores of any fubftance not of itfelf capable of imparting any thing to the water; and by this means every thing which is fimply fufpended in the liquor, but fo intimately diffufed as not to be feparable by mere repofe, is detained in the filter, and the water paffes through clear and limpid. This is a procefs which is performed largely within the earth, and hence we find the pureft waters to arife through clean fand or filiceous rock. To imitate this natural procefs, nothing is better than the porous free-ftone of which filtering ftones are ufually made. Sand, clear gravel, pounded glafs, and fimilar fubftances, are equally fitted for this purpofe. Filtration may be performed either by caufing the water to defcend by its own weight through a porous fubftance, or to afcend through it by capillary attraction. The latter method, where it can be adopted, appears preferable. It is to be obferved, however, that common filtration will not render water lefs faline, or feparate any thing that is truly diffolved, but only what is fufpended. I have faid *common* filtration, for it has been ſuppoſed by ſome, that ſea water when paſſing up through a conſiderable ſtratum of ſand, may be deprived of its ſalt, as well as the impurities which viſibly foul it. It is certain that in many places remarkably good freſh water is found by digging a few feet in the ſand on the ſea ſhore, at a very ſhort diſtance from the high-water mark. This is the caſe at Yarmouth on the Norfolk coaſt, and the water procured from theſe wells, is purer than any other that is found about the town; but there is no direct evidence that this is ſea water filtered by aſcent through the ſand, ſince it may be well ſuppoſed to be freſh water riſing from a greater diſtance within land, that has undergone the laſt degree of purification, by its paſſage through the fine clear ſand of which the ſoil is compoſed, for a conſiderable diſtance off the ſea ſhore.

Again, there are numberleſs inſtances where ſprings of freſh water of great purity, unqueſtionably ariſing from the country higher up, are ſeen cloſe to the ſea ſhore. Thus at Scarborough, the haven is always left dry at low water, and at that time a number of freſh water ſprings are detected pouring their contents on the beach which is left bare by the tide. However the poſſibility of ſweetening ſalt water by mere filtration be determined, there is no method that we are yet acquainted with of performing this with ſufficient eaſe and expedition, to be employed for ordinary purpoſes. A turbid brine, by paſſing through a tub of clean ſand, will run through perfectly clear, but quite as ſalt as before. It appears, however, that an earth ſuſpended by carbonic acid, as for example, the carbonat of lime, will in a conſiderable degree be ſeparated in the filter, owing to the very divided ſurface of the water, by which much of this acid will be diſſipated; and thus a hard water will ſometimes be rendered ſofter, as well as clearer, by filtration.

CHAPTER IV.

ON PARTICULAR MINERAL WATERS.

IN this chapter, I propoſe to give an account of ſome of the celebrated mineral ſprings that are employed medicinally, eſpecially thoſe of our own country, or which are imported from foreign parts, and uſed in this kingdom as medicines, and are of acknowledged efficacy and eſtabliſhed reputation. A complete hiſtory of every circumſtance which is intereſting to the ſcientific and medical inquirer relating to any mineral water, embraces a number of particulars, all of which contribute to give a clear idea of its properties, and to determine the choice of the invalid.

The *hiſtory* of any celebrated ſpring, the firſt diſcovery of its remarkable powers, the gradual ſteps by which it has acquired a high degree of fame, and the elegant baths or other buildings which have contributed to its convenience and embelliſhment, are particulars which are entertaining and often inftruc-tive; and the fcientific reader will frequently find, that it is only by flow degrees that the efficacy of any mineral water in every fpecies of difeafe to which it is applicable, has been eftablifhed; as for inftance, where its ufe as a bath long preceded its employment as an internal remedy.

A collateral branch of inquiry of con-fiderable importance, is that of *fite*, under which term may be included all that relates to foil, general ftate of the atmofphere, purity of air, and face of the country around the fpot that is enriched by this natural treafure; and which are circum-ftances of no fmall confequence to the inva-lid, fince the advantages of air, exercife, and agreeable profpects, in moft cafes admirably coincide with the general curative effect of the fpring itfelf. Thefe advantages have often given a deferved preference to one water over another of equal medical powers, but placed in a lefs favoured fituation. The fite of the fpring itfelf, the ftrata of earth through which it penetrates, and the nature of the foil out of which it rifes into day, are alfo circumftances more particularly connected with, and often throwing much light on its chemical compofition.

In examining the water itfelf, the *fenfible properties* claim the firft notice, as by thefe we are often able to form a pretty accurate idea of the nature of its contents, efpecially thofe to which the peculiar medicinal effects are to be attributed. *The appearance to the eye*, that is, whether fparkling or quiet, clear or turbid, or with a flight fhade of colour; and efpecially the *tafte*, whether faline, chalybeate, or bitter; and the *fmell*, whether fetid, fulphureous, or fcentlefs; all thefe are circumftances of great importance, and naturally precede the chemical inquiries. The *temperature*, as determined by the thermometer, is alfo particularly to be noticed, as it fometimes forms the diftinguifhing feature of a feparate clafs of natural waters, and is independent of chemical compofition. After the fenfible properties have been afcertained, the nature and quantity of foreign contents are to be determined by accurate *chemical analyfis*, for it is by this alone, that we can come to a certain knowledge of the compofition of any mineral fpring. Chemifts are in the habit of ufing two methods for the analyſis of waters; the one, by teſts or re-agents, which being added to the ſubject to be examined, will produce either a change in colour, or more uſually a turbidneſs, and precipitation of one or other of its contents, generally in conjunction with a part of the re-agent; the other, by evaporating the water to dryneſs, and collecting and examining the gaſeous and ſolid contents which are ſeparated during the proceſs. Much praiſe is due to ſeveral eminent chemiſts of the preſent day (among whom we may particularly mention the Preſident of the Royal Iriſh Society, Mr. Kirwan) for improving and bringing to great perfection the analyſis by re-agents, and eſpecially by enabling the experimenter to employ this method for aſcertaining the quantity, as well as the nature of many of the foreign contents of natural waters; and this may prove of great convenience to the medical inquirer, as he may hereby, without much labour, gain a very accurate knowledge of thoſe ſubſtances which are peculiarly intereſting to him, and neglect thoſe which merely concern the chemiſt. We muſt not however intirely confine ourſelves to this method of analyfis; but, where it is applicable, it promifes great advantages on the ground of expedition and convenience.

The foreign contents of a mineral water being known, the next object of inquiry, is the *fenfible effects* which it produces on the human body on being received into the ftomach, as thefe directly indicate the cafes in which it may be applicable as a medicine, and lead to one of the moft important of all the ufes to which a natural fpring can be employed. To determine thefe with precifion, and efpecially to point out to which of the foreign contents they are to be attributed, often requires much judgment and obferva-tion; and in fact is one of the moft interefting fubjects connected with the hiftory of a mineral water. The circumftance of adding to the daily ingefta fo large a quantity of liquid, and alfo fome peculiarities in particular waters, likewife demand fome attention as to the *mode of ufing them*, the dofes which it is proper or fafe to begin with, the time of the day in which they fhould be employed, and the general mode of living which will in the beſt manner co-operate with theſe natural medicines. Theſe, with the requiſite duration of the courſe, and certain other local circumſtances, are generally laid down with great judgment and diſcretion by the writers and practitioners on the ſpot, to whom we may ſafely refer as the beſt authorities.

When all the particulars which I have enumerated are fully aſcertained, we may then look upon our knowledge of any of theſe ſalutary ſprings as complete, at leaſt as far as our preſent ſtate of information will allow, and we ſhall then be better prepared to make the moſt important uſe of the facts that we are poſſeſſed of, which is, a ſyſtematical arrangement of the materia medica of natural waters, founded on actual experiment, and of their application to every diſeaſe in which they promiſe to produce any benefit.

Writers on mineral waters have been at much pains to form an arrangement of the great variety of ſpecies that occur, the baſis of which is generally a claſſification of their foreign contents. This doubtleſs may be done to a certain degree, if we are not anxious to claſſify with too much minuteneſs; but great difficulties will always attend ſuch a diviſion, eſpecially as the diſtinction muſt in many caſes be entirely artificial.— The acquiſition of foreign ingredients to any natural ſpring of water, muſt often depend on accidental circumſtances, and, in general, nature ſeems to follow no rules for the formation of claſſes of mineral waters, except that of not counteracting the eſtabliſhed laws of chemical affinity. So we find the chalybeate principle either ſolitary, or united with a natural alkaline, or an earthy ſalt, and both in cold and thermal ſprings. Again, the mere circumſtance of temperature forms an important diſtinction in mineral waters, eſpecially with regard to their uſe as a bath in various diſeaſes; and here, pretty conſiderable differences of chemical compoſition are of little practical conſequence. Still, however, it is of conſiderable uſe, to arrange under ſome order the numerous individual ſprings that have the appellation of *mineral*, (and no order is ſo good as one founded on chemical diſtinction) where the object is to preſent a complete catalogue of all thofe that have acquired any degree of local celebrity; only, in proportion as chemical knowledge increafes, this mode of claffification muft undergo fucceffive alterations. Such, however, is not my object in the following pages; for, independently of the great extent requifite to notice every mineral water, there are a vaft number that are but little known and inquired into, and therefore the chemical analyfis of thefe muft be very imperfect; and there are ftill more, perhaps, whofe medical virtues may be referred to one or two well-known fubftances that exift in higher perfection in other and more frequented fprings.

I have therefore felected among a great number, thofe only that deferve particular attention, or have acquired great celebrity, or may be confidered as fair fpecimens of a numerous clafs. The order which I have preferred to follow, is chiefly that of degree of foreign impregnation with any thing that fhews a fenfible and ftriking difference from common water; beginning with the moft fimple, and proceeding to thofe that are the moſt compound, and whoſe analyſis is the moſt complicated. Some of theſe are to be conſidered as examples of a whole genus, as where the Malvern water is made the head of the remarkably pure waters, or the Tunbridge, of the ſimple chalybeates; others again, ſuch as that of Bath or Buxton, have been conſidered as peculiar natural productions, and on that account they are given without reference to any particular claſs. We have ſtill to regret conſiderable deficiencies in the analyſis of ſeveral waters, and inaccuracy in others; though in many caſes theſe more concern the curious than the directly uſeful part of the inveſtigation of mineral waters.

MALVERN WATER.

The extenſive and lofty range of the Malvern hills, diſtinguiſhed by the ſtriking elegance of their outline, occupies a great part of the ſouth weſt of the county of Worceſter, forming a diſtant boundary to the rich vale of the Severn lying to the eaſt, and ſtanding as a frontier between this county and that of Hereford. The range of hilly country which beautifully diverſifies the face of Herefordſhire, terminates in the Malvern hills, and from their ſummit the eye is gratified with a view of rich cultivation and natural beauty inferior to none which England can produce, conſiſting of numerous orchards, of large plantations of hops, and an agreeable mixture of open and arable land.

The village of Great Malvern, ſituated about half way between Ledbury and the city of Worceſter, has for many years been celebrated for a ſpring of remarkable purity, which has acquired the name of the Holy Well, from the reputed ſanctity of its waters, and the real and extenſive benefit long derived in various cafes from its ufe. The Holy Well iffues high up the hill, midway between the villages of Great and Little Malvern, from a foil which is chiefly limeftone, but interfperfed with a large quantity of quartz, and a hard red filiceous earth. The limeftone on the Herefordfhire fide is ufed largely both for burning into lime and for building.*

The Holy Well water, when firft drawn, appears quite clear and pellucid, and does not become fenfibly turbid on ftanding. It poffeffes fomewhat of an agreeable pungency to the tafte, but this is not confiderable. In other refpects, it does not differ in tafte from pure good foft water. With different reagents it fhews the following properties:

* See the Medical Tracts of the late John Wall, M. D. of Worcefter, firft publifhed in 1756, and fince re-publifhed by his fon Martin Wall, M. D. in 1780. The Treatife by Dr. John Wall on Malvern Holy Well is highly judicious and fenfible, and contains many ftriking cafes, but, from the time in which it was written, is defective in the chemical part. This is fupplied in a fatisfactory way in the Appendix given by his fon, along with valuable additions to the medical part. As the obfervations are all given from perfonal experience during a long refidence on the fpot, and appear perfectly authentic, we may rely with confidence on fuch refpectable authority.

On adding lime water to it fresh from the spring, a precipitate of fine flocculi was formed, shewing the presence of carbonic acid.

No alkali, however, caused any sensible turbidness, and with soap, the water mixed uniformly into a smooth opaline solution.

Nitrated silver gave a white precipitate, growing dark by exposure to air, which shewed the presence of some salt with the basis of muriatic acid.

Iron filings added to the fresh water, and the bottle corked up, were so far acted on as to give sensible tests of a chalybeate after standing some hours, indicating the presence of some disengaged carbonic acid.

On evaporating two pounds of the water to dryness, about two grains of an earth was left behind, which effervesced with dilute sulphuric acid; the water, when much concentrated, gave now some precipitate with a caustic alkali.

The absolute quantity of residuum is differently estimated. Dr. J. Wall evaporated, after a very dry season, three quarts of the water in a silver vessel, and found no other sediment than a slight trace or discoloration left upon the ſilver; and even after a rainy ſeaſon, only half a grain was collected from two quarts of water. Dr. Martin Wall, however, found a reſiduum of one grain in the pint of the freſh water; whence we may conclude, that it is not preciſely the ſame at every time, and is in ſome meaſure affected by the degree of moiſture of the ſeaſon; but even in its leaſt pure ſtate, it contains leſs ſolid matter than almoſt any other natural ſpring that we are acquainted with.

The contents of Malvern Holy Well, therefore are; ſome carbonic acid, which is in an uncombined ſtate, capable of acting on iron, and of giving a little taſte to the water, but the exact quantity of which has not been aſcertained; a very ſmall portion of earth, either lime or magneſia, united with the carbonic and marine acids; perhaps a little neutral alkaline ſalt; and a very large proportion of water; for we may add, that, the carbonic acid perhaps excepted, the foreign matter is leſs than that of any ſpring water which we uſe. No iron or metal of any kind is found in it, though there are chalybeates in the neighbourhood.

It is ſingular, that notwithſtanding its apparent purity, this water is ſaid not to keep well, and ſoon acquires a fetid ſmell by ſtanding in open veſſels. Dr. Wall conjectures, that part of this may be owing to the impurities of tubs and other veſſels being ſo readily ſoluble in this remarkably pure water.

Malvern water, like many others, was at firſt only employed as an external application, and this indeed is ſtill its principal uſe, though it is extended with ſome advantage to a few internal diſeaſes. It has been found highly efficacious in painful and deep ſeated ulcerations, the conſequence of a ſcrophulous habit of body, and which are always attended with much local irritation and often general fever. Applied to the ſore, it moderates the profuſeneſs of the diſcharge, corrects the fœtor which ſo peculiarly marks a caries of the bone, promotes the granulating proceſs, and a ſalutary exfoliation of the carious part; and by a long perſeverance in this courſe, very dangerous and obſtinate caſes have at laſt been intirely cured. Inflammation of the eye, eſpecially the ophthalmia which is ſo troubleſome in ſcrophulous habits, often yields to this ſimple application, and we find that for a great number of years, perfons afflicted with fore eyes, have been in the habit of reforting to Malvern Holy Well. Another order of external difeafes for which this water is greatly celebrated, is that which has been included under the general name of cutaneous eruptions; and even thofe obftinate cafes of dry defquamations, that frequently follow a fudden application of cold in irritable habits, are often cured by this remedy. Where the fkin is hot and dry, it remarkably relieves the intolerable itching of herpetic diforders, and renders the furface of the body more cool and perfpirable. It appears, however, from a nice obfervation of Dr. Wall, that this method of treatment is not fo fuccefsful in the cutaneous eruptions of very lax leucophlegmatic habits, where the extremities are cold, and the circulation languid; but that it fucceeds beft where there is unufual irritation of the fkin, and where it is apt to break in painful fiffures, that ooze out a watery acrid lymph. On the firft application of this water to an inflamed furface, it will often for a time increafe the pain and irritation, but theſe effects go off in a few days.

The great benefit ariſing from uſing Malvern water as an external remedy in diſeaſes of the ſkin and ſurface of the body, have led to its employment in ſome internal diſorders, and often with conſiderable advantage. Of theſe, the moſt important are painful affections of the kidnies and bladder, attended with the diſcharge of bloody, purulent, or fœtid urine; the hectic fever produced by ſcrophulous ulceration of the lungs, or very extenſive and irritating ſores on the ſurface of the body, and alſo fiſtulas of long ſtanding that have been neglected, and have become conſtant and troubleſome ſores.

The Malvern water, though unqueſtionably of great benefit in many of the caſes that we have juſt enumerated, is in general a perfectly ſafe application, and may be uſed with the utmoſt freedom, both as an external dreſſing for ſores, and as a common drink; and this is particularly the caſe with the common people that reſort to this ſpring for cutaneous complaints or other ſores, who are in the conſtant habit of dipping their linen in the water, dreffing with it quite wet, and renewing this application as often as it dries. The perfect fafety of this practice on a preternaturally irritated furface, has been afcertained by long experience, and is in itfelf an important circumftance in illuftrating the effect of moifture on the furface of the body.

The internal ufe of Malvern water, is fometimes attended at firft with a flight naufea, and not unfrequently for the firft day or two, it occafions fome degree of drowfinefs, vertigo, or flight pain of the head, which comes on a few minutes after drinking it. This effect Dr. Wall ingenioufly explains from the temporary plethora of the veffels of the head, occafioned by the great eafe and rapidity with which this pure liquid enters the abforbent fyftem. Thefe fymptoms go off fpontaneoufly after a few days, or may readily be removed by a mild purgative. The effects of this water on the bowels are not at all conftant; frequently it purges brifkly for a few days, but it is not uncommon for the body to be rendered coftive by its ufe, efpecially, as Dr. Wall obferves, with thofe who are accuftomed to malt liquors. In all cafes it decidedly increafes the flow of urine, and the general health of the patient; his appetite and fpirits almoft invariably improve during a courfe of the water, if it agrees in the firft inftance. To this, the fine mountain air, and beauty of the fituation, which tempt the invalid to active exercife, will doubtlefs much contribute; and the temperance and regularity of life which are generally obferved in thefe places by patients of every rank, will affift in fecuring the advantage which has been gained by the ufe of the water.

The duration of a courfe of Malvern water muft vary very confiderably, on account of the different kinds of difeafe for which this fpring is reforted to. Cafes of obftinate fcrophulous fores, efpecially with caries in any bone, are always long in healing, and require a refidence here for a confiderable time. The fame may be faid of very obftinate herpetic eruptions; but where the cutaneous affection is mild, or where a tendency to it comes on at ftated times, which is fometimes the cafe, this habit may be checked by a fhort ufe of this water; and hence fome perſons who are liable to this diſorder make an annual viſit to this ſalubrious ſpring. (*a*)

Adjoining to Great Malvern, and a little higher up the hill, is a very light, pleaſant, chalybeate water; but which, except the iron, held in ſolution by carbonic acid, is as free from foreign contents as the Holywell, and forms a valuable addition to the natural riches of this ſituation.

The Malvern water may be conſidered as the beſt ſpecimen that we poſſeſs of a remarkably pure natural ſpring, which has acquired a high reputation as a medicine: there are ſeveral others in this, as in moſt other countries, which have riſen to great conſequence, and have been in like manner celebrated in the cure of inflammations of the eyes, ſcrophulous ſores, and all cutaneous eruptions. Indeed it appears natural, in theſe unſightly and often loathſome diſorders, for the ſufferer to repair to the pureſt and moſt copious ſource of the

(*a*) As I think that the greater part of the good effects of this water are to be attributed to its purity, I ſhall take ſome further notice of it in the chapters on the medicinal uſe of *ſimple water*, at the end of the volume, to which I ſhall beg leave to refer the reader.

cleanſing element water, whoſe refreſhing coolneſs is ſo powerful in allaying irritation. One more example of this claſs deſerves ſome notice, for the celebrity which it formerly enjoyed on this account, and the ſanctity attached to its waters.

Saint Winifrede's well, in the pariſh of the town of Holywell, in the county of Flint, is one of the fineſt and moſt copious ſprings in the kingdom. (*a*) It riſes out of the lower extremity of a limeſtone rock, and boils up with great vehemence through the crevices of a handſome ſtone reſervoir. This is incloſed in a beautiful polygonal building, of the form of a temple in Gothic architecture, dedicated to the tutelary ſaint of the fountain, which preſerves its ſource from accidental pollution. From the ſpring head it flows into a ſpacious bath, neatly conſtructed of ſtone, and overflowing thence, it purſues its courſe in a deep ſtony channel, and forms a conſiderable ſtream; which, in the ſhort courſe of two miles to the Dee, where it terminates, is made eminently ſubſervient to the purpoſes of manu-

(*a*) See Pennant's Tour in North Wales, and the Hiſtory of the Pariſhes of Whitford and Holywell, by the ſame eminent author.

facture, by turning the machinery of corn mills, cotton mills, and especially the vast and numerous works in copper and brass of the Anglesea copper company. (*b*) (*c*)

Saint Winifrede's well is a remarkably clear, pure, well-tasted water, and is used by the inhabitants around for all domestic purposes. A century ago, the virtues of this noble spring were more celebrated than they are at present, and the town of Holywell, then chiefly known for its possessing this natural treasure, was crouded with visitors from every part of North Wales. Though its utility now is principally confined to the inhabitants, and to the purposes of manufacture, there is no reason to doubt of its medicinal efficacy in the disorders before mentioned, which are precisely those for which the Malvern spring is now frequented.

(*b*) See Aikinn's Tour in North Wales.

(*c*) It is a singular circumstance that mill wheels, and other machinery, if made of wood, are rotted remarkably soon by remaining in this water. This is found to be owing, as Mr. Pennant observes, to a species of moss which attaches itself to the wood, and for the production of which this water appears unusually favourable. This inconvenience has obliged the manufacturer to use cast-iron water wheels.

BRISTOL HOTWELL.

This celebrated ſpring is ſituated at the bottom and ſouthern extremity of St. Vincent's rock, a lofty cliff on the banks of the Avon, on the Glouceſterſhire ſide, about a mile below the city of Briſtol, and within four of the noble and extenſive arm of the ſea, known by the name of the Briſtol Channel.

The ſite of Briſtol Hotwell appears to be one of thoſe choice and favoured ſpots that are peculiarly calculated for the pleaſure and comfort of the invalid. High ridges of dry limeſtone cliffs ſhelter it from the bleak north and eaſt winds, and from the boiſterous weſt which are ſo frequent and powerful on that ſide of the kingdom; and it is only open to the ſouth, a quarter in which expoſure is the moſt agreeable. By the lover of picturesque beauty the banks of the Avon have been long cheriſhed, for the whole adjacent country abounds with beautiful ſcenery and romantic proſpects. The fine open downs on the neighbouring hills enjoy a pure and healthful atmoſphere, and delightful views of the ſhores of the Avon, on the one ſide an abrupt rock, on the other a gentle ſlope wooded to the water's edge; and in the diſtance is ſeen the wide eſtuary of the Severn in the Briſtol Channel.

St. Vincent's rock, from the bottom of which the Hotwell ſprings into day, is compoſed principally of a hard, compact, and very fine limeſtone, interſperſed with calcareous ſpar, and alſo containing thoſe very tranſparent quartz cryſtals, formerly much eſteemed and known by the name of Briſtol Stones. This rock is the ſcene of great buſineſs, on account of the large quarries that are hollowed out of its ſide, whence is procured a fine ſtone for the purpoſes of building, and alſo excellent for being burnt into quicklime, which is conſumed to a large extent in the country, and exported in vaſt quantities to the Weſt Indies, where it is employed in the manufacture of ſugar.

The Hotwell ſpring is a very fine clear tepid water, ſo copious as to diſcharge about forty gallons in a minute. The freſh water is inodorous, perfectly limpid and ſparkling, and ſends forth numerous air bubbles when poured into a glafs. It is very agreeable to the palate, but without having any very decided tafte, at leaft none that can be well diftinguifhed by a common obferver. Its fpecific gravity is only 1.00077 which approaches fo near to that of diftilled water, that this circumftance alone would fhew that it contained but a very fmall admixture of foreign contents. This water, as its name imports, is a thermal fpring, but one in which the heat is very moderate. The exact temperature is given differently by different obfervers, which may be partly owing to a flight actual variation in its heat, but principally to a little difference in thermometers. Taking the average of the moft accurate obfervations, it may be reckoned at 74°, and this does not very fenfibly vary during winter or fummer. A little peculiarity attends this fountain, which requires to be mentioned. The fpring tides are known to rife to a remarkable height in the Severn and Avon, and with great rapidity. The Hotwell, although confiderably higher than the river, is however fo far affected by a fpring tide, as to become thereby in fome degree turbid, and is then not thought quite fo efficacious. This gives rife to a refinement in practice, in avoiding the medical ufe of the Hotwell during thefe periods, till by about two hours pumping, the water returns to its original purity (*a*).

Briftol water, befides being employed medicinally at the fpring head, which is in fact but a fmall part of its confumption, is ufed largely at the table at the Hotwells, and for all domeftic purpofes. Its foftnefs, or freedom from earthy falts, is almoft proverbially known; and from its excellent quality of keeping untainted for a great length of time in hot climates, it forms a moft valuable water for long voyages, and is accordingly exported in great quantities to diftant parts.

The contents of this water have been afcertained at various times by able chemifts, and in the modern improved ftate of chemical analyfis, nothing further feems to be required to complete our knowledge of this water; nor does it appear probable, that there exifts in it any fubftance which has not been detected,

(*a*) The real difference of the water at thefe times, is however, very trifling. Dr. Carrick found it to amount to no more than about three grains and a half of folid matter in a gallon, during the fpring tides.

although ſome difference may ariſe in eſti-mating the exact quantities of theſe contents, none of which are in themſelves at all un-common or peculiar to this ſpring.

Briſtol water contains both ſolid and gaſeous matter, and the diſtinction between the two requires to be attended to, as it is owing to the very ſmall quantity of the former, that it deſerves the character of a very pure natural ſpring; and to an exceſs in gaſeous contents, that it ſeems to be principally indebted for its medical properties, whatever they may be, independent of thoſe of mere water, with an increaſe of temperature.

The ſolid contents are eſtimated by Dr. Higgins, at 57 grains in the gallon; by Dr. Nott, at 52; by Dr. Carrick, at 47¾; by others, ſtill lower; but as the analyſis of Dr. Carrick comes the neareſt to the average of the different calculations, and as he gives the quantity of gaſeous matter, and all the par-ticulars of an examination apparently con-ducted with attention and accuracy, we ſhall chiefly follow this authority. (*b*)

(*b*) See Dr. Carrick's "Diſſertation on the Medical and Chemical properties of the Briſtol Hotwell, 1797."

Freſh Briſtol water, when warm from the ſpring, ſhews the following appearances with the ſeveral re-agents:

The blue of ſyrup of violets is ſlightly changed to a green, ſhewing the preſence of an uncombined alkali, or elſe an aerated earth.

The yellow of turmeric is not altered, ſhewing therefore the abſence of an alkali, and, by direct inference, that the change on the preceding teſt was produced by an aerated earth.

The red of Brazil wood, and the blue purple of litmus, are ſcarcely changed by the water, indicating that the carbonated earth is in very ſmall quantity.

The fixed and volatile carbonated alkalies produce a white precipitate, by decompoſing ſome earthy ſalt diſſolved in the water.

Pruſſian alkali and tincture of galls occaſion no change; ſhewing thereby the abſence of any kind of metallic ſalt.

The preſence of carbonic acid is detected, by cauſing an immediate milkineſs and white precipitate when lime water is added.

The precipitate produced by acid of ſugar, added to this water, indicates the preſence of lime; muriat of barytes difcovers fulphuric acid: and nitrat of filver exhibits the muriatic acid.

Nothing of a fulphureous nature appears by the delicate teft of acetite of lead.

A further analyfis of Briftol water by flow evaporation to drynefs, gave to Dr. Carrick, the following contents in the wine gallon:

Of muriated magnefia . .	7.25
— muriated foda	4.00
— fulphated foda	11.25
— felenite	11.75
— carbonated lime . . .	13.50
	47.75

Total $47\frac{3}{4}$ grains of folid contents.

During the evaporation, 33 cubic inches of air were expelled, which, when collected in proper veffels, and fubjected to examination, were found to confift of 30 inches of carbonic acid gas, and 3 inches of common air.

It appears, therefore, that a Winchefter gallon (of 231 cubic inches) of Briftol Hotwell water contains only $47\frac{3}{4}$ grains of folid contents, of which rather lefs than half are neutral falts with the bafis of foda, and the remainder are calcareous falts: but that it alfo holds in ſolution about $\frac{1}{7}$ to $\frac{1}{8}$ of its bulk of a gas, which is chiefly carbonic acid.

The general inference from this, as well as every other analyſis of Briſtol water, is, that it is conſiderably pure for a natural ſpring, containing no other ſolid matter than is found in almoſt all common ſpring water, and in leſs quantity. Moſt of theſe contain at leaſt 8 or 10 grains in the pint of foreign contents, and often much more, and are very commonly hard; Briſtol water contains only ſix grains, and is ſoft. This quantity, however, is more than in ſeveral river waters. On the other hand, its gaſeous contents far exceed thoſe of common ſprings, as theſe ſeldom hold in ſolution more than from $\frac{1}{100}$ to $\frac{1}{16}$ of their bulk of any kind of air; but, as a *mineral* water, the proportion of air, even in Briſtol water, is very ſmall. It may, therefore, be deſcribed as a pure, warm, ſlightly acidulated ſpring.

The ſenſible effects generally allowed to be produced by this water when warm and freſh from the ſpring, are, at firſt a gentle glow in the ſtomach, to which ſucceeds ſometimes a ſlight degree of head-ach and giddineſs, but which ſoon go off. Indeed this water may be more ſafely tried in every ſtate of health than moſt of the other mineral ſprings (*c*). A continued uſe of Briſtol water is allowed in moſt caſes to increaſe the flow of urine, and at the ſame time to keep the ſkin moiſt and perſpirable; and the appetite and general health are uſually improved by a reſidence at the Hotwells. The effects which the water produces on the bowels are by no means conſtant, as indeed may readily be imagined from a review of its compoſition, the purgative ſalts being in very ſmall quantity, and their operation, whatever it might be, eaſily counteracted by the ſuperior doſe of calcareous ſalts. On the whole, a tendency to coſtiveneſs ſeems to be the more general conſequence of a continued courſe of Briſtol water, and therefore the uſe of a mild aperient is often requiſite. The ſenſible effects juſt enumerated are principally applicable to invalids, for perſons in health, who, from curioſity, taſte the water at the ſpring-head, often diſcover nothing in it but warmth, that diſtinguiſhes it from any common drink.

The following are the directions uſually

(*c*) See Dr. Nott's "Treatiſe of the Hotwell Waters near Briſtol, 1797."

given for employing this water medicinally. The time recommended for the firſt doſe is before breakfaſt, as early in the morning as the patient chooſes to riſe, when it is uſual to take two glaſſes, with about half an hour ſpent in gentle exerciſe interpoſed between them. Two more glaſſes, with the ſame interval, are generally given midway between breakfaſt and dinner, and the water is ſeldom repeated afterwards in the courſe of the day. The ſize of the glaſs varies from a quarter to half a pint, which laſt is reckoned a full doſe: but at no time ſhould it be taken in ſuch a quantity as to cauſe any oppreſſion or ſenſe of weight in the ſtomach. Three days before and after every full and new moon, the clearneſs of the water, as has been mentioned, is ſomewhat diſturbed by the ſpring tides in the Avon, and this cauſes a little irregularity in the time of uſing the water, as it requires ſome hours pumping in order to run clear again.

To produce the full medicinal effects of Briſtol water, it ſhould unqueſtionably be drank at the fountain head; for by carriage or mere keeping, it loſes much of its carbonic acid as well as its temperature, and this laſt cannot be reftored without a further lofs of this volatile acid. It ftill, however, continues to be a pure and excellent water for the table, and is ufed as fuch at the Hotwells.

That the reader may form a better idea of the properties of this water as a medicine, I fhall give the folid and gafeous contents of each dofe, calculated from the refults of the analyfis already quoted. This plan will be purfued, where it is practicable, with all the other mineral waters that will be noticed in the courfe of this work.

Half a pint of frefh Briftol water, which is a full dofe, contains

Of fulphat of foda, muriat of foda, and muriated magnefia, gr. 1.404, or fomewhat lefs than a grain and a half.

Of fulphat of lime and chalk held in folution by carbonic acid, gr. 1.577, or rather more than a grain and a half; and

Of carbonic acid, mixed with a little common air, 2 cubic inches, or about an ounce in meafure. Therefore, fuppofing the above quantity taken four times in the day, the patient will have added to his daily ingefta about five grains and a half of purgative falts; fix grains and a half of calcareous falts; and about a quarter of a pint in bulk (*d*) of carbonic acid; the whole diſſolved in a quart of water of the temperature of 74°.

Briſtol Hotwell has obtained great celebrity in the cure of a number of diſeaſes of very oppoſite natures; and in common with all pure waters, it has been recommended in thoſe diſorders in which it is of importance to increaſe the quantity of aqueous drink, without adding any principle which may prove pernicious to irritable and weakened organs. It is probably to the watery ingredient, aſſiſted by a higher temperature than uſually prevails in natural ſprings, that we may attribute the benefit which is derived from this fountain in ſeveral diſorders of the alimentary canal, in the dyſpeptic ſymptoms which ſo often impair the health of the European who has long reſided in hot climates, in bilious diarrhœa, and ſlight dyſentery. On the ſame grounds, that is, on the *purity* of the aqueous part, we may perhaps account for the celebrity which the Hotwell has acquired in the cure of diabetes, or at leaſt in affording conſiderable relief in this troubleſome and ſingu-

(*d*) By this expreſſion, I mean all along the *bulk* that ſuch a quantity of water would occupy.

lar malady, and rendering the urinary organs more fitted to receive benefit from thofe medicines which are generally prefcribed and fometimes fuccefsful. But the high reputation which this fpring has acquired, is, above all, in the cure of pulmonary confumption, one of the moft diftreffing in its fymptoms, delufive in its appearance, uncertain in its progrefs, and difficult to be refifted, of all the diforders with which we are acquainted. Much difference of opinion has arifen on the fuppofed virtues of Briftol water in this difeafe, and from the number of unfuccefsful cafes among thofe that frequent this place, many have been difpofed to deny any peculiar power to this, fuperior to any fimple water.* It is not eafy to determine how much may be owing to the favourable fituation and mild temperate climate which Briftol enjoys; but it cannot be doubted that the Hotwell water, though by no

* The water of Briftol is celebrated for its purity, and for its virtues in confumptions, and feveral weakneffes. It has certainly no claim to be thought a pure water; and, as far as my experience goes, it has as little juft pretence to any of the medicinal virtues which it has been thought to poffefs.——*Comment. on the Hiftory and Cure of Difeafes, by W. Heberden, M. D. p.* 79.

means a cure for confumption, alleviates fome of the moft harraffing fymptoms in this formidable difeafe. It is particularly efficacious in moderating the thirft, the dry burning heat of the hands and feet, the partial night fweats, and the fymptoms that are peculiarly hectical; and thus in the earlier ftages of phthifis, it may materially contribute to a complete re-eftablifhment of health; and even in the latter periods it may confiderably relieve, when the profpect of a cure has long been doubtful, if not hopelefs. We are not yet fully acquainted with the medical virtues which we may expect from the union of a fmall quantity of carbonic acid with water; but from comparing the effects refulting from this gafeous acid when in a larger dofe, and giving very fenfible properties to the water with which it is combined, there appears to be fome reafon for attributing to this fubftance, a part at leaft of the virtues of Briftol water.

The feafon for the Hotwells is generally from the middle of May to October, but as the properties of the water are the fame during the winter, the fummer months are only ſelected on account of the benefits ariſing from the concomitant advantages of air and exerciſe, which may be enjoyed more completely in this ſeaſon. However, the invalid may with advantage chooſe this ſheltered ſpot as a winter reſidence, and thus the uſe of the water will be uninterrupted. The uſe of this ſpring is intirely internal, and the duration of the courſe varies according to the diſorder; but as the effects are very gradual, and never at any one time particularly ſenſible, it often requires a conſiderable period to experience the full benefit which the waters will produce.

It ſhould be mentioned, that another ſpring nearly reſembling the Hotwell, has been diſcovered at Clifton, which is ſituated on the ſummit of the ſame hill from the bottom of which the Hotwell iſſues. The water of the Sion ſpring, as it is called, is one or two degrees colder than the former, but in other reſpects it ſufficiently reſembles it to be employed for all ſimilar purpoſes.

MATLOCK WATER.

The village of Matlock, ſituated in a hilly part of Derbyſhire, is known to moſt of the lovers of pictureſque ſcenery, as one of the moſt ſtriking and beautiful ſpots that can attract the attention of travellers. It is built half way down a ſteep limeſtone hill, at the foot of which flows the clear and rapid ſtream of the Derwent, whoſe ſteep banks are covered with thick woods.

A number of ſprings iſſue from this limeſtone rock, all of them poſſeſſing the clearneſs and purity that diſtinguiſh mountain ſtreams which riſe from a clean rocky ſoil; but ſeveral of theſe poſſeſs a temperature ſteadily above that of natural waters in our climate. The cold and tepid ſprings are ſingularly ſituated in this limeſtone hill. All the tepid waters ariſe from fifteen to thirty yards above the level of the Derwent, whilſt thoſe both above and below are cold; and even the ſources of the latter intermix with thoſe of a higher temperature (*a*). The

(*a*) See Dr. Short's Hiſtory of Mineral Waters.

ſupply of tepid water is very copious, and part is received into baths where the water is uſed for medical purpoſes. The temperature, according to Dr. Percival, is 66° with little variation (*b*), and hence the Matlock bath has a claim to be admitted into the liſt of the few Engliſh thermal waters, and is the loweſt in temperature.

In ſenſible properties, this water ſcarcely differs from common good ſpring water. It is beautifully clear, and exhales no ſteam, except in very cold weather. It contains very little exceſs of air of any kind, as it does not ſend forth any conſiderable bubbles when it is freſh poured out. This water, when firſt taken up, curdles ſoap; but this effect goes off after ſtanding a few days, (owing probably to the depoſition of carbonat of lime) and it mixes well with milk without curdling it. The taſte is that of good pure water, without any acidulous flavour or unuſual briſkneſs. It is only four grains in the pint heavier than diſtilled water.

Matlock water has not been analyſed with ſo much exactneſs as to aſcertain the quantity

(*b*) Percival's Eſſays, vol. II.

of all the foreign matter which it contains; neither does this appear at all neceſſary, ſince its medical virtues, independently of thoſe of pure water, may ſafely be aſcribed to temperature alone. It is found to contain a ſmall quantity of a neutral ſalt, probably muriat of ſoda, and about as much of an earthy ſalt, which is chiefly calcareous. No traces of iron are diſcoverable by any teſt, nor does there appear to be any exceſs of carbonic acid, as in the Briſtol Hotwell.

Matlock water may be employed in all thoſe caſes where a pure diluent drink is adviſeable; but it is principally uſed as a tepid bath, or at leaſt one which comes to the extreme limits of a cold bath. On this account it produces but little ſhock on immerſion, and is therefore peculiarly fitted for thoſe delicate and languid habits, that cannot exert ſufficient re-action to overcome the effects of the ordinary cold bath, and on which the benefits it produces chiefly depend. Matlock water forms a good intermediate bath between Bath or Buxton and the ſea, and may be employed in preparing the invalid for the latter. The abundant ſupply of water always at the ſame temperature, is a circumſtance in favour of natural baths, and the purity of the air, and exquiſite beauty of the ſituation, muſt always render Matlock a favourite reſort of the invalid of taſte and leiſure.

BUXTON WATER

Buxton is ſituated on the north-weſtern ſide of the county of Derby, on the borders of Cheſhire, in a narrow funnel-ſhaped valley, ſurrounded on all ſides by very lofty hills. The whole of this angle of Derbyſhire conſtitutes what is called the Peak hundred, a wild mountainous diſtrict, thinly inhabited, and expoſed to almoſt perpetual ſtorms.

The face of the country around Buxton is moſtly bleak and barren; the ſummits of the hills are bare, and their ſides covered with but a ſcanty verdure. The vallies, however, are fertile and beautifully attractive, and generally divided by a clear rapid ſtream. The ground is moſtly compoſed of two or three ſpecies of hard ſiliceous rock, of a ſhivery laminated argillaceous ſtone, called ſhale, and eſpecially of a very large proportion of limeſtone, of which there is a great variety, many kinds burning into a remarkably good compact lime. This is in high eſtimation with the country around, and great quantities of it are prepared at and near Buxton, and conveyed to a confiderable diftance, to be ufed in manufactures of various kinds, and principally as manure for the cold ftiff clay lands of the neighbouring parts of Chefhire.

The mountains around Buxton abound with large chafms and clefts, and fome remarkable natural caverns have been penetrated into, whofe ftalactical grottoes are great objects of curiofity to the numerous vifitors that annually frequent this place. This is likewife the part of Derbyfhire that has been for many centuries famous for its lead mines, and fome of the moft ancient works in the kingdom are to be found in this diftrict, though now but little wrought.

The climate of this mountainous region is highly ungenial. The winters are fevere, the fpring tardy, and the vegetation much checked by bleak north-eaft winds, which blow with great vehemence over the vallies. The fummer is uncommonly rainy, fo that it is very rare to experience many days in fucceffion of dry clear weather. The fummits of the furrounding hills are generally enveloped with mift, which often fweeps down into the vallies below with great rapidity, overcafting in a few minutes the fineft fky, and filling the whole atmofphere with hurrying fhowers. However, unfavourable as the climate appears, there are feveral circumftances which render Buxton more tolerable to the invalid than would be at firft imagined. One of confiderable importance is the drynefs of the foil, which, being principally a clean hard limeftone, does not retain much moifture; and from the inequality of the ground, the fhowers that fall fo frequently are quickly carried off in rapid torrents into the ftreams that occupy the vallies. Hence it is, that the leaft interval of clear weather may be immediately taken advantage of by the invalid; and all the mifchiefs that can ever be fuppofed to arife from the ftagnation of air are alfo intirely prevented by this turbulent atmofphere.

Few places fo little favoured by nature with any but the wild romantic beauty of bare mountains and deep vallies, are fo much indebted to induftry and cultivation as the village of Buxton and its neighbourhood. Under the aufpices of the Duke of Devonfhire, the prefent noble proprietor, a range of ſtone buildings has been erected, forming a moſt magnificent creſcent, which ſtrikes the eye of the traveller with uncommon grandeur, when deſcending towards it from the adjoining hills. The roads too are excellent, and even many of the naked hills are beginning to ſhew ſome marks of cultivation, and bear young plantations, which in time may make a material alteration in the face of the country.

Buxton has long been celebrated for its warm ſprings, and they appear to have enjoyed conſiderable reputation in the cure of various diſeaſes for a longer period without interruption, than almoſt any mineral water in the kingdom. As early as the year 1572, a treatiſe was written on the virtues of this ſpring by a Dr. Jones of Derby, and it appears at that time to have been a place of great reſort from all the neighbouring counties. Several remains of Roman antiquity have alſo been diſcovered at or near this ſpot, which makes it probable that this fountain was not unknown to that people (*a*).

(*a*) Short's Hiſtory of Mineral Waters.

The warm ſprings of Buxton riſe into day through a number of ſmall fiſſures in a hard calcareous free-ſtone, which forms the upper ſtratum of the ſoil. The ſprings are very numerous, and the quantity of water is always abundantly ſufficient for the large conſumption required to ſupply the numerous baths, and the other purpoſes for which it is employed. A particular deſcription of the ſeveral ſprings is not here neceſſary for our preſent purpoſe; it will be ſufficient to obſerve, that the original and moſt ancient fountain is St. Ann's Well, which is now incloſed in an elegant ſtone building; and that there are ſeveral other warm ſprings beſides, all of which appear to be preciſely ſimilar to St. Ann's, and are received into a number of beautiful and convenient baths, public and private, where every care is taken to preſerve the heat and cleanneſs of the water, and to conſult the accommodation of the bathers.

In ſenſible properties, the Buxton water cannot be diſtinguiſhed from common ſpring water heated to the ſame temperature. It is perfectly clear and colourleſs, and does not become turbid, by being expoſed to the air for any length of time, nor does it leave any depofit, or form any incruftation, on the pipes or ftone channels through which it flows in its courfe to the feveral baths. It is intirely void of fmell or tafte; it fparkles a little when firft drawn, but apparently not more than the water of many common fprings. Its temperature in the gentlemen's bath, is invariably 82°, which therefore entitles us to confider Buxton water as a thermal fpring, though but low in the fcale of thefe natural waters.

A thin column of fteam generally hovers over the furface of the bath during the cool of the morning and evening, and fometimes during the whole day, which laft circumftance is confidered as a fure indication of approaching rain. The principal peculiarity in the appearance of this fpring, is a very large quantity of a permanently elaftic vapour, which rifes along with the water through the crevices in the floor of the bath, forming clufters of bubbles of various dimenfions, that pafs through the water without mixing with it, and break as foon as they reach the furface. Thefe bubbles may eafily be collected by any veffel filled with water, and inverted fo as to intercept them in their courſe upwards. The nature of this air was firſt aſcertained by Dr. Pearſon, as we ſhall mention preſently.

The chemical analyſis of Buxton water exhibits a few foreign contents, both ſolid and gaſeous, which are detected in the uſual manner by re-agents, or by evaporation and ſubſequent examination of the products (*b*). On applying the various teſts, the following appearances take place. No change is produced by adding to freſh Buxton water tincture of litmus, tincture of galls, or Pruſſian alkali; ſhewing by the firſt, that no uncombined acid exiſts, and by the two latter, the abſence of iron or any other metal. A ſlight green is occaſioned by the addition of ſyrup of violets, indicating carbonated lime in the water. Lime water produces a ſlight precipitate, and iron filings ſhaken with the freſh water for a few minutes, gives it a ſlight chalybeate impregnation, both of which ſhew the preſence of a ſmall quantity of carbonic acid. An earthy ſalt is detected by adding a fixed alkali, and the muriatic acid by nitrat of ſilver. The water

(*b*) See Dr. Pearſon's "Obſervations and experiments for inveſtigating the Chemical Hiſtory of Buxton Water.—1784."

in a flight degree curdles foap, which effect is prevented, by adding one grain of alkali to one ounce of the frefh water. Nothing fulphureous appears either from the fmell, or by thofe delicate tefts, the folutions of lead and filver. By evaporation to drynefs, Dr. Pearfon found in the gallon of Buxton water only 15 grains of refiduum, of which he eftimates $1\frac{3}{4}$ grain to be muriat of foda, $2\frac{1}{2}$ grains to be fulphat of lime, and $10\frac{1}{2}$ grains to be carbonat of lime.

A quantity of air was long obferved to be both contained in frefh Buxton water, and to rife up along with it through the crevices of the pavement of the bath. The perfect infignificance of the folid contents, led chemifts to pay more attention to the gafeous products: the gas which rifes through the water was fuppofed to be carbonic acid; but Dr. Pearfon by his experiments fully afcertained that this was a miftake, and that it is in fact azotic gas mixed with a fmall portion of atmofpherical air. Buxton water contains about $\frac{1}{64}$ of its bulk of air in true chemical combination. Sixteen pints of the water, expofed to a boiling heat for a confiderable time, yielded about

4 to 4½ ounces meaſure of an air, which was ſcarcely diminiſhed by nitrous gas, did not explode when mixed with common air on the application of a candle, proved fatal to animal life, was in a very ſmall degree abſorbed by cauſtic alkali, and by all theſe teſts proved to be almoſt pure azotic gas, or exactly the ſame as that which riſes in bubbles along with the water without mixing with it. There is, however, a ſmall proportion of carbonic acid contained in Buxton water, but not more than is ſufficient to hold diſſolved the carbonat of lime, of which it contains a greater quantity than of any other ſolid ingredient, and therefore not uncombined.

The analyſis of other chemiſts agrees ſufficiently with that of Dr. Pearſon with reſpect to the ſolid contents, to which their attention was principally directed. The higheſt eſtimate is 24 grains in the gallon. Dr. Higgins reckons 17⅘ grains, and the proportion of each ingredient nearly the ſame as Dr. Pearſon (*c*).

(*c*) Dr. Higgins is the only chemiſt who aſſerts the exiſtence of iron in Buxton water, in a very minute quantity. As this has been repeatedly tried by other chemiſts without ſhewing the

The general refult therefore of the analyfis of Buxton water is the following: it is a remarkably pure water, and poffeffes no peculiar fenfible properties except that of a higher temperature than all the adjacent fprings; and as this circumftance is invariable in every feafon, the fource of the heat depends on fome internal caufe, in which it differs from the cold natural waters. The little folid matter which it contains is fuch as is found in every common fpring, and is of the moft inactive kind. It holds in folution, however, a fmall quantity of azotic gas, as this air is very imperfectly foluble in water. In this refpect only, does the chemical analyfis of Buxton exhibit any thing different from the pump water in common ufe (*d*).

fmalleft traces of that metal, it is prefumed that Dr. Higgins was mifled by fome accidental circumftance. It was only the refult of his analyfis, and not the procefs, that Dr. Higgins thought proper to make public, and therefore it cannot require any further attention.

(*d*) Dr. Pearfon's analyfis being conducted at a time when the nature of the gafeous fluids was but very imperfectly known, confiderable merit is due to this ingenious chemift for his refearches into that which gives Buxton water its peculiarity of compofition. At the fame time it may be added, that there is ftill room (if it be thought worth while) for a more accurate ex-

The water of Buxton is employed largely both in external and internal uſe, and the one is often applicable in caſes where the other would be prejudicial. With regard to its uſe as a bath, we may obſerve, that there can be no reaſonable ground for conſidering it, here at leaſt, as any other than common water. The great recommendation of the Buxton baths is the copious ſupply of a very pure clean water of the high temperature of 82°, and which is always the ſame in every property, and abundantly ſufficient for all the baths that enrich and decorate this ſituation. As the temperature of 82° is ſeveral degrees below that of the human body, there is a ſlight

amination of this water, to determine the preciſe proportion of the gaſeous contents. In a mere chemical view, the ſubject will admit of intereſting inquiry with regard to this ſingular production of azotic gas, which (including that which riſes through the water) is often in conſiderable quantity. It ſhould be remarked that Dr. Prieſtley appears to be the firſt chemiſt who detected the exiſtence of azot or phlogiſticated air, in union with a natural water, by an examination of the Bath water made with a view to its gaſeous contents, and noticed in his "Experiments and Obſervations on different kinds of Air," publiſhed in 1775, vol. II. page 222.—The ſame gas has ſince been found in Harrogate water by Dr. Garnet.

ſhock of cold felt on the firſt immerſion into this bath; but this is almoſt immediately ſucceeded by a highly ſoothing and pleaſurable glow over the whole body, which perſons often expreſs to be as if the ſkin was anointed with warm cream, and is entirely the effect of temperature combined with that of ſimple moiſture. On account of the ſlightneſs of the ſhock of immerſion, very delicate and irritable habits, and eſpecially parts weakened by diſeaſe can generally bear this degree of cold, and overcome it by a very ſmall re-action, to produce which, appears to be often a moſt ſalutary effort of the conſtitution.— Hence, *the Buxton bath* is become almoſt a technical term for any bath heated to the higheſt degree that is compatible with giving ſome ſenſation of cold when the body is firſt plunged into it. The caſes moſt relieved by Buxton water uſed externally, and which include the greater number of complaints affecting invalids who reſort to theſe ſprings, are thoſe in which a loſs of action, and ſometimes even of perfect ſenſation, has come on particular limbs, owing to long or violent in-flammation or external injury, where the firſt increafe of action is paft. Thus, the chronic rheumatifm in all its forms, fucceeding to the acute, and where the inflammation has been chiefly feated in moving parts, is often wonderfully relieved by this bath; and the healthy actions is foon fo far reftored, as to enable the patient to ufe the more powerful remedy of fea bathing, or the common cold bath. On the other hand, the lofs of action produced by true paralyfis will feldom admit of much relief by a Buxton bath, but requires the more direct ftimulus of heat (*b*).

The ufe of Buxton water, when confidered as an internal medicine of great activity and confiderable efficacy, is a fubject that demands fome attention, as much controverfy has arifen as to the fource of its medicinal powers. It is not eafy to collect from the writers on this fubject, what are the precife fenfible effects produced on the body by a moderate dofe; or wherein they differ from thofe of mere water. In fact, it is at all times difficult, even in thofe mineral fprings whofe foreign

(*b*) For further obfervations on this fubject, the reader is referred to the chapter on the external ufe of water, afterwards confidered in this volume.

contents are the moſt indiſputably active, to determine the agency of each, intimately mixed as they are with ſo large a portion of their watery vehicle. The high *activity* of Buxton water, and its *inflammatory tendency*, have been points much inſiſted on by ſeveral medical writers on this ſubject, and theſe have been attributed either to ſomething yet undiſcovered by chemical analyſis, or to the only ſubſtances which we know are contained in the water, that can be ſuppoſed to have any active powers, viz. the gaſeous contents (*c*). Agreeably to this opinion, concerning the power of Buxton water in producing as much miſchief where miſapplied, as benefit where uſed prudently, its application to various diſeaſes has been regulated by long experience. Buxton water is found of conſiderable ſervice in a number of ſymptoms of defective digeſtion and derangement of the alimentary organs, conſequent to a life

(*c*) For further obſervations on this ſubject, the reader is referred to the concluding chapter of this work. In the preſent part I have wiſhed chiefly to confine myſelf to the ſelection of ſuch facts concerning the various waters as are not diſputed, and particularly exhibit their chemical properties and medical uſes.

of high indulgence and intemperance (*d*). A judicious ufe of this fimple remedy will often relieve the diftreffing fymptoms of heart-burn, flatulency, and ficknefs; and, if perfevered in, will increafe the appetite, render the fecretions more regular, and improve the general health and fpirits that are fo intimately connected with the functions of the digeftive organs. A large number of the invalids that refort to Buxton are of this clafs. The water appears to produce various effects on the bowels. Not unfrequently a fpontaneous diarrhœa is the confequence of its ufe for fome days, and this is always falutary; but it is more common, efpecially in habits where the action of the bowels is naturally fluggifh, for coftivenefs to come on during a courfe of the water, which muft be remedied by aperient medicines. Another clafs of diforders much relieved by the internal ufe of Buxton water, is the painful complaints of the kidnies and bladder, connected with the formation of calculus. The pain of thefe affections is much

(*a*) See a very fenfible "Treatife on Buxton Water," chiefly with a view to its medical effects, by Dr. Denman, long a practitioner on the fpot.

relieved by the water, and its ufe as a bath will often affift its employment as an internal medicine. The comparative purity of the water may here be a principal caufe of its efficacy. Buxton has been much recommended in various cafes of gout, efpecially where the high inflammation of particular limbs has gone off, and where it has left either a number of dyfpeptic fymptoms, or a rigidity or impaired action in the feat of the difeafe. In this diforder however, the ufe of Buxton water feems to me to be very ambiguous, and feldom admiffible. We are advifed by Dr. Denman always to add fome aromatic tincture to the water taken in thefe cafes, without which it would not be fafe or advifeable: but it appears to me generally hazardous to employ fuch means of qualifying the medicinal powers of a mineral water, as highly apt to bring on a habit of accuftoming the ftomach to the exceffive ftimulus of ardent fpirit, under the infidious form of a ftomachic medicine, and can hardly fail of doing much more injury than will be counteracted by the good produced by any mineral water fo exhibited. Indeed I think it may be laid down as a general rule, that the only additions which it is ad-viseable to uſe, are, either that of mere temperature, which is often neceſſary in giving the cold medicinal waters to delicate ſtomachs, or that of an additional quantity of any of the natural ingredients, as for inſtance where a purging chalybeate may be ſtrengthened in its operation by ſome vitriolated magneſia or ſoda. Sometimes, however, the ſtomach of a gouty patient will bear the Buxton water in its ſimple ſtate, and will derive much advantage from its gradual action on the general habit. As an external application in gout, Buxton water is ſometimes found of ſervice, though in general the warmer temperature of that of Bath is the beſt fitted to reſtore healthy functions to parts ſo diſeaſed.

We are directed to avoid the uſe of Buxton water in all caſes of active inflammation, more eſpecially thoſe of the young and plethoric, where there is naturally a ſtrong tendency to a determination to the lungs. Theſe cautions are founded on the ſuppoſed heating properties of Buxton water, and certainly we muſt allow that in ſuch caſes of increaſed circulation and fever, unattended with any idiopathic derangement of the organs of digeftion, it is not to this mineral fpring that we fhould truft to check thefe dangerous fymptoms. From what has been faid, it will appear that it is chiefly in chronic cafes, unattended with much vafcular action, that Buxton might be vifited with advantage by invalids; and the numbers that annually receive here very important relief, afford a very honourable teftimony to the efficacy of its waters.

The dofes prefcribed by the earlier practitioners were, according to the cuftom of former times, much more abundant than are employed at prefent, and would make the modern directions quite fuperfluous. Now, however, it is confidered as a full courfe to take two glaffes of about a third of a pint each before breakfaft; interpofing between the two a little gentle exercife, and to repeat the fame quantity again between breakfaft and dinner. It is feldom taken medicinally in the evening.

A calculation of the actual quantity of foreign contents in thefe dofes will exhibit very minute portions of very inactive fubftances. A fingle dofe of a third of a pint contains about $\frac{1}{13}$ of a grain of common falt, and about half a grain of fulphat of lime and carbonat of lime, for the ſolid contents: and for the gaſeous, two ſcruples in bulk, or leſs than a tea-ſpoonful of an air which is moſtly azotic gas. Suppoſing therefore four of theſe doſes taken in the day, the patient will have taken about $\frac{1}{3}$ of a grain of common ſalt, two grains of calcareous ſalts, two drams and two ſcruples in bulk, or about three tea-ſpoonfuls of azotic gas; the whole diſſolved in one pint and a third of lukewarm water.

It ſhould be added, that the inhabitants of the place employ the ſame water as common drink, and for all domeſtic uſes which its hardneſs will admit of, and hence the invalid will probably take much more of the water than is preſcribed, by its being uſed at table and for all culinary purpoſes.

As the caſes for which Buxton is recommended are moſtly chronic, a conſiderable time of reſidence is requiſite in order to ſecure the benefits that may ariſe from this ſpring; and the ſplendid buildings that decorate this ſpot, are ſo well furniſhed with every thing that can contribute to accommodation, convenience, and comfort, as to leave very little to be deſired by the tendereſt invalid of faſhion and opulence.

BATH WATER.

The city of Bath is fituated in a deep narrow valley, on the banks of the Avon, in the county of Somerfet, a few miles higher up that river than Briftol, and at the extremity of its navigable courfe for fmall veffels from the Briftol Channel. The country around is compofed of hills of moderate height, generally fteep in their fides, and pretty uniform in their outline; and of contracted valleys, highly fertile, and well cultivated. The valley which is decorated by the beautiful city of Bath, is confined on all fides by lofty hills, which block up every outlet except thofe that admit the Avon, which takes a fine ferpentine courfe through a rich vale, and bounds the city from the North-Eaft to the South-Weft quarter. The view therefore from the neighbouring hills is rather confined; but befides the natural advantages of the place, it poffeffes that noble affemblage of fplendid buildings, decorated with a profufion of elegant architectural ornaments, which have juftly entitled modern Bath to the pre-eminence in beauty over all the towns in our iſland.

This city is of conſiderable antiquity, being noticed by the earlier of our own hiſtorians, and many intereſting Roman remains have been found on the ſpot. The moſt important of theſe is a ſet of baths, with all the apparatus for warm and vapour bathing, that uſed to form an important part of Roman luxury, which were diſcovered accidentally ſeveral years ago, beneath the foundation of an old priory, that had been ſtanding for a great length of time (*a*). This circumſtance makes it highly probable that theſe thermal waters were much in uſe even with the Romans when in this iſland, and eſtabliſhes the precedency of the Bath waters over all the other mineral waters in the kingdom.

Bath is divided into two diſtricts, the Old and New Town; the former of which contains

(*a*) See Lucas's accouut of the city and thermal waters of Bath, contained in his 'Eſſay of Waters, 1756;' a work that abounds with curious and important information, the reſult of perſonal experience, written with great freedom of remark, and containing many acute obſervations and conjectures, ſome of which have been fully verified by late experiments.

the baths; the latter, the greater part of the elegant buildings in which the viſitors of faſhion and opulence reſide. The older part of the city is contiguous to the Avon, is narrow, irregular, and moſtly ill-built, and has its foundation on a marſhy and clayey ſoil. The ground riſes with a ſteep aſcent, juſt behind the Old Town, and becomes gravelly and rocky; and upon this ſoil the beautiful buildings of the New Town are founded. A number of fine ſprings flow from this quarter down towards the Avon, and yield a copious ſupply of excellent pump water to the inhabitants. The ſoil of the valley of the Avon is highly favourable for the production of all kinds of fruit and vegetables for the table; and theſe, from the great heat of the ſituation, in conſequence of the ſhelter of the ſurrounding hills, and the reflection of the ſun's rays, come to the utmoſt perfection and maturity. The country alſo poſſeſſes ſome very valuable natural mineral riches, ſuch as coal, clay for pottery and bricks, limeſtone, and eſpecially a very valuable freeſtone, which is ſo ſoft in the quarry, as to be readily worked into every form that ufe or ornament can require, but by expofure to the air for a fhort time, hardens into a very firm folid ftone. All the buildings of the New Town are conftructed of this material, a circumftance that contributes not a little both to their elegance and durability.

The climate of Bath, like that of the whole of this fide of the kingdom, is in general very mild and genial; an advantage which is however fomewhat counterbalanced by the inconvenience of a larger proportion of rain than falls on the Eaftern part of our ifland. The New Town, indeed, from the great inequality of its fite, and the rockynefs of its foil, is very foon dry after the fevereft fhowers; but then it is expofed to all the violence of the Weft and South-Weft winds, which are here always the moft boifterous and prevalent. The lower part of the city is more fheltered by the adjacent hills.

The city of Bath has been celebrated for a long feries of years for its numerous hot fprings, which are of a higher temperature than any in this kingdom, and indeed are the only natural waters which we poffefs, that are at all hot to the touch; all the other thermal waters being of a heat below the animal temperature, and only deferving that appellation from being invariably warmer than the general average of the heat of common fprings. Thefe waters, which have at firft given celebrity to this fpot on the banks of the Avon, and have been the means of erecting and fupporting a fplendid city, are now eminently accommodated to the ufe of invalids, by the erection of elegant baths, and by various other buildings, calculated for convenience or amufement.

There appears to be three principal fources of thefe waters, called the King's Bath, the Crofs Bath, and the Hot Bath. Thefe fprings all arife within a fhort diftance from each other, at the lower part of the town, and not far from the Avon, into which the hot water terminates, after having paffed through the feveral baths. The fupply of water is fo copious, that all the large refervoirs ufed for bathing are filled every evening with water frefh from their refpective fountains. There appears to be a flight difference in the properties of the water of each of thefe three baths, which we fhall take occafion to notice, where it gives rife to a felection in their medical ufe.

The ſenſible properties of Bath water are the following (*b*): when firſt drawn it appears quite clear and colourleſs, and remains perfectly quiet without ſending forth any bubbles, or giving any ſign of briſkneſs or effervеſcence (*c*). On ſtanding in the open air for ſome hours, it becomes ſomewhat turbid by the ſeparation of a pale yellow ochery precipitate, which gradually ſubſides. The quantity of this ſediment is extremely ſmall, but is ſufficient to give iron mould ſtains to the linen of the bathers. The water ſtill remains ſlightly turbid and of a whey colour, after the ochre is precipitated, but does not actually depoſit any other ſubſtance in any aſcertainable quantity. No odour of any kind is perceivable by the niceſt ſenſe from a glaſs of the freſh water; but from a large body of water,

(*b*) See Falconer's "Eſſay on the Bath waters, 1772."

(*c*) I mention this laſt circumſtance particularly, and from my own obſervation, as it has been aſſerted by ſome writers on this ſubject, that the freſh drawn water appears briſk and ſparkling, as if it were ſtrongly impregnated with ſome gas: which is certainly a miſtake. This appearance can never be depended on, till the firſt agitation ariſing from the pouring out the water be gone off, and when the truly gaſeous waters, ſuch as the Seltzer or Spa, will continue to emit bubbles, though merely expoſed to air of the ordinary temperature.

fuch as the King's Bath juft filled, a flight degree of pungency ftrikes the nofe, fimilar to that of an effervefcing mixture, but according to Dr. Falconer, never accompanied with any thing fetid or fulphureous. The tafte of the water deferves particular attention, from fome peculiarities that attend it. When hot from the pump, it fills the mouth with a ftrong chalybeate impreffion, without any particular pungency, and accompanied with fcarcely any kind of faline tafte; on this account it is by no means difagreeable, and may be taken in a larger draught without difguft than moft other waters in which the tafte of iron predominates: what is remarkable, however, is, that as foon as the water cools, even before there is any fenfible precipitation, the chalybeate tafte is entirely loft, and nothing but the flighteft faline fenfation to the tongue remains; or rather, there is then no diftinguifhable difference between this and common hard fpring water (*d*).

(*d*) Dr. Falconer afferts, that Bath water, when cold, becomes not only more faline to the tafte, but acquires a peculiar and indefcribable flavour which lafts fome time longer. I cannot help thinking this an inftance of a kind of refinement in obfer-

The ſpecific gravity, as aſcertained by Dr. Falconer, of the King's and Hot Baths, is 1.0020: and of the Croſs Bath 1.0018.—This exceeds the weight of all the cold pump waters in the city, of which there is a great number, and very excellent. The heavieſt of theſe is 1.0016, and the Avon water only 1.0008 (*e*).

The temperature of the King's Bath, which is that uſually employed for drinking, was determined by very careful obſervations, and eſtimated by Dr. Falconer, to be when freſh drawn in the glaſſes, about 116°: that of the Croſs Bath water is only 112°. This high temperature, however, is only found in the water freſh from the pump, for as it flows into the ſpacious baths, it rapidly loſes a part of its heat, and is ſeldom more to the bathers than from 106° to about 100° in the hotter baths, and about 94° to 92° in the Croſs Bath,

vation in which ſome able and ingenious men occaſionally indulge themſelves. The ſame author has mentioned his perceiving a ſlight coppery taſte in the Malvern water, giving a ſuſpicion that it contained a portion of this dangerous metal; a ſuſpicion which has been diſproved by the moſt accurate chemical experiments.

(*e*) See Falconer's "Diſſertation on the Bath waters, 1790."

which is the cooleſt. It always, however, keeps nearly up to theſe degrees of temperature in the reſpective baths; for, from the large body of water in the baths, the ſteam that is always in part interpoſed between its ſurface and the air, eſpecially from the freſh ſupply from the ſprings which is continually pouring in, any further loſs of heat during the time of bathing is prevented. This temperature is greater than that of any natural ſpring in our own country; but there are ſeveral on the continent much higher.

When the daily bathing is finiſhed, the water is let off through waſte channels that terminate in the river; and the floors of the ſeveral baths, as well as theſe channels, are found to be lined with a thin ſtratum of ochery ſediment, the ſame as that which is depoſited when the water remains to cool in any veſſel. Along with the water as it guſhes from the various ſources, there is brought a large quantity of an aſh-coloured pyritical ſand. This has been examined with great minuteneſs by various chemiſts, and is found to be compoſed of a ſiliceous earth, interſperſed with metallic looking ſpots. When thrown on hot coals, it burns with a blue flame, and fulphureous odour; and leaves a refidue which is in a fmall degree magnetical. If digefted with water, it is faid to render it flightly chalybeate. There is alfo a brown or olive coloured fcum, which floats on the furface of the water in fmall quantities, and which fome years ago gave rife to much difcuffion, as it was fuppofed to be a fulphureous compound of a peculiar nature, and was called *Bath Sulphur*. Dr. Lucas has the merit of refuting this opinion, and detecting fome petty frauds which were practifed to keep up the idea of its fulphureous nature. It is doubtlefs only a vegetable fubftance of the nature of a conferva *(f)*. Another matter which is brought up along with the Bath water from the different fprings, is a quantity of gas, which is conftantly to be obferved rifing through the body of water in the baths, in large clufters of bubbles, and may be readily collected by an inverted bottle held at the furface of the water. This circumftance had been noticed long before the nature of the gas was afcertained; and at firft, indeed, an erroneous opinion was formed concerning it, as, from

(f) Lucas, vol. 2. p. 208.

its precipitating lime water, it was ſuppoſed to be intirely carbonic acid gas. It was that acute and excellent philoſopher, Dr. Prieſtley, who firſt aſcertained the compoſition of this gas, which happened to engage his attention whilſt purſuing thoſe experiments on aeriform ſubſtances which firſt threw light upon pneumatic chemiſtry. He found that this gas contained in fact no more than about $\frac{1}{20}$ of its bulk of fixed air or carbonic acid, whence aroſe the precipitation with lime water; but that the remainder was ſcarcely altered by nitrous gas, and was almoſt intirely phlogiſticated air, or, as it is now termed, azotic gas (*g*).

On account of the high repute in which Bath water has been held for a long ſeries of years, and the numerous invalids of the firſt rank and conſequence, who have reſorted to theſe excellent ſprings, there is no water that has excited ſo much attention with a view to its chemical analyſis. The reſults of theſe inquiries have been variouſly reported at different times, and the explanation of theſe

(*g*) Prieſtley's "Experiments and Obſervations on Air, 1775," vol. 2. p. 225.

phenomena has followed the changes in theoretical reaſoning which it has been the lot of this ſcience to experience for ſeveral years paſt. We are now in poſſeſſion of a ſufficient number of *facts*, determined by cautious and judicious chemiſts, to give us a pretty exact idea of the nature of this water, which, as a chemical compound, as well as a medicinal preparation, is deſerving of particular attention. With ſuch good authorities as Lucas, Falconer and Gibbs (*b*), we may aſcertain the peculiar conſtitution of this thermal ſpring; always keeping in view the corrections which the modern improvements in chemiſtry have enabled us to make.

We ſhall begin as uſual with the appearances produced by the different re-agents, and it is to be underſtood, that in the experiments, the water from the King's Bath is employed, where not otherwiſe ſpecified, and always warm and freſh from the pump.

Litmus tincture does not alter its colour when added to the water; ſhewing that there is no exceſs of acid.

(*b*) See three papers by Dr. Gibbs on the Analyſis of the Bath waters, inſerted in the third volume of Nicholſon's Journal for 1799 and 1800.

Syrup of violets is not changed at firſt, but after ſome hours aſſumes a pale graſs green colour. This is obviouſly owing to the ſmall quantity of carbonat of lime diſſolved in the water, which may be collected by further analyſis; and the teſt with litmus ſhews, that there is no more carbonic acid, or ſcarcely more, than is neceſſary to keep the lime ſuſpended.

Lime water cauſes an immediate milkineſs with the freſh water, leſs when it has ſtood uncorked for half an hour, and none at all after twenty-four hours. The precipitate thus produced conſiſts both of the lime that is added, and that in ſolution with the water, both in the ſtate of calcareous carbonat.

Acetite of lead produces a white precipitate, which does not turn brown by ſtanding; and ſilver leaf is not in the leaſt tarniſhed by it; ſhewing the abſence of any thing ſulphureous.

Nitrated ſilver, and muriated or acetited barytes, produce an immediate turbidneſs, indicating the preſence of the muriatic and ſulphuric acids.

The oxalic acid ſhews the preſence of lime, and this is the moſt abundant in the Hot Bath.

When tincture of galls is added to the fresh water, in a few moments it becomes discoloured, and after standing a short time it becomes of a full purple: but this effect is not produced if added to the water when it has grown cold, even though kept in a close corked bottle. This indicates a minute portion of iron in the former case, and that by cooling, it separates from the water either intirely, or so much as not to be then in a state capable of detection by the usual re-agents.

The carbonated alkalies cause a copious white precipitate: the caustic alkalies give also the same appearance, only in much less quantity.

Bath water at all times curdles soap, and is in general so hard as to be unfit for many domestic purposes.

When any considerable quantity of this water is evaporated, a pellicle gradually forms on the surface of the liquor, and a slight discoloured ring appears at the edge of the vessel. At the same time an earthy powder is precipitated. As the solution becomes more concentrated, it becomes yellowish, and when the water is all evaporated, it leaves a grey cryſtalline maſs. Nothing ſenſible to the ſmell eſcapes during the whole proceſs, but a ſmall portion of gas is given out, which may be collected and examined. The ſolid reſiduum is partly ſoluble in water, partly in any acid, and it is partly inſoluble in any liquid menſtruum. If a moderate quantity of water be firſt added, it diſſolves out of the maſs ſulphat of ſoda and common ſalt; a larger portion will take up ſelenite; muriatic acid will diſſolve the carbonat of lime, and that minute portion of iron which gave the chalybeate taſte and purple colour to galls when the water was freſh; and laſtly, there will remain an earth, which is found to be ſiliceous earth, a diſcovery that we owe to Dr. Gibbs.

The actual quantities of theſe ſeveral ingredients have been eſtimated very differently by ſeveral perſons who have analyſed the waters. This may partly ariſe from an actual difference in the water at various times, but principally from the circumſtance of a greater heat being applied to dry the ſubſtances before weighing in one caſe than in another. Dr. Lucas eſtimates the ſolid contents in the following manner: Of ſulphat of lime 31½ grains; of carbonat of lime $22\frac{1}{2}$ grains; of ſulphat of ſoda 26 grains; of common ſalt 52 grains; and of oxyd of iron about $\frac{1}{18}$, or not quite a quarter of a grain in the wine gallon. Total 132 grains nearly, of which 54 are earthy, and little ſoluble in water, and 78 are neutral alkaline ſalts, and very ſoluble.

Dr. Charlton's analyſis (*i*) comes very near to that of Lucas. He obtained 34 grains of reſiduum in a quart of the King's Bath water, of which 20 parts were ſoluble in rain water, and 14 ſubſided. This, if brought to the proportions of a gallon, will give 136 grains for the whole contents, 56 of which are earthy, and 80 are ſoluble neutral ſalts.

The next analyſis, in order of time, is that of Dr. Falconer. The examination of this learned phyſician gives a conſiderable difference from the two former, both in quantity of ſolid contents, and proportion of their component parts. From ſix gallons of King's Bath water he obtained only ſeven drams and

(*i*) See Dr. Charlton's "Three Tracts on the Bath Water," &c. 1774.

half a fcruple, or 430 grains of folid refiduum, which is only about 71 grains in the gallon. The proportion of foluble to infoluble matter alfo differs. Out of 80 grains of folid refiduum, warm water, repeatedly added, could diffolve only 31 grains, leaving, therefore, 49 for the infoluble part. This, if brought to the proportion of the 71 grains of total refiduum in the gallon, will give about 27½ grains of the neutral falts, and 43½ of the felenite and infoluble calcareous earth.

Laftly, Dr. Gibbs, whofe analyfis is not complete, obtained a folid refiduum in the proportion of about 93 grains to the gallon, after the water had been intirely evaporated, and the remaining mafs thoroughly dried. Of this there were diffolved in the proportion of 77¾ grains by the united action of water and nitrous acid, but about 15¼ grains were left behind, which, when mixed up with foda and expofed to the blow pipe, effervefced and fufed into a perfect glafs, and was therefore filiceous earth (*k*). This difcovery of filex, where it was not fufpected, appears to be of importance in explaining fome apparent errors

(*k*) Nicholfon's Journal, vol. 3.

in the former calculations, as we ſhall mention preſently.

The quantity of gaſeous contents in Bath water appears to have been much over-rated by ſome writers. The eſtimate made by Dr. Prieſtley ſeems to determine this point in a more ſatisfactory manner. This ingenious chemiſt relates the following experiment (*l*): " In order to aſcertain what proportion of air is contained in the Bath water in the ſtate in which it is drank, I filled a pint phial with water hot from the pump, and expelled the air from it by boiling it for about four hours, receiving the produce in quickſilver. This air was about $\frac{1}{30}$ of the bulk of the water, and about one half of it was fixed air, precipitating lime in lime water, and being readily abſorbed by water. The reſiduum appeared by the teſt of nitrous air to be rather better than air in which a candle had burned out."

From this experiment it would appear, that Bath water contains only $\frac{1}{60}$ of its bulk of carbonic acid, which is almoſt entirely employed in holding in ſolution the carbonat of

(*l*) Prieſtley's Experiments and Obſervations on different Kinds of Air, 1775, vol. 2. p. 222.

lime which the water contains, and the oxyd of iron; for neither is this quantity enough to give any appearance of brifknefs or effervefcence to any water, nor do we find in the Bath water any marks of an uncombined acid by the delicate teft of litmus (*m*). This water has therefore no claim to the title of a brifk carbonated mineral fpring, for the quantity of carbonic acid is lefs than in many common pump-waters, neither is there any thing unufual in the combinations of this acid, except that of holding diffolved a minute portion of iron.

With regard to the quantity of this metal, nothing certain however has been afcertained, except that it is extremely fmall, probably nearly the leaft that is poffible to be detected by chemical tefts. The method ufed by the

(*m*) In order that waters fhould redden litmus they muft contain at leaft about $\frac{1}{18}$ of their bulk of carbonic acid, uncombined with an earth or alkali, as Kirwan obferves in his excellent Treatife on Mineral Waters, page 36; but thofe waters that hold in folution a much lefs quantity of this acid, will ftill diffolve a minute portion of iron, and become fenfibly chalybeate. Hence it is, that many waters that do not redden litmus, will however give a purple with tincture of galls after they have been for fome minutes fhaken with iron filings; and as Dr. Falconer obferves, the chalybeate of Bath water is increafed by this procefs.

analyſers of Bath water to eſtimate this quantity, was the very uncertain one of comparing the ſhades of purple produced, by adding an equal number of drops of tincture of galls to a ſolution of ſulphat of iron of a known ſtrength, and to Bath water. Hence we find the reſults to vary conſiderably, for Dr. Carlton reckons it only $\frac{1}{70}$ of a grain in a pint, and Dr. Lucas $\frac{1}{38}$.

The diſcovery of ſiliceous earth in this water will clear up a difficulty in its analyſis, which muſt ſtrike the chemical reader. If $22\frac{1}{2}$ grains of carbonat of lime were contained in the gallon of water (which is the loweſt eſtimate, and is that of Dr. Lucas), it could not be ſuſpended by only $\frac{1}{60}$ of its bulk, or 3.85 cubic inches of carbonic acid. Mr. Kirwan eſtimates from very accurate calculations, that where the quantity of this earth is ſmall compared with that of the water, an addition of half its weight of uncombined carbonic acid would hold it in ſolution (*n*); but if the gallon of Bath water contained $22\frac{1}{2}$ grains of carbonat of lime, it would require $11\frac{1}{4}$ grains, or about 24 cubic inches of car-

(*n*) Kirwan on Mineral Waters, page 20.

bonic acid to keep it diffolved; whereas Dr. Prieftley's experiments did not fhew an eighth of this quantity. But fince Dr. Gibbs finds in this water $15\frac{1}{4}$ grains of filiceous earth in the gallon, all which remains in the refiduum that is infoluble in water, as well as the carbonat of lime, we may well fuppofe that the two have been confounded with each other; and that in fact the Bath water contains only about feven or eight grains of the calcareous earth, which would require for their folution about as many cubic inches of carbonic acid, which is ftill however much more than Dr. Prieftley's calculation.

From the various chemical inveftigations that have been mentioned, we may form this general conclufion concerning the compofition of Bath water; that it contains a good deal of calcareous falts, which render it hard and unfit for domeftic purpofes; that it holds in folution but little, if any, neutral alkaline falts, and therefore is fcarcely faline; that it is in a very flight degree impregnated with carbonic acid; in a ftill flighter with iron, and as it fhould appear, only when hot from the fpring; and that it holds fufpended a fmall portion of ſiliceous earth, which will deſerve notice from the chemiſt, as a curious, though not a ſingular occurrence. The preciſe quantities of all theſe ingredients it is not eaſy to determine, on account of the difference in the reſult of experiments made by different perſons, none of which are at all improbable, as there are many waters that contain leſs foreign matter than the loweſt eſtimation, and more than the higheſt.

Perhaps we ſhall make a pretty near approximation to the truth, if we reckon a gallon of the King's bath water to contain, for its *gaſeous* contents, about 8 cubic inches of carbonic acid, and the ſame quantity of air nearly azotic: for the *ſolid*, about 80 grains, in the whole of which, perhaps one half may be ſulphat and muriat of ſoda, $15\frac{1}{2}$ grains of ſiliceous earth, and the remainder ſelenite, carbonat of lime, and a very minute portion, ſcarcely appreciable, of oxyd of iron (*o*).

(*o*) I take no notice of aluminous earth which Dr. Gibbs ſuppoſes to exiſt, from the ſlight precipitation produced by cauſtic ammonia. It is certainly true, that pure ammonia, will not precipitate lime, but when added to a water containing carbonat of lime in ſolution, it will itſelf become a carbonated alkali, and thus precipitate calcareous earth by double affinity. It is

The waters of the three baths differ in fome degree in chemical compofition. According to Dr. Falconer, the folid refiduum from a gallon of each water, is in the proportion of 71 grains in that of the King's bath, 78 grains in the Hot bath, and 86 grains in the Crofs bath. Of 80 grains of each refiduum, the faline part foluble in water, was 31 grains in the firft, 29 in the fecond, and only 11 in the third. This latter therefore, contains much more infoluble matter, and as this refiduum does not effervefce very ftrongly with nitrous acid, it is probably chiefly fulphat of lime. The depth of colour produced with tincture of galls, was the greateft in the firft mentioned water, lefs in the fecond, and leaft of all in the third.

The degree of precipitation with lime water followed the fame order.

rather furprifing this ingenious chemift fhould deny that pure ammonia will precipitate magnefia, a fact which is perfectly well afcertained, as indeed it is in the *readinefs* with which this earth is precipitated, that it is in fome degree diftinguifhable from alumine. The affinity of pure ammonia for acids, is however fo little above that of magnefia, that it never intirely precipitates this earth.—See Kirwan's Mineral Waters, page 93; Fourcroy's Chemiftry, &c.

Hence we may conclude, that the King's Bath water is the ſtrongeſt chalybeate, that it contains the moſt carbonic acid, and active neutral ſalts, and the leaſt of the ſelenite and other earthy reſiduum. The Hot Bath water is a very little weaker as a chalybeate, as well as in gaſeous and ſaline contents, but yields more earthy reſiduum. The Croſs Bath water is ſtill leſs gaſeous, chalybeate, and ſaline, but much more earthy. The temperature alſo of its water in the pump, is two degrees lower than that of the others.

It has been already mentioned, that the exiſtence of ſulphur in the Bath waters, was a ſubject much agitated by all the earlier analyſers of theſe mineral ſprings. Though the preſent advanced ſtate of chemical knowledge has, beyond a queſtion, proved that this combuſtible ſubſtance is not in any degree contained in theſe waters (excepting as a conſtituent part of ſulphuric acid), the chemical hiſtory of theſe ſprings would be imperfect if we did not take ſome notice of this controverſy. It is but of late years, that the nature of ſulphur, and the forms under which it appears in mineral waters, have been at all underſtood, and for want of well defining what was meant by this term, ſeveral ſubſtances have been confounded with this inflammable. But the obvious teſt of the ſulphureous odour which this ſubſtance gives out on combuſtion, when it can be collected in a ſolid form, has been long known as one of its eſſential characters. On this account Dr. Lucas, even at the time when his reſearches into Bath water excited a good deal of attention, was able to undeceive the public with regard to the nature of the moſs, or conferva, which is ſometimes found floating on the water of the baths, and which was conſidered as a kind of ſulphur, and accordingly called Bath Sulphur. He likewiſe expoſed the ſecret of a common trick with the Bath guides of tarniſhing ſilver into a reſemblance of gold; which was performed in a myſterious manner, and was ſuppoſed to be effected by the waters. The other ſource of the ſulphur, which was imagined to exiſt in theſe waters, was the pyritical ſand that is brought up in conſiderable quantities by the force of the ſpring. This is certainly ſulphureous, but it does not impart any ſuch quality to the water.

We at preſent know from the ſtricteſt chemical reſearch, that there are only two forms in which ſulphur is ever united to waters, that of ſulphurated hydrogen gas, or inflammable air holding ſulphur in ſolution, and of ſulphuret of ſoda, or ſulphur diſſolved by the mineral alkali. Of theſe two forms, the firſt is by far the commoneſt, the latter extremely rare. In all caſes the ſulphur will be detected by tarniſhing ſilver or mercury, blackening the ſolutions of ſilver, lead, or biſmuth, and by other chemical teſts. The Bath waters, however, exhibit not the ſlighteſt traces of ſulphur when ſo examined. The uncertainty of the ideas of former chemiſts concerning the nature of ſulphur, is abundantly ſhewn by ſuch definitions as the following: "The "ſulphureous principle of the Bath waters, is "an exceeding fine aromatic balſam, entirely "diſſimilar from common brimſtone."(*p*)—But it is unneceſſary to take further notice of this controverſy.

Having finiſhed our account of the chemical compoſition of theſe intereſting waters, the

(*p*) Charlton, on the Bath waters.

next object of inquiry is the ſenſible effects produced by them, and their application to the healing art. There are few of the natural waters in which it is ſo difficult to ſeparate the effects of the mere liquid, joined to temperature, from thoſe of the foreign contents, that are found in the freſh drawn water. Indeed this is in ſome degree impoſſible, becauſe the increaſed heat appears to give an activity and power to ſubſtances ſo minute in quantity, that they would probably paſs inactive through the circulation, were they taken cold. That much of the effect of Bath water is merely owing to its warmth, can hardly be doubted, and there may be ſome conſtitutions, to whom this is the only effect, as well as ſome diſeaſes, which never require more than this ſimple remedy; but there are other habits, and eſpecially the delicate and irritable, who feel ſtrongly the peculiar compoſition of this water, and with theſe it requires ſometimes conſiderable precaution in its uſe.

The Bath water, as Dr. Falconer ſays, (*q*) when drank freſh from the ſpring, has in

(*q*) See Falconer's Diſſertation on the Bath waters. 1790.

moſt perſons the effect of raiſing, and rather accelerating the pulſe, increaſing the heat, and exciting the ſecretions. Theſe ſymptoms generally come on very ſoon after drinking the waters, and, with certain habits, will laſt for a conſiderable time. It is however particularly in invalids that they are produced at all. The above mentioned effects then, demonſtate, that Bath water poſſeſſes heating properties, but at the ſame time ſhew that its ſtimulus is of a peculiar kind, and acts more immediately on the nervous ſyſtem.

Beſides theſe, it has alſo a conſiderable diſpoſition to paſs off by urine, even when taken in a moderate doſe; and this may be conſidered as one of its moſt ſalutary operations.

Its effect on the bowels, like that of all waters which do not contain any purgative ſalt, is very various; but in general, a coſtive habit of body comes on after the uſe of this water, not ſo much owing to any aſtringency which it may poſſeſs, as from the want of an active ſtimulus to the inteſtines, and probably alſo from the determination which it occaſions to the ſkin; for if perſpiration is ſuddenly checked, during a courſe of Bath water, a purging ſometimes ſupervenes.

These circumſtances ſeem to ſhew, that the ſtimulant properties of this water, are primarily and more eſpecially excited in the ſtomach, for it is there only that we can diſcover any thing peculiar in its operation, and it occaſions, at times, a variety of ſymptoms, ſometimes ſlight and tranſient, but at other times ſo conſiderably permanent, as to render its continuance improper. When the waters are likely to prove beneficial, they excite, on being firſt taken, a pleaſing glow in the ſtomach, to which ſoon ſucceed an increaſe of appetite and ſpirits, and a rapid determination to the kidnies. On the other hand, when they occaſion head-ach, thirſt, and dryneſs of the tongue, when they ſit heavy on the ſtomach, and produce ſickneſs, and do not paſs off by urine or perſpiration, their operation is unfavourable, and their further employment is not to be adviſed.

One of the moſt important uſes of the Bath water is, however, its external application; and its effects here appear to me to differ in no reſpect from thoſe of common water, heated to the ſame temperature, and ſimilarly applied.

Bath certainly poſſeſſes conſiderable advantages, in having a ſupply of water ſufficient to fill the numerous reſervoirs for immerſion, and to preſerve them at a ſteady temperature. But its eulogiſts, not content with this, have affirmed, that even when uſed externally, it exerciſes a ſtimulant power on the ſkin, which renders it preferable to common water. One of its moſt zealous advocates, Dr. Falconer, admits that, as a mere detergent, Bath water is inferior to rain water, ſince it is very hard, curdles ſoap, and has conſequently a much leſs cleanſing power; yet he aſſerts that it is ſuperior as a ſtimulant application.

This, I own, appears to me extremely doubtful, for, whatever minute portion of active matter it may contain, that is capable of acting on the ſtomach, it appears by the moſt accurate chemical inveſtigation, to be far too ſmall in quantity, and too inſignificant, to be felt by that leſs ſenſible organ, the ſkin. Such being the compoſition of the water, it is indeed difficult to conceive how, when uſed only as a bath, it ſhould be more ſtimulant than common water; ſhould raiſe the pulſe and animal heat to a higher degree; ſhould occaſion much leſs relaxation and faintneſs, and leave the bathers more alert and vigorous for the whole day.

We are even aſſured, that theſe natural warm baths produce leſs perſpiration, yet that they increaſe the urinary diſcharge much more than a common warm bath, and other circumſtances equally difficult to be admitted. As all theſe effects, however, are only alledged to be greater in degree, than thoſe occaſioned by a common warm bath, we ſhould, I think, refer them to the greater equability of temperature exiſting in the large, natural baths; to the quantity of aqueous vapor in which the bathers are conſtantly immerſed; and in ſhort, to any accidental difference either in the bath, or in the ſtate of the patient, rather than to admit an opinion ſo contrary to all probability. One circumſtance, I apprehend, will particularly give a preference to the natural bath, which is, the conſtant motion which the patients are uſing when immerſed; the ſize of the public baths being ſuch as to admit the bathers to walk about with great freedom;

and this alone will be ſufficient, I think, to account for any ſlight difference that may be obſerved between this and a common bath. Moſt of the natural thermal waters, poſſeſs this advantage of copious ſupply, a convenience which can ſeldom be commanded to any great extent in other ſituations. (*r*)

(*r*) It has been ſuggeſted, in order to account for the effects upon the head, which have been ſuppoſed to be peculiar to the waters of Bath and Buxton, that the large quantity of azotic gas which they are conſtantly giving out, might produce ſome important changes in the reſpiration of the bathers, whilſt they are immerſed in this atmoſphere. This ſingular operation of the gaſeous oxyd of azot upon the nervous power, when taken into the lungs, as aſcertained by Mr. Davy and Dr. Beddoes, might at firſt ſeem to give ſome probability to this conjecture; but it appears to me that the caſes are by no means parallel; for, in the firſt place, it is azotic gas, and not the gaſeous oxyd of azot, which the Bath as well as Buxton waters give out, and the difference between theſe two gaſeous bodies is very well defined; and, in the next place, we find that theſe peculiar effects on the nervous power, are almoſt intirely confined to the internal uſe of theſe waters, ſince they have hardly been at all remarked in thoſe who merely bathe at Buxton, and only in a ſmall degree in thoſe at Bath, which is of a much higher temperature. I ſtill therefore muſt be of opinion, that both theſe thermal waters, when uſed externally, can only be conſidered as ſimple water of a given temperature. Employed as an internal medicine, the quantity of azotic gas which *then* comes within reach of the body, is extremely ſmall, and goes intirely to the ſtomach; ſo that nothing can be here inferred, in analogy with its effects on the proceſs of reſpiration.

The warm bath is ufed either generally or locally. The latter confifts in pumping the water for a confiderable time on the part affected. This mode, which is much employed at Bath, as well as at moft of the thermal fprings, both in this and other countries, is here called *dry pumping*, becaufe in it only one part of the body is wetted, whilft the reft is kept dry. The continuance of this application is meafured by the number of ftrokes of the pump, and from fifty to an hundred are generally ufed at a time. This is in many cafes an excellent remedy, and the water thus applied, as it comes immediately from the fountain head, is of a confiderably higher temperature than in the large baths, which require fome hours in filling, and thus lofe feveral degrees of their heat.

The difeafes for which thefe celebrated waters are reforted to, are very numerous, and are fome of the moft important and difficult of cure of all that come under medical treatment. In moft of them the bath is ufed along with the waters as an internal medicine (*s*).

(*s*) The Reader will find much information in confulting on this fubject Charlton's " Tracts on the Bath Water; and Falconer's " Practical Differtation on the Medicinal Effect of the Bath Waters." 1790.

The general indications of the propriety of ufing this medicinal water are in thofe cafes where a gentle, gradual, and permanent ftimulus is required, and where there is little to be feared from the fudden and tranfient heat, and increafe of pulfe that fo often attend its exhibition. Bath water may certainly be confidered as a chalybeate, in which the iron is very fmall in quantity, but in a highly active form; and the degree of temperature is in itfelf a ftimulus, often of confiderable power. Thefe circumftances, again, point out the neceffity of certain cautions, which from a view of the mere quantity of foreign contents might be thought fuperfluous. Although, in eftimating the powers of this medicine, allowance muft be made for local prejudice in its favour, there can be no doubt but that its employment is hazardous, and might often do confiderable mifchief in various cafes of active inflammation, efpecially in irritable habits where there exifts a ftrong tendency to hectic fever; and even in the lefs inflammatory ftate of difeafed and fuppurating vifcera, and in general, wherever a quick pulfe and dry tongue indicate a degree of general fever.

The cafes therefore to which this water are peculiarly fuited, are moftly of the chronic kind, and by a fteady perfeverance in this remedy very obftinate diforders have given way. A few of the principal we fhall enumerate.

Chlorofis, a difeafe which at all times is much relieved by fteel, and will bear it, even where there is a confiderable degree of feverifh irritation, receives particular benefit from the Bath water, and its ufe as a warm bath excellently contributes to remove that languor of circulation and obftruction of the natural evacuations which conftitute the leading features of this common and troublefome diforder.

The complicated difeafes which are often brought on by a long refidence in hot climates, affecting the fecretion of bile, the functions of the ftomach and alimentary canal, and which generally produce organic derangement in fome part of the hepatic fyftem, often receive much benefit from the Bath water, if ufed at a time when fuppurative inflammation is not actually prefent. I can only, however, confider it as an auxiliary of fome efficacy, but by no means as forming the principal part of the plan of cure.

Another and lefs active difeafe of the biliary organs, the jaundice, which arifes from a fimple obftruction of the gall ducts, is ftill oftener removed by both the internal and external ufe of thefe waters.

Bath is better known than moft other watering places, as a refort for patients afflicted with thefe diforders, which, at firft, and in their moft inflammatory ftate, affect the whole conftitution, and afterwards leave a weaknefs, lofs of motion, pain, or other difeafed condition of particular limbs. Of this kind are gout, rheumatifm, and feveral other diforders, which give rife to many varieties of paralyfis. It is not my intention to enter into a hiftory of thefe formidable complaints, which often require the utmoft fkill in their treatment; but merely to offer a few remarks concerning the ufe of this remedy in fuch cafes. We fhould always keep in mind that this water, whether from its warmth, or from other caufes, though capable of increafing a febrile ftate of body, where fuch already exifts, will ſeldom, if ever, produce it in a healthy ſubject. In each of theſe diſorders there is at one time or other a high phlogiſtic diatheſis, which is generally ſo well marked as not to be eaſily miſtaken. Moſt of the patients affected with them do not apply to Bath till long after the firſt inflammatory ſtage is over, and this is eſpecially the caſe in rheumatiſm and gout. Paralytic affections are the effect of a variety of morbid cauſes, but are often connected with original ſtructure, and a conſtitutional determination to the head; and in theſe diſorders alone does it appear, that this water can ever be ſo miſapplied as ſuddenly to produce conſiderable miſchief. In almoſt every other caſe we have ample time to watch the effects of this remedy, and if it proves detrimental we may ſtop its application before any real injury be done. In rheumatic complaints, the power of this water, as Dr. Charlton well obſerves, is chiefly confined to that ſpecies of rheumatiſm which is unattended with inflammation, or in which the patients pains are not increaſed by the warmth of his bed. A great number of the patients that reſort to Bath, eſpecially thoſe that are admitted into the hofpital, are affected with rheumatifm in all its ftages, and it appears from the moft refpectable teftimony, that a large proportion of them receive a permanent cure (*t*).

In gout, the greateft benefit is derived from this water in thofe cafes where it produces anomalous affections of the head, ftomach, and bowels, and it is here a principal advantage to be able to bring by warmth that active local inflammation in any limb which relieves all the other troublefome and dangerous fymptoms. Hence it is that Bath water is commonly faid to produce the gout, by which is only meant, that where perfons have a gouty affection fhifting from place to place, and thereby much difordering the fyftem, the internal and external ufe of the Bath water will foon bring on a general increafe of action, indicated by a flufhing in the face, fulnefs in the circulating veffels, and relief of the dyfpeptic fymptoms; and the whole diforder will terminate in a regular fit of the gout in the

(*t*) The Reader will find much information on this fubject in Dr. Falconer's "Account of the Ufe, Application, and Succefs of the Bath Waters in Rheumatic Cafes." 1795.

extremities, which is the crifis always to be wifhed for. That painful and obftinate colic, produced by the poifon of lead, and the paralyfis or lofs of nervous power in particular limbs, which is one of its moft ferious confequences, is found to be peculiarly relieved by the ufe of the Bath waters, more efpecially when applied externally either generally or upon the part affected. In this diforder there is feldom, if ever, any thing to be apprehended from the ftimulant effect of thefe waters, but all the action which it does exert is highly falutary. It forms, therefore, a very important remedy in thefe cafes, at all times, but efpecially after the firft affection of the bowels is removed, and only the partial paralyfis remains.

Befides thefe diforders, for which the Bath waters may be faid to be peculiarly calculated, there are others in which this medicine probably operates, principally as mere water of a certain temperature. Such are in general all thofe for which warm bathing and a warm diluent may at any time be of advantage, and which therefore do not concern its powers as a *mineral* water. The cure of various cutaneous complaints, and the relief produced in hypochondriafis, by the warm bath, and much of the benefit derived from the water in dyfpeptic affections, fpafm of the ftomach, or inteftinal canal, and fimilar diforders, may, I think, fairly be attributed to this caufe alone, and therefore, to complete the hiftory of the medical powers of this as well as every other water, I muft beg to refer the reader to thofe parts of this work that treat of the warm bath, and the aqueous regimen (*u*).

The quantity of water taken daily during a full courfe, and by adults, is recommended by Dr. Falconer not to exceed a pint and a half or two pints; and in chlorofis w irritable habits, not more than one pint is employed. The morning is conftantly the time for taking the waters, and the daily allowance is generally divided into three portions, of which two may be taken before breakfaft at different times, and one afterwards. As the water of the Crofs Bath is confidered as lefs ftimulant, and is certainly

(*u*) In the concluding chapter the reader will alfo find fome further notice taken of the *modus operandi* of the Bath Water, efpecially as concerns its chalybeate impregnation.

lower in temperature, this is ſometimes introduced, by a refinement in practice, where the King's Bath is ſuppoſed to be too heating. From the difference in the calculations it is impoſſible to give the preciſe doſe of foreign ingredients taken daily with ſuch a quantity of water; but according to our general eſtimate, it is probable that each doſe of half a pint contains no more than half a cubic inch, or about two drams in bulk of carbonic acid, and as much azotic gas, and perhaps five grains of ſoluble neutral ſalts, and the ſame quantity of earths and earthy ſalts. The proportion of iron it would perhaps be of more conſequence to aſcertain with exactneſs, but this is ſo ſmall, that the higheſt computation would not make it ſo much as $\frac{1}{70}$ of a grain in half a pint of the water, and therefore we cannot at preſent come to any exact concluſion upon this ſubject. The whole, however, furniſhes a ſtriking example of conſiderable effects produced by quantities of active ſubſtances, ſo very minute, that in any other ſituation they would be thought, and perhaps juſtly, to be perfectly inadequate to bring on any change whatever in any functions of the human body; and therefore whatever powers Bath water may have above thofe of fimple warm water, are eminently due to the peculiar mode of combination of its foreign contents (*x*).

The time at which the bath is made ufe of, is generally the morning, which is partly for convenience, and partly becaufe this has ufually been confidered as the beft time for this application. This is by no means, however, invariably the cafe, and in ufing the cold bath it is often neceffary to deviate from this general rule. From two to three times a week the warm bathing is ufually employed, and

(*x*) Dr. Gibbs fuggefts the probability that the filiceous earth affifts materially in the general effect of the Bath waters. After what has been faid of the great powers of very minute quantities, it will not be thought a fufficient objection againft this opinion, that no more than a grain of filex, according to Dr. Gibb's own calculation, is contained in half a pint of the water; nor will its general infolubility in any of the animal fluids be an objection, fince it is already prefented to the ftomach in a ftate of folution; nor its want of the fenfible properties of tafte and fmell in any of its known combinations, fince we know of fome indifputably powerful medicines which have little of either; and therefore this opinion, though it does not imprefs the mind with any great degree of probability, certainly remains to be confirmed or refuted by further inveftigation.

the patients continue in from ten minutes to half an hour. If it produces head-ach or any degree of vertigo, it muft be ufed very carefully in perfons of a full plethoric habit; and the time of remaining in the bath is in a great meafure to be regulated by the fenfations of the patient, who fhould always leave it when any degree of laffitude or faintnefs comes on. The choice of the different baths is here a circumftance of more importance, perhaps, than when the water is employed for internal ufe, fince there is a very decided difference in their refpective temperatures. That of the Crofs Bath is about 94; whereas the Hot Bath is at leaft 8 degrees higher (*y*), and therefore the former is, in fact, only a tepid bath, being of a lefs heat than that of the human body, though it feels warm to the fkin, even on the firft immerfion. The topical warm bath, applied by pumping on any difeafed part, from the impetus of the falling water, is always a greater ftimulus than mere immerfion, and as the fyftem is not thereby generally affected, it may be ufed in every cafe more

(*y*) Falconer's Practical Differtation on Bath Water.

frequently and with greater freedom than any other way in which thefe waters are ever employed.

The waters of Bath are certainly among thofe that require a confiderable time to be perfevered in before a full and fair trial can be made. Their operation is very gradual, as indeed might be expected from a medicine which fhows fo few fenfible properties or immediate effects. Frequently too they are apt to lie heavy upon the ftomach when they have been taken for fome weeks, and when this is the cafe they muft be intermitted for a time, and may afterwards be refumed. Indeed it muft be owned, that a large proportion of the patients who refort to thefe fprings are afflicted with diforders that are in themfelves only to be palliated, or at leaft are always very difficult of cure. Chronic rheumatifm, habitual gout, dyfpepfia from a long courfe of high and intemperate living, and the like, are diforders not to be removed by a fhort courfe of any mineral water, and many of thofe who have once received benefit at thefe fountains find it neceffary to make an annual vifit to them, to repair the wafte in health during the preceding year. However, with well-regulated expectations, and a judicious mode of treatment, the invalid will feldom be here difappointed, and we may fairly confider the thermal fprings of Bath as among the moft valuable natural waters which our ifland poffeffes.

It has frequently been fuggefted to me by profeffional men and others, that I am too incredulous refpecting the efficacy of Bath Water in the cure of difeafes, and that I have attributed its powers on the animal economy too much to its temperature and watery vehicle. In my own juftification on this fubject, I hope the reader will excufe the following quotation from the pofthumous work of the late Dr. Heberden, a man not lefs celebrated as a fcholar and philofopher, than as a profound and accurate obferver.

" The difficulty of afcertaining the powers
" of medicines, and of diftinguifhing their
" real effects from the changes wrought in
" the body by other caufes, muft have been
" felt by every phyfician: and no aphorifm

" of Hippocrates holds truer to this day,
" than that in which he laments the length
" of time neceſſary to eſtabliſh medical truths,
" and the danger, unleſs the utmoſt caution
" be uſed, of our being miſled even by expe-
" rience. This obſervation is fully verified
" in the uncertainty, under which we ſtill
" remain, in regard to the virtues of the
" waters of Bath. Few medicines have been
" more repeatedly tried under the inſpection
" of ſuch numerous and able judges; and
" yet we have had in the preſent age a diſ-
" pute between thoſe who by their experi-
" ence and ſagacity were beſt qualified to
" decide this queſtion, in which one ſide
" aſſerted that paralytic patients were cured,
" and the other that they were killed, by the
" uſe of theſe waters. Such contrary deci-
" ſions, ſo diſreputable to phyſicians, and ſo
" perplexing to the ſick, could never have
" happened after ſo long a trial, if a very ſmall
" part of thoſe, whoſe practice had afforded
" them frequent opportunities of obſerving
" the effects of Bath waters, had told the public
" what in their judgment was to be hoped or
" feared from them. It is probable that in

" ſome caſes it would have been almoſt una-
" nimouſly determined they do good: in
" others, that they do no harm, though it
" might be doubtful whether they be of
" much uſe: in a third ſort they would be
" generally condemned: and in a fourth claſs
" of diſeaſes, ſome might judge them to be
" beneficial, and others detrimental.

" Wherever the generality of voices paſſed
" either of the two firſt ſentences upon theſe
" waters, there the uſe of them might be ad-
" viſed, or permitted, without any heſitation;
" and all ſhould be cautioned againſt them,
" where a great majority agreed that they
" were hurtful. It would be no great loſs
" to avoid going to Bath, in caſes where the
" weight of evidence was ſo equally divided,
" as to make it doubtful whether the waters
" were a remedy or a poiſon; for the proba-
" bility is, that in all ſuch diſorders they are
" in reality inſignificant, and that the patients
" who uſe them, either recover by other me-
" dicines, or the ſtrength of their conſtitu-
" tions, or elſe ſink under the natural pro-
" greſs of their diſeaſes. It is here taken
" for granted, that no chemical analyſis can

" do much towards afcertaining the virtues
" of thefe mineral fprings, but that almoft all
" our ufeful knowledge of them, as medicines,
" muft be gained from experience. Their
" virtues may be confidered either as they are
" ufed externally, or internally.

" Externally ufed, either by immerfing
" the whole body, or by deriving a ftream to
" fome particular part, they appear to be
" ferviceable againft contractions and other
" fpafmodic affections of the mufcles. In
" flight cutaneous diforders, warm bathing
" will fometimes clear the fkin for a little
" while, but can hardly be confidered as a
" cure. It has been a doubt with me,
" whether any weaknefs left by the rheuma-
" tifm, gout, or palfy, have been fooner re-
" moved by bathing at Bath, than they
" would have been without it. In fome pa-
" tients thefe weakneffes have been mani-
" feftly increafed after a courfe of bathing at
" Bath; and, according to my experience,
" cold bathing in thefe cafes is preferable.
" It is by no means clear to me, that the
" external ufe of Bath water is more bene-

" ficial than that of equally warm common
" water, or at all different from it.

" Internally, these springs are of singular
" use in remedying the morning sickness and
" vomiting, the loss of appetite, pains of the
" stomach, and other ill effects of hard
" drinking, where it has not been so long
" continued as to make the liver scirrhous,
" or to bring on a dropsy; for in both these
" cases they are so far from relieving, that they
" aggravate the patient's misery, and hasten his
" death. They are so generally beneficial
" in other disorders of the stomach and bowels
" that the probability of considerable benefit
" will make them very well worth any one's
" trying, who is afflicted with indigestion,
" a chronical diarrhœa, hiccup, flatulency,
" vomiting, or any spasmodic affections, and
" weaknesses and pains of these parts, pro-
" vided the pulse be in a natural state. For
" if there be no signs of hectical feverishness,
" I never had reason to suspect that Bath
" was prejudicial in any of these complaints,
" though it may have sometimes failed of
" being a cure. But I have never yet been

" able to ſatisfy myſelf, amidſt the endleſs
" variety of theſe ails, upon what particular
" circumſtances it has depended, that in ſome
" it has not been attended with ſucceſs.

" Many judicious and experienced phyſi-
" cians have a ſavourable opinion of the in-
" ternal uſe of Bath water in flying pains and
" weakneſſes of the limbs, in rheumatiſms,
" and in ſimple jaundice, where the liver is
" not diſeaſed. From the caſes of this ſort
" which have fallen under my obſervation,
" I ſhould rather conclude it to be innocent
" in them, than of any great uſe. More
" perhaps ought to be ſaid in its commen-
" dation in the colic of Poitou; and yet it
" appears difficult to find a time in this cruel
" diſorder when we would wiſh to apply to
" Bath. During the paroxyſm, while the
" bowels are in torture, much ſtronger me-
" dicines are indiſpenſably neceſſary to the
" eaſe and ſafety of the patient: after the fit
" is ended, if the limbs do not become para-
" lytic, I ſuppoſe the patient would remain
" well without any relapſe, if the manner in
" which lead had been introduced into the
" body could be found out, and a ſtop be put

" to its ever being introduced again. For all " my experience tends to make me believe " with the learned and judicious Sir George " Baker, that lead is the ſole cauſe of this diſ- " temper, though it be difficult in many caſes " to trace its admiſſion into the ſtomach. " Some of the worſt fits of this colic, from " which I ever ſaw the patient recover, when " the cauſe was known, and could be avoided, " have, by keeping out of its reach, never " returned in many years; from which it is " probable there was no fomes morbi left. " I have likewiſe obſerved this happen in a " more chronical kind of this colic, where " the limbs were become ſemiparalytic; the " weakneſs of which gradually abated, and " the pains never returned, after leaving off " the uſe of white Liſbon wine, the drinking " of a pint of which every day was conjectured " to have brought on this malady. Now, if " the manner in which this poiſon inſinuates " itſelf be undiſcoverable, and ſo cannot be " guarded againſt, there neither Bath nor any " other known means would, in my opinion, " prevent the return of theſe torments, nor " hinder them from ending in a lingering

" death. But it may be ſuppoſed that a per-
" ſon has taken ſo much of this poiſonous
" metal, as may be ſufficient, without any
" repetition, to occaſion frequent fits of the
" colic, and to bring on at laſt the paralytic
" weakneſs peculiar to it; and that theſe bad
" effects may poſſibly be obviated by drinking
" the Bath waters, or that the weakneſs may
" be cured by them after it has been brought
" on. How much truth there is in theſe
" ſuppoſitions I know not, but I can eaſily
" allow them ſo much weight, as to be ſuf-
" ficient reaſons for the uſe of the Bath
" waters in theſe circumſtances, as they are
" unqueſtionably ſafe, and as I fear we are in
" want of other remedies upon which we
" might with more certainty depend. Beſides,
" in all chronical illneſſes, where theſe waters
" are innocent, there will be a good reaſon
" for any one's taking a Bath journey, who
" can afford it, in the benefit which he may
" hope to receive from the change of water,
" and air, from the breaking of ſome un-
" healthful habits, and from that ſuſpenſion
" of buſineſs and cares, in which the viſitors
" of Bath indulge themſelves; all which cir-

" cumſtances make a place of this ſort highly
" uſeful in eſtabliſhing the general health.

" The Bath waters have always appeared
" to me unqueſtionably prejudicial in all
" ſcirrhous and ulcerous affections of the
" lungs, or of the abdominal viſcera. They
" increaſe the hectical heat which uſually
" attends ſuch maladies, and ſpeedily put an
" end to what little hopes might have been
" entertained of their cure. All patients
" therefore of this ſort cannot be too earneſtly
" warned againſt meddling with the Bath
" waters, if they would avoid making their
" condition utterly deſperate; which, with
" the greateſt care, and under the beſt ma-
" nagement, is always dangerous.

" In extreme dejection of ſpirits, languor,
" laſſitude, inattention, tremblings, catchings,
" faintings, giddineſs, confuſion of the head,
" and palpitations without any other apparent
" diſtemper, which are uſually called hypo-
" chondriac, hyſteric, or nervous; in all theſe,
" whether the patients had uſed the water
" externally, or internally, I have obſerved
" them return worſe from Bath; but I hardly
" ever knew them better, if we except only

" ſome little relief of the pains, and flatulence,
" and acidities, which often accompany the
" before-mentioned ſymptoms. Nor does the
" vacancy of a Bath life ſuit complaints, which
" are more frequently cauſed by too little,
" than too much application and employ-
" ment. It will indeed ſometimes happen,
" that ſome degree of theſe miſerable ſen-
" ſations will be produced by a too great
" weight of buſineſs; the vexations of which
" in ſome evil hour may entangle a man ſo
" much, as to diſable him from extricating
" himſelf by his own ſtruggles, unleſs for a
" while he eaſes himſelf of the load by re-
" tiring to ſome ſuch place as Bath, where
" the manner of living will effect the cure,
" though the reputation of it may be put to
" the account of the waters. The ſame often
" happens in that languor and weakneſs,
" which are left by a long illneſs, and require
" only time and quiet for their removal." *

* Vide *Comment. on the Hiſtory and Cure of Diſeaſes, by W. Heberden, M.D. p.* 71.

OF SIMPLE SALINE WATERS.

In purfuing our plan of confidering mineral waters, as far as can be done, in the order of the degree of fenfible properties which they poffefs, and the fimplicity of their compofition, as far as regards their active foreign contents, we fhall notice a few individuals of a numerous clafs of waters which may properly be termed the *fimple faline*, or thofe that only differ from common water in being impregnated more or lefs ftrongly, with fome neutral falt with either an alkaline or earthy bafis, that renders it purgative, when taken in fuch a dofe as the ftomach can bear without being much incommoded by the mere bulk of liquid. In the fecond chapter of this work, I enumerated four neutral falts that appear to have a decidedly purgative effect, the muriats of foda and magnefia, and the fulphats of foda and magnefia. Of thefe, the two latter are the beft known as medicines, fince they form two important articles of the materia medica, and are familiar to every one, under the names of Glauber's ſalt and Epſom ſalt.

It ſeems highly probable that ſuch waters can only be conſidered, in a medical view, as a mere ſolution of theſe ſalts in a larger proportion of liquid, and ſuch as may with perfect eaſe be imitated artificially, without any particular precautions or apparatus. This we ſhall ſee is not the caſe with the more compound waters, eſpecially thoſe that contain much of any gaſeous body, the activity of which, as a chemical agent, is generally fully equal to that which it poſſeſſes as a medicine. The ſimple ſaline waters uſually contain ſeveral ſalts, ſome active, others apparently inert; they are moſtly cold, but ſometimes warm; and not unfrequently they are found in the neighbourhood of a chalybeate ſpring, which latter is often very purely ſo, whilſt the other is ſtrongly ſaline. When the ſaline waters become themſelves chalybeate or ſulphureous, they form a ſeparate claſs, which will be noticed in its proper place.

SEDLITZ OR SEYDSCHUTZ WATER.

The ſtrongeſt of the natural ſprings of the water, which I have termed the ſimple ſaline, is that which is found at the village of Sedlitz, in Bohemia, a country abounding in mineral waters of various deſcriptions. This ſpring, which was long neglected by the ruſtic inhabitants on account of the ſalt bitterneſs of its water, that rendered it unfit for moſt domeſtic purpoſes, was brought into notice by the celebrated Hoffman about the year 1721, as a medicine of conſiderable efficacy; and this writer has given us a detached account of its properties and medical virtues, that affords ſufficient information of the nature of its contents, and contains a number of good obſervations, which will apply more generally to all the ſaline purging waters (*a*). The chemical compoſition of this natural ſpring has likewiſe been fully aſcertained by the illuſtrious Bergman (*b*).

The ſalt ſpring of Seydſchutz is found at

(*a*) "Examen Chymico-medicum Fontis Sedlicencis Amari, in Bohemiâ noviter detecti."—*Hoffmanni Opera. tom.* v.

(*b*) See Bergman's Eſſays. Vol. I.

a very ſhort diſtance from that of Sedlitz, the former is ſituated on higher ground, and appears to communicate with the latter. They both poſſeſs the ſame chemical compoſition, only the water of Seydſchutz is ſomewhat more ſaline than the latter. They ſo nearly reſemble each other, however, that the ſame deſcription will ſerve for both.

To the taſte, this water is very ſaline and bitter, but not in the leaſt briſk and acidulous. It gives no bubbles of gas when any ſtrong acid is added; with ſyrup of violets it ſcarcely aſſumes a green colour, and it does not in the leaſt alter the colour of galls. Paper tinged by logwood becomes quickly blue; cauſtic potaſh cauſes an immediate flocculent precipitate, which is magneſia; the oxalic acid ſhews the preſence of lime; nitrat of ſilver and acetite of lead indicate the ſulphuric and muriatic acids. The ſpecific gravity of the Seydſchutz water, according to Bergman, is 1.0060. Whilſt boiling it depoſits a ſmall portion of carbonated lime. The gaſeous products obtained from this water by heat, are no more than 6 cubic inches to 100, or one fifteenth of the bulk of the water, of which two-thirds are carbonic acid, which is intirely employed in fuſpending the carbonat of lime that is diſſolved.

The ſolid contents procurable from this ſaline water by evaporation to dryneſs, according to Bergman's analyſis, are in the following proportion (*c*). The Engliſh wine pint of 28.875 cubic inches contains, of

	grains.
Carbonated lime - - - - - -	.944
Selenite - - - - - - - - - -	5.140
Carbonated magneſia - - - -	2.622
Muriated magneſia - - - -	4.567
Vitriolated magneſia - - -	180.497
	193.770

Total 193$\frac{77}{100}$ grains, or about three drams, thirteen grains and a half.

(*c*) The quantities here mentioned are reduced from thoſe given by this excellent chemiſt, which are all proportioned to the Swediſh Kanne, and in the Swediſh weights and meaſures. The Kanne is here aſſumed to be equal to 190 Engliſh cubic inches, and contains about 6.58 Engliſh wine pints. The Swediſh pound is divided in the ſame manner as the Engliſh Troy pound, and the correſponding diviſions of the former are equal to 1.1382 of the latter; that is, the Swediſh pound is from $\frac{1}{7}$ to $\frac{1}{8}$ larger than the Engliſh Troy pound; the ounce, than the Troy

From this analyſis it appears, that Seydſchutz water is ſtrongly impregnated with vitriolated magneſia, or Epſom ſalt, and it is to this, along with probably the ſmall quantity of muriat of magneſia, that it owes its bitter and ſaline taſte, and its purgative properties; and as there are no other active ingredients to be found, it is to the Epſom ſalt that we muſt alſo principally attribute its medicinal virtues. The identity of the ſulphat of magneſia, contained in this ſpring, with that found in the mineral water of Epſom, was firſt ſatisfactorily eſtabliſhed by Hoffman; and as the Sedlitz water contains even more than the Engliſh water, the ſalt has been largely procured at this place by the uſual proceſſes of evaporation and cryſtallization, and was long known in the materia medica by the name of *Sedlitz ſalt.*

The effects which this water produces when taken into the ſtomach are in a very high

ounce, &c. The Swediſh cubic inch is equal to 1.9 Engliſh cubic inches, but as the Kanne contains 100 Swediſh cubic inches, the bulk of gaſeous products procured from a Kanne given in Swediſh inches, will exactly expreſs the proportion per centum. *See the Appendix to Kerr's Tranſlation of Lavoiſier's Elements.*

degree purgative, more actively ſo, indeed, than might be inferred from the mere quantity of the ſalt. A pint of the water is generally a full doſe for an adult, and the ſtrongeſt perſons ſeldom take more than two pints. This operates very ſpeedily, and is particularly of uſe in freeing the body from crude, viſcid, acid, and acrid bilious contents. It has beſides, as Hoffman remarks, a peculiar advantage over the ſtrongeſt draſtic purges that are exhibited in a ſolid form, or even the milder aperients, ſuch as manna, caſſia, or ſenna, in not producing thoſe griping pains and flatulency which often cauſe ſo much inconvenience and ſuffering. It is partly on this account, probably, that a frequent uſe of this natural purgative water does not reduce the ſtrength, impair the appetite, and induce that ſtate of nauſea, dryneſs in the mouth, and weakneſs of digeſtion, which attends a long continued courſe of the reſinous or other pharmaceutical purgatives.

Hoffman then enumerates the diſeaſes to which the Sedlitz water is particularly applicable. When the ſtomach is filled with crude and ill-digeſted humours, and a tough mucus adheres to its ſurface, inducing nauſea, diſtaſte for food, eructation, ſwelling of the ſtomach, and a painful tightneſs acroſs the breaſt, nothing ſooner relieves theſe ſymptoms than the Sedlitz water, which both ſtimulates the ſtomach and bowels to expel their morbid contents; and aſſiſted by its bitterneſs, reſtores the tone of theſe organs, and with it the appetite and healthy digeſtive powers.

When the preſence of hypochondriaſis is marked by anxiety, general languor, perturbed dreams, a livid hue in the face, difficult breathing, pain of the back and head, vertigo, and coldneſs of the extremities; when a bilious humour and depraved ſecretion of the ſtomach impairs its tone and healthy action, and is attended with obſtinate coſtiveneſs, this water, by evacuating its contents, and reſtoring the due force of contraction, enables it to throw off the offending matter. When aloetics and the more draſtic purgatives are given in theſe complaints, either by the mouth or in glyſters, the coſtiveneſs and flatulent diſtention of the abdomen return directly after their operation, and even ſome of the milder aperients are not without this inconvenience; and rhubarb, which is in other refpects the beft of thefe, is too flow in its effects. But this faline water is excellently fitted to fulfil the curative plan; and perfons who for a length of time have had no evacuation from the bowels, except fuch as has been procured by the ftronger purgatives, by ufing for awhile the water of this falubrious fpring, have found fo great a change, that the inteftines have returned fpontaneoufly to their healthy and natural functions.

Numerous trials have fhewn the efficacy of this faline water in that cachexy of females attended with a fuppreffion of the menftrual difcharge, whereby are produced a general languor, difficult refpiration, febrile heat and irritation, wafting of the body, and lofs of appetite. Alfo, when women have arrived at that time of life when this periodical evacuation begins to ceafe, and is fucceeded by a number of anomalous diforders, fuch as proftration of appetite, and flatulent pains, irregular flufhings, pains in the back, and fwelling of the feet, a courfe of Sedlitz water reftores the wavering appetite, and difperfes the tumours and other morbid fymptoms.

Men of from forty to fifty years of age, who have led a very ſedentary life, and have been accuſtomed to intenſe thought and profound meditation, become frequently affected with œdematous tumours in the extremities, a want of due action in the ſtomach, eructations after taking food, and a generally impaired ſtate of health: all of which are for the moſt part very certainly removed by a liberal uſe of this water.

Perſons of a plethoric habit of body, who from ſome obſtruction to the free circulation of blood through the abdominal viſcera, have acquired a ſtrong diſpoſition to hæmorrhoidal affections, become thereby often expoſed to very ſerious evils. For if the obſtructed blood be determined to the ſtomach and bowels, there ariſe ſevere pains over the whole abdominal region, extending round to the back; if to the breaſt and head, it occaſions a ſenſe of weight and oppreſſion about the præcordia, nauſea, difficult reſpiration, a dry cough, heavineſs of the head, and anxiety of mind; and always attended with either an obſtinately coſtive ſtate of body, or at leaſt too ſparing an evacuation from the bowels. Theſe diſorders are in general treated with aloetics, combined with the warm reſins or balſams, with a view of ſtimulating the inteſtines and determining the blood to the veſſels of the rectum; and in many caſes, eſpecially in females, and in thoſe of a phlegmatic temperature, much advantage is derived from theſe remedies. But, at the ſame time, an indiſcriminate and frequent uſe of theſe medicines in all habits, and in every ſtate of body, is often productive of ſerious conſequences. For when the body is in a highly irritable and plethoric ſtate; and eſpecially where there is an hereditary tendency to hæmorrhoidal complaints, a violent determination to the lower inteſtines and os ſacrum often occaſions painful protruſions of the rectum, which, if neglected, will frequently degenerate into fiſtula. To ſuch perſons, a ſaline water, like that of Sedlitz, is much more ſafely applied, eſpecially if accompanied with blood-letting when requiſite, and a general antiphlogiſtic plan of cure.

Another important uſe of the Sedlitz water is in removing from the ſyſtem thoſe impurities and acrid humours which are uſually termed ſcorbutic, and which from their frequency, the obſtinacy of their attacks, and the great trouble which they occaſion, require particular attention in their treatment. For theſe complaints our author recommends the Sedlitz water to be uſed, in the ſpring, for ſome days, and then to be followed by a courſe of three or four weeks of the Lauchſtadt chalybeate, or the acidulous Seltzer water. A remarkable circumſtance ſometimes occurs here, which is, that in theſe caſes, if the Lauchſtadt water be firſt taken, though it is a ſimple chalybeate without any purgative ingredient, it frequently brings on a very briſk and violent purging, ſo that the patient can hardly bear to ſit upright; but if it be preceded by the Sedlitz water, no ſuch effect is produced, the latter having already carried off all the acrid matter by the bowels (*d*).

The doſe of Sedlitz water ſufficient to produce the deſired effect, varies according to the

(*d*) This is a curious fact, and ſerves to explain in a ſtriking manner, the difference of effects which the ſimpler mineral waters, ſuch as thoſe of Malvern or Buxton, produce upon the bowels, according to the previous ſtate of the patient. It does not however detract from the efficacy of the Sedlitz waters as an active purgative, ſince the effects of this ſaline water are the ſame in all perſons.

age and habit of the patient. To ſome perſons about five or ſix tea-cupsfull of the water prove ſufficiently aperient, and a few require ſo much as two pints. If the ſalt alone be uſed, it may be diſſolved either in pure water, or that of Spa, in the proportion of half an ounce to a pint of the ſolvent, and thus a purgative chalybeate will be formed. The Sedlitz water is alſo an active medicine when employed as a clyſter, and its operation may be ſtrengthened by an additional quantity of the ſalt.

A ſingle doſe of half a pint of this water will contain, according to Bergman's analyſis, about 97 grains of foreign contents, of which 90 grains, or a dram and a half, is ſulphat of magneſia, a quantity amply ſufficient to give very ſtrong ſenſible properties. It may be obſerved, that Hoffman, like all the authors who are not quite of our own times, recommends a much larger bulk of water for a ſingle doſe, than we are now in the habit of employing. Few patients would now be willing to take at once a pint or quart of any water, and the effect on the bowels will certainly be as well ſecured, if it be taken in a ſmaller quantity, and at two or three draughts, with a ſhort interval interpoſed between each.

Hoffman judiciouſly recommends, during a long courſe of this water, that its uſe ſhould now and then be interrupted for a day or two. It is likewiſe a great advantage attending theſe natural ſaline purgatives, that little or no other medicine is required whilſt theſe are uſed: but great attention is always to be paid to diet, exerciſe, and the ſtate of the mind, ſo that the patient ſhould always avoid heavy indigeſtible food, ſhould be kept free from anxiety and care, and ſhould make it a conſtant part of his daily occupation to ſtrengthen his body by moderate and prudent exerciſe.*

* Being of opinion that the Sedlitz water, from its contents, and the operation which it produces on the human body, is well calculated to remove many diſorders to which the people of this country are ſubject, as well as thoſe who have returned from a long reſidence in warm climates, I recommended to Mr. Paul to prepare an artificial Sedlitz Water, and to cover its bitter taſte by impregnating it ſtrongly with carbonic acid; I have found it to anſwer every expectation as an habitual laxative, capable of removing hepatic and other viſceral obſtructions, and increaſing the natural and healthy ſecretions when deficient in quality or quantity. The proportion of ſulphated magneſia, is two drams to half a pint; the proper doſe to be taken before breakfaſt, is from half a pint to a pint of the artificial Sedlitz water, to be varied according to its effects. The uſe of this artificial water in India, might ſuſpend the progreſs of liver complaints, until a more perfect recovery can be effected by a change of climate.

EPSOM WATER.

This water, though now ſcarcely at all employed in medicine, deſerves ſome notice, as being one of the firſt of the ſaline purgative ſprings that was brought into uſe, and becauſe the ſalt to which it owes this property was long prepared from the water, and known all over Europe as a peculiar ſaline ſubſtance, called Epſom ſalt. It has now partly loſt this diſtinguiſhing name, and is better known to the chemiſt as vitriolated or ſulphated magneſia; though as a medicine it ſtill retains excluſively the term of *Bitter Purging Salt*. This ſalt, which is ſo largely employed medicinally, is now prepared from ſea water, which has been boiled down, to procure from it its muriated ſoda. An uncryſtallizable brine remains, which is chiefly muriated magneſia, and by preſenting to it the ſulphuric acid, under any form of combination, the ſulphat of magneſia is readily procured.

The ſpring that yields this ſaline water is ſituated about half a mile from Epſom, a conſiderable market town in the county of

Surrey, about ſixteen miles ſouth of London, adjoining to a range of chalk hills of great extent, covered with a remarkably fine ſhort turf, and forming excellent downs for the breeding of ſheep.

The Epſom water is tranſparent and colourleſs, and at firſt appears ſcarcely ſapid, but on examination it is found to leave a decidedly bitter and ſaltiſh taſte on the tongue. It does not change materially by mere expoſure to the air, which ſhews the fixity of that which gives its peculiar ſenſible property; it keeps well for ſome months, when corked up in clean veſſels, but if careleſsly kept, it will ſoon putrify. With re-agents it ſhews the following appearances (*a*).

Syrup of violets is ſoon changed green, owing probably to carbonated lime, or eſpecially carbonated magneſia.

The nitrats of lead and ſilver are rendered white and opake, and the nitrat of mercury of a deep yellow colour.

The ſulphuric acid diſengages a few bubbles of air, but not in any conſiderable quan-

(*a*) See Lucas, vol. 1. and Munro's Treatiſe of Mineral Waters.

tity. Cauſtic ammonia precipitates a white flaky earth, which is magneſia.

The Epſom water has not been analyſed with any conſiderable accuracy, but we can eaſily determine which are the moſt important ingredients. Epſom water, evaporated to dryneſs, leaves a reſiduum, the quantity of which has been eſtimated very differently. Some make an ounce and a half in the gallon, others only an ounce; and Dr. Lucas only five drams and one ſcruple. This reſult ſeems better to agree with the ſmall degree of ſapidity of the water when firſt taken. Of the total reſiduum, by far the greater part, about four or five-ſixths, is ſulphated magneſia, mixed with a very few muriats, ſuch as that of lime, and probably magneſia, which render it very deliqueſcent, and increaſe the bitterneſs of taſte, till purified by repeated cryſtallizations. About a ſixth of the reſiduum is inſoluble in a moderate quantity of cold water, and is probably ſelenite mixed with a little carbonat of lime. There is nothing ſulphureous or metallic ever found in this ſpring.

Half a pint therefore of Epſom water will, according to the loweſt calculation, contain lefs than a fcruple of the Epfom falt, and according to the higheft, about double that quantity. On that account, the water muft be taken very largely, fo that to produce the full purgative effect, the patient muft take from two to three pints, the one fucceeding the other, in a fhort length of time. It operates in a mild efficacious manner in this dofe, but in a fmaller, it rather determines to the kidnies.

With refpect to the difeafes to which it is applicable, they are precifely thofe for which Hoffman recommends the Sedlitz water. It fhould be remembered, however, that the latter is much ftronger of the vitriolated magnefia, a circumftance of fome confequence in a water where the bulk of the requifite dofe is always more than can be well borne by delicate ftomachs.

There are many other of the fimple faline fprings that might be enumerated, all of which agree with that of Epfom, in containing for their moft active ingredient, and the only one that can be at all confidered as a medicine, a notable proportion of fome purging falt. This, for the moſt part, is either Epſom ſalt or Glauber's ſalt, or often a mixture of both. The neighbourhood of this metropolis furniſhes many examples of ſuch waters, among which may be particularly mentioned, the purging ſalt ſprings of Acton, of Kilburne, of Bagnigge Wells, and of the Dog and Duck, in St. George's Fields, which laſt has acquired ſome reputation from the recommendation of Dr. Fothergill. None of theſe however are ſufficiently ſaline to be certain in their operation on the bowels, except they are taken in exceſſively large quantities. It is therefore a common cuſtom to quicken their operation by the addition of ſome of the ſame ſalt as that which gives them their purgative quality, which is certainly a judicious practice; but by this means they are rendered ſo ſimilar to an artificial ſolution of vitriolated ſoda or magneſia in common water, that they loſe all pretenſions to be conſidered as natural medicated waters.

Adjoining to ſeveral of theſe ſaline waters, are often found ſimple chalybeate ſprings, where the oxyd of iron is held in ſolution by carbonic acid; and theſe generally contain a much lefs quantity of faline contents than the others. None however of the fimple faline fprings in this kingdom are much reforted to, their place being fupplied either by the faline chalybeate of Cheltenham, or the waters of the ocean, which laft muft be added to the lift of fimple faline purging waters, and requires fome particular notice.*

* The Kilburn Well is fituated at the fouth weftern extremity of the Parifh of Hampftead, about two miles from Tyburn Turnpike, in the road leading from thence to Edgware; the refult of a very accurate analyfis of it is given by Mr. Blifs, of Hampftead (to whom I afterwards refer on the fubject of Hampftead waters). The refult of his analyfis is as follows:

Oxyd of iron not appreciable

	Grains.	
Carbonate of lime - - - - - -	8	$\frac{40}{100}$
——— of Magnefia - - - -	10	$\frac{75}{100}$
Extractive matter - - - - - -	3	
Muriate of Magnefia - - - - -	33	
——— of Lime - - - - - -	14	$\frac{75}{100}$
——— of Soda - - - - - -	18	
Sulphate of Soda - - - -	117	$\frac{50}{100}$
——— of Magnefia - - -	265	
——— of Lime - - - -	42	
Infoluble matter - - - - - - -	1	$\frac{50}{100}$
	513	$\frac{90}{100}$

Gafeous Contents.	Cubic Inches	
Of Carbonic Acid Gas - - - -	18	0
Of Common Air of ordinary purity	5,	5
	23,	5

SEA WATER.

Among thofe natural waters that are fimply faline, that contain no unufual quantity of gafeous bodies, and the compofition of which is not doubtful, the waters of the ocean, for the immenfe fupply and degree of faline impregnation, hold a very confpicuous place.

Sea water is by far the ftrongeft in faline matter of all the natural waters which are ufed medicinally, and indeed of all the waters that we are acquainted with, certain brine fprings and falt lakes excepted, which laft are only employed for the purpofe of extracting their contents.

The water of the fea, as it wafhes the fhores of our ifland, is a very heterogeneous compound, containing a confiderable quantity of faline fubftances, and holding fufpended an infinite number of minute animal and vegetable particles, compofed of all the variety of marine productions that people this element.

Sea water, taken up near a rocky or clean fandy coaft, or at a confiderable diftance from ſhore, has the following properties: it is quite clear and colourleſs in appearance, void of ſmell, and ſhews no marks of any unuſual quantity of air of any kind. To the taſte it is highly ſalt, and at the ſame time nauſeous and very bitter. By keeping, it grows highly offenſive, owing, doubtleſs, to the putrefaction of the animal and vegetable matters which it holds in ſolution; for theſe, like all marine productions, are extremely prone to ſpontaneous alteration, the ſalt with which they are ſurrounded not being ſufficient in quantity to prove at all antiſeptic.

The temperature of the ſea, though it varies conſiderably in different ſeaſons, is however, on the whole, much more uniform than that of any inland water that is ever expoſed to the atmoſphere, and which is not a thermal ſpring, poſſeſſing in itſelf a ſource of caloric, owing to cauſes conſtantly operating, the nature of which is intirely unknown to us. The vaſt body of water in the ſea, and the perpetual agitation to which it is expoſed, render it leſs liable to be affected by external changes of temperature; and this is particularly the caſe at a conſiderable depth below the ſurface. At its upper part, however, it poſſeſſes an extenſive range of temperature in different times of the year; and it is only this part which is ever employed for bathing or drinking. On the ſhores of England, the ſurface of the ſea is ſeldom, in the ſevereſt weather lower in temperature that 40°, or higher in the hotteſt ſummer than 65°, whereas the heat of rivers, eſpecially when ſhallow and their current ſlow, riſes higher and ſinks lower than each of theſe points.

It is found by accurate experiments often repeated, that the proportion of ſalt in ſea water varies conſiderably at different depths and different latitudes. In general, the water at the tropics is ſalter than at the poles, and the ſurface leſs ſalt than at a conſiderable depth. The quantity of ſalt is about from $\frac{1}{20}$ to $\frac{1}{30}$ of the weight of the water, and in ſome inland ſeas, eſpecially the Baltic, it is leſs. The water of our own coaſts may be reckoned, at an average, as containing $\frac{1}{30}$ of its weight of ſalt.

The chemical compoſition of ſea water, as far as regards the nature of its ſalts, and the proportion which they bear to each other, may be confidered as nearly the fame in all places; in freedom from accidental extraneous matter, efpecially animal and vegetable fubftances, the deeper water is in general the purer. The compofition of fea water is very accurately given by Bergman; that which this excellent chemift analyfed, was taken up at 60 fathoms beneath the furface, about the latitude of the Canaries (*a*). This water had no fmell, and its tafte, though intenfely falt, was not fo naufeous as water which is taken from the furface. Its fpecific gravity was 1.0289.

Paper, tinged with Brazil wood, was rendered a little blue, and litmus paper had its blue colour a little heightened by the water, indicating the prefence of a carbonated earth, which in this cafe was magnefia. The oxalic acid immediately indicated lime; a fixed alkali precipitated a white earth which was magnefia, and muriated barytes fhewed the fulphuric acid. Pruffian alkali gave no indications of any metal.

(*a*) It was fent by the celebrated Dr. Sparrman, who accompanied the Forfters and Captain Cook in their voyage to the Southern Ocean. *See Bergman's Effays*, vol. 1.

A quantity of this water, evaporated to dryneſs, yielded a ſaline maſs, of which part was ſoluble in alcohol, part was inſoluble in a moderate quantity of water, and the reſt was not more ſoluble in hot than cold water. By further examination, three diſtinct ſalts were found, which, when reduced to Engliſh weights and meaſures, were in the following proportion:—An Engliſh wine pint of 28.875 cubic inches contained

	grains.
Of muriated ſoda, or common ſalt	241
Of muriated magneſia - - -	65.5
Of ſulphated lime, about - -	8.
	314.5

Total $314\frac{1}{2}$ grains of ſolid contents, beſides a very minute portion of carbonated magneſia, ſeparated during the evaporation, and too ſmall to be worth noticing.

It is to be remarked, that by this analyſis, no vitriolated magneſia is found to exiſt in ſea water in its natural ſtate, though this ſalt is largely procured from the uncryſtallizable part of ſea brine after the muriated ſoda is extracted from it; but the Epſom ſalt is formed from the muriated magnefia, as has been already mentioned, by adding the fulphuric acid in fome form or other, generally as fulphat of iron. It is the muriated magnefia which gives the bitter tafte to fea water, and probably affifts much in its operation upon the human body.

The foregoing refults will give a proportion of 1 of faline contents to about $23\frac{1}{4}$ of water, but on our fhores, it is not greater than 1 of falt to about 30 of water, and therefore the quantities muft be reduced to this ratio. Sea water on the Britifh coaft may therefore be calculated to contain in the wine pint,

	grains.
Of muriated foda -	186.5
Of muriated magnefia	51.
Of felenite - - - -	6.
	243.5

Total $243\frac{1}{2}$ grains, or half an ounce, and three grains and a half of faline contents.

Among the fenfible effects that fucceed a moderate dofe of fea-water, may be particularly mentioned that of thirft. It feldom excites naufea except to very irritable ſtomachs, or to thoſe to whom the taſte is peculiarly unpalatable. In the quantity of a pint it generally proves purgative, eſpecially where the ſtomach has not been long uſed to this medicine. It is a valuable property which this water poſſeſſes in common with the other bitter ſaline waters, that it may be perſevered in for a conſiderable time, and a daily increaſed evacuation from the bowels be produced, without debilitating the ſtomach and inteſtines, and impairing the digeſtive powers; but on the contrary, the appetite, ſpirits, and general health, will for the moſt part be improved by a moderate courſe of ſea-water.

The diſorders for which the internal uſe of ſea water has been and may be reſorted to, are, in general, the ſame for which all the ſimple ſaline waters may be uſed, and have been already enumerated. However, the internal employment of ſea water is chiefly made an auxiliary to its very extenſive external application. The ſea is by far the moſt frequented of all our medicated baths, and this cuſtom appears to be ſo rapidly on the increaſe, that there is ſcarcely a fiſhing village on the whole extent of our coaſt, unprovided with ſome accommodation for bathers; and many have riſen to be towns of conſiderable extent and opulence, from the ſupport which they annually derive from their numerous viſitors.

As the ſea is a cold bath, it is employed in thoſe caſes of debility unaccompanied with general inflammatory ſymptoms, for which cold bathing has been always found beneficial.

Sea water, from the quantity of its ſaline contents, certainly poſſeſſes conſiderable ſtimulant powers, which it particularly exerts when applied either to an ulcerated inflamed ſurface, (eſpecially in the ſuperficial inflammation of cutaneous eruptions) or to the ſound uninjured ſkin, where it is aſſiſted by warmth, by mechanical means, ſuch as daſhing from a conſiderable height, or where the body is long expoſed to its action.

A very large proportion of the patients who reſort to the internal uſe of ſea water, are thoſe who ſuffer under various forms of ſcrophulous affection, producing ſometimes hard indolent tumours in certain glands, eſpecially thoſe of the neck, that are ſlow in ulcerating, and always tedious in their cure; at other times a deep-feated inflammation, followed by caries of bone, profufe difcharge, and tedious exfoliation; or elfe a troublefome and painful ophthalmia; fo often characteriftic of this diforder. In all fuch cafes, the internal ufe of fea water is almoft intirely confined to thofe periods of the difeafe when there is no general fever and hectic tendency, when no fymptoms of danger are prefent, and when the object is rather to prevent a relapfe, than oppofe any prefent difeafe. The external ufe of fea water, either as a general cold bath, or as a topical application to indolent fwellings, or granulating ulcers where the healing procefs has commenced, coincides perfectly well in thefe cafes with the general intention. The peculiar power of fea water and fea falt, as a difcutient, employed either internally or externally in fcrophulous habits, was brought confiderably into notice by Dr. Ruffel (*a*), and fubfequent experience has

(*a*) See "Ruffel on the Ufe of Sea Water in the Difeafes of the Glands. London, 1760."—This author alfo recommends another marine preparation, the Sea-wrack, (*alga veficulofa*), a plant very common on all our fhores, which bears a number of veficles that are filled with a falt liquor. This vegetable, when fully proved the advantage derived from this medicine judiciously applied.

Sea water, when used internally, should be taken in such doses as to prove moderately purgative, the increase of this evacuation being the peculiar object for which it is employed. About a pint is generally sufficient, and this should be taken in the morning at two doses with an interval of about half an hour between each. It is seldom necessary to repeat the dose at any other time of the day. This quantity contains half an ounce of purgative salt, of which about three-fourths are muriated soda, a salt which we know is highly capable of stimulating the bowels, though we have no experiments to shew its comparative effects with those of Glauber or Epsom salt, which are more frequently employed in medicine.

There is very little danger ever to be apprehended from an excessive dose of sea

calcined in the open air, gives a black residue, consisting of the carbonaceous part of the plant largely mixed with sea salt and a little soda, or, in short, it is a kind of kelp. This, when levigated, Dr. Russel calls *vegetable æthiops*, and asserts, what is very probable, that it is fully equal in properties to burnt sponge.

water, except the inconvenience of a temporary diarrhœa, and ſometimes a ſoreneſs at the extremity of the rectum, which all ſaline purgatives are now and then apt to produce.

Indeed the enormous quantities of ſea water which the country people will often take when they can make a ſhort viſit to the coaſt, amply prove the ſafety of this natural medicine.

It is often neceſſary to perſevere for a long time in the uſe of the ſea water, and it is a great recommendation to it, that ſuch a perſeverance is ſo ſeldom productive of any bad conſequences to general health. Dr. Ruſſel mentions caſes where a pint of this water has been taken daily for 200 mornings, without any interruption, which produced a continued courſe of moderate purging, and yet the appetite continued all this time perfectly good, and the health improved.

It is only by great patience and perſeverance, that this medicine has been able to aſſiſt ſo materially in performing cures in ſome of the moſt obſtinate diſorders that are at all to be removed by the healing art.

SELTZER WATER.

One of the moſt celebrated of the foreign mineral ſprings is that of Seltzer, in the village of Nieder-Seltzer, in the biſhoprick of Triers. This village is ſituated in a fine woody country about ten miles from Frankfort, and thirty-ſix from Coblentz, in a diſtrict which abounds with valuable mineral ſprings. The water is brought over to this country in ſtone bottles cloſely corked and ſealed, containing about three pints each, and when well ſecured, it will keep unaltered for a conſiderable length of time.

The properties and analyſis of this water have been fully aſcertained by Hoffman (*a*), Bergman (*b*) and others, and they are ſuch as to render it very intereſting to the chemiſt and phyſician. Seltzer water when freſh or well preſerved is perfectly clear and pellucid, and ſparkles much when poured into a glaſs. To the tongue it is ſomewhat pungent, but much

(*a*) See Hoffman "De elementis et viribus fontis Selterani," in vol. V. of his works.

(*b*) Bergman's Eſſays, vol. I.

lefs fo than might be fuppofed from its mere appearance, and has a gently faline and decidedly alkaline tafte. If it be expofed to the air for about a day, or even be kept in veffels carelefsly corked, it intirely lofes its pungency, and the alkaline or lixivious flavour becomes proportionably ftronger.

The habitudes of this water with different re-agents are ftrikingly illuftrative of its chemical compofition.

Tincture of litmus grows red upon the addition of a fmall quantity of Seltzer water, but in the open air, or efpecially when the mixture is heated, the blue colour returns.

Paper, tinged with Brazil wood, becomes blue; with litmus tincture, becomes more blue; and with turmeric, is a little changed to red; fyrup of violets turns green; and tincture of rhubarb red, by this water; but thefe laft tefts are much more perceptible when the quantity of water is leffened by evaporation. Thefe fimultaneous marks of both an acid and an alkali, and the circumftance of the former being loft by gentle heat, clearly indicate that the alkali is fuper-faturated with a volatile acid, which muft be the carbonic, and it is on this account too that the tafte is both acidulous and alkaline.

Any of the ftrong acids, or even old Rhenifh wine, (as Hoffman fays) dropped into frefh Seltzer water, will immediately difengage copious bubbles of gas, which is almoft pure carbonic acid. Nothing metallic is difcoverable by the nice tefts of galls, or Pruffian alkali.

Cauftic alkali precipitates carbonated lime from the water. This it does by becoming itfelf carbonated by means of the water; for when a mild alkali is employed, no precipitate is perceived, as none of the excefs of carbonic acid which holds the lime fufpended, is driven off.

The oxalic acid fhews the prefence of lime; the nitrat of filver that of muriatic falt.

No fulphuric acid is difcoverable by the niceft tefts.

When this water is heated to boiling, a large quantity of carbonic acid gas is expelled, amounting to about 60 per cent. of the bulk of the water. During evaporation, carbonated lime and carbonated magnefia are depofited, and a faline mafs remains. This is common ſalt, with a ſmall admixture of carbonated ſoda. The exact contents of this water, given by Bergman, and brought to the proportion of an Engliſh wine pint, are,

	grains.
Of carbonated lime, about . . .	3
— carbonated magneſia	5
— carbonated ſoda	4
And of muriated ſoda	17.5
	29.5

Total, $29\frac{1}{2}$ grains of ſolid reſiduum.

The quantity of gas given out, is by far more copious than any that has been hitherto mentioned, being 60 cubic inches to the hundred of water; or upwards of 17 cubic inches to the wine pint. It is almoſt intirely pure carbonic acid gas.

Seltzer water, therefore, is a ſaline water ſlightly alkaline, highly acidulated with carbonic acid, containing more of this volatile principle than is ſufficient to ſaturate the alkali, and the earths which it holds in ſolution; and hence it is ſomewhat acidulous to the taſte, and ſhews the preſence of an acid by chemical teſts, notwithſtanding the alkali, which is alſo, and at the ſame time indicated by other re-agents. It is however a hard water, and curdles ſoap, the ſoda not being in ſufficient quantity to prevent this effect. This water is obſerved by Hoffman, to become not only vapid, but putreſcent, and ſtrongly fetid in a very ſhort time when expoſed to the air. Perhaps this may be owing to a ſmall quantity of vegetable extractive matter. It requires therefore to be kept cloſely corked, and the mouth of the bottles covered with a cement, to prevent the eſcape of the carbonic acid, for as long as this antiſeptic acid remains, the water continues perfectly ſweet.

Seltzer water is the only example which we poſſeſs of a water, ſaline, alkaline, and at the ſame time highly acidulated. Moſt of the other ſtrongly carbonated waters, are more or leſs chalybeate, and no other of the ſaline waters contains ſo much carbonic acid.

The effects of this water, when drank in moderate doſes, are to raiſe the ſpirits, and increaſe the appetite; it produces no particular determination to the bowels, as its ſaline contents are in very ſmall quantities, but it pretty certainly increaſes the flow of urine.

It is chiefly to the ftrong impregnation with carbonic acid, and to the fmall proportion of foda which it contains, that we are to look for the explanation of the very important benefit which is derived from it in a variety of difeafes.

Few mineral waters have acquired a higher reputation than that of Seltzer, and we may add, that few deferve greater confideration from the real medical virtues which it poffeffes, and from the variety of diforders to which it is applicable. Hoffman has fpoken of it with the higheft commendation, and if we muft allow fomething for the natural partiality which a German writer muft feel for his own mineral fprings, we muft however admit, that the greater number of his obfervations on this fubject, have been amply confirmed by later practitioners. The cafes for which Seltzer water may be ufed with an undoubted profpect of advantage, feem to be the following: (*a*)

(*a*) See in the *London Medical Obfervations and Enquiries*, v. 4. a very fenfible paper on the analyfis and virtues of Seltzer water, by the late Dr. Brocklefby, read July, 1768.—The chemical obfervations of that period are now fuperceded by the more accurate and modern inquiries; but this paper contains fome very fatisfactory and interefting cafes.

It is particularly ſerviceable in relieving ſome of the ſymptoms that indicate a morbid affection of the lungs; in ſlow hectic fever, attended with frequent fluſhing, profuſe night ſweats, conſtant cough, and fetid purulent expectoration, it will often, in a high de-degree, check the violence of perſpiration, diminiſh the diſcharge from the lungs, and correct its fetor; and under the operation of this medicine, the patient will for a time be able to gain quieter nights, and more appetite. This excellent property of allaying feveriſh irritation, may alſo be applied in many anomalous caſes, where a tendency to hectic fever is ſuſpected.

Another claſs of diſorders for which this water often brings conſiderable relief, is in thoſe exanthematous eruptions of the ſkin, that are attended with general irritation, which were formerly aſcribed to a ſcorbutic acrimony of the humours. Miliary eruptions, and all thoſe that are not merely local, and with which the ſtomach ſtrongly ſympathizes, often give way to the uſe of this water.

From the nature of both the active contents of Seltzer water, the ſoda, and carbonic acid, we may expect great benefit from its uſe in various derangements of the alimentary canal; and accordingly we find that this is one of the moſt important of its uſes. Foulneſs of ſtomach, bilious vomiting, acidity and heart-burn, ſpaſmodic pains in any part of the alimentary canal, and bloody or highly offenſive ſtools, are the ſymptoms for which this medicine brings the greateſt relief.

On account of the property of this natural water in relieving ſpaſmodic pains, and from its rapid determination to the kidnies, and, perhaps, its alkaline contents, it has been ſometimes employed with great advantage in diſeaſes of the urinary organs, eſpecially thoſe that are attended with the formation of calculus. What ſolvent power it may exerciſe over theſe concretions is not yet fully determined; but it is certain that under the uſe of this medicine, the mucous, ſabulous, and often purulent diſcharge, that accompanies the urine, is rendered much leſs painful, and in general, micturition is much leſs difficult. A large proportion of the Seltzer water, either genuine or artificial, that is conſumed in this country, is for the relief of theſe diſorders. Even in gonorrhœa, either ſimple or venereal, Hoffman aſſerts that advantage is to be derived from this medicine.

In hypochondriac complaints, and their attendant ſymptoms, eſpecially thoſe of dyſpepſia, Seltzer water is of conſiderable ſervice in correcting the ſtrong tendency to ſpaſmodic pains in the ſtomach, and other irregularities of the alimentary canal. A judicious practice is here recommended by Hoffman, which is for the patient to uſe the Sedlitz, or Caroline purgative waters, for about a week, and then to employ the Seltzer waters freely for a month or more; or elſe to keep the bowels in a regular ſtate, by adding to the doſe of Seltzer water, every ſecond or third day, a ſufficient quantity of vitriolated magneſia.

Seltzer water mixes well with milk, and will not ſoon coagulate it. This mixture is ſtrongly recommended by Hoffman in caſes of hectic fever with expectoration, and it may alſo be ſometimes adviſeable in order to dilute the water, which in its moſt active ſtate proves too powerful for very irritable habits.

The uſual doſe of this water is from half a pint to a pint.. Half a pint contains 2 grains of mild ſoda, about 9 grains of common ſalt, and 4 grains of carbonated earths for its ſolid contents; and for the gaſeous, about $8\frac{1}{2}$ cubic inches, or more than a quarter of a pint in bulk of pure carbonic acid.

Seltzer water is one that may be drank freely in moſt caſes, and ſeems to require leſs precaution in its exhibition than moſt of the other mineral waters, whoſe ſenſible properties and medicinal powers are ſo conſiderable. The chief precaution neceſſary during its uſe, is to preſerve a regular ſtate of the bowels. From its pleaſant taſte, and the exhilarating effects which it produces on the ſpirits, it is largely uſed at table as a common drink in Germany and Holland; and the circumſtance of agreeable flavour is no ſmall recommendation with patients, who, during a long indiſpoſition and irritability of ſtomach, have conceived an utter averſion to any of the numerous claſs of tonics and ſtimulants, that ſtand on the liſt of the Materia Medica.

OF CHALYBEATE WATERS.

ONE of the leading diſtinctions among mineral waters, with every writer on this ſubject, has been that of chalybeate impregnation; and very juſtly, for iron is the only metal which is ever found in any conſiderable number of ſprings, and it imparts very diſtinguiſhable ſenſible properties and medicinal virtues. Another reaſon too for this great diſtinction of the chalybeate, from other waters is, that the operation of this metal may in general be traced out, and in ſome degree ſeparated from that of the other bodies with which it may be combined; and from the activity of this medicine, it may perhaps become a queſtion intereſting not merely the chemiſt, but the practical phyſician, to aſcertain with preciſion both its quantity and mode of combination in thoſe chalybeate ſprings, which are ſo largely employed as medicines.

TUNBRIDGE WATER.

THIS mineral ſpring may be ſelected as a good example of a very numerous claſs of waters, which we may term the *ſimple carbonated chalybeates*, or thoſe that differ from common ſprings in no other reſpect, than in containing a ſmall portion of iron, held in ſolution intirely by a ſmall quantity of this gaſeous acid, which is not ſo abundant as to render the water briſk and acidulous. It is merely to the chalybeate principle and its ſolvent, that ſuch mineral ſprings owe their medicinal properties; theſe are however very conſiderable. When the carbonic acid is in exceſs, it forms the *highly carbonated chalybeates*, ſuch as the Spaw and Pyrmont waters, which will be ſeparately conſidered.

The moſt noted of the ſimple chalybeates in this country, and eſpecially in this part of the kingdom, is that of Tunbridge Wells, a populous village ſituated in a ſandy valley in the county of Kent, about thirty-ſix miles South of London. This valley is ſurrounded by hills of a moderate height, compoſed chiefly of a crumbling ferruginous ſand ſtone, naturally barren, but from their neighbourhood to the metropolis, and from the number of opulent inhabitants that reſide in the vicinity, they now, for the moſt part, preſent the appearance of a very pleaſant and well cultivated country.

Tunbridge contains many chalybeate ſprings, all of which reſemble each other very cloſely in chemical properties. Two of theſe are chiefly uſed, which yield each about a gallon in a minute, and therefore afford an abundant ſupply for the numerous invalids who yearly reſort thither (*a*).

The ſource of theſe ſprings is probably at a conſiderable depth, for the water preſerves very conſtantly the temperature of 50° at all ſeaſons, and experiences very little change from the heat of the external atmoſphere. When not much uſed, the water overflows the ſtone baſon into which it riſes and forms

(*a*) For the chemical part of this ſubject, the reader is referred to a ſmall pamphlet, "An Analyſis of the Medical Waters of "Tunbridge Wells.—London, 1792." This contains a very judicious ſeries of experiments, made by Dr. Babington, Lecturer in Chemiſtry at Guy's Hoſpital, whoſe fidelity and accuracy may be relied on.

a ſmall ſtream, the track of which is marked by an ochery depoſition (*b*).

The ſenſible properties of this mineral water as it is firſt taken up by the reſervoir, are the following: it is quite colourleſs, clear, and bright, and exhales no perceptible ſmell: it does not ſparkle in the glaſs, but ſlowly ſeparates a few bubbles, which adhere to the ſides of the veſſel, in ſomewhat larger quantities than common ſpring water; to the taſte it is neither acidulous nor ſaline, but ſimply chalybeate in a ſlight degree, and is by no means unpalatable.

When the water has ſtood for ſome hours expoſed to the air, the ſides of the veſſel become covered with minute bubbles, the liquid grows turbid, a yellowiſh irideſcent pellicle incruſts the ſurface like a very thin ſcum, and in twenty-four hours the water has intirely loſt its chalybeate properties: the ſame effect takes place more rapidly when the water is heated. This circumſtance ſhews that all the iron is ſuſpended by the carbonic acid alone.

The ſpecific gravity of the freſh water is 1.0014.

(*b*) Lucas—Vol. II.

The chemical analyſis of Tunbridge water is perfectly ſatisfactory, and not very complicated. With the uſual re-agents the following appearances are obſerved:

Tincture of litmus is almoſt inſtantly changed into a light red or garnet colour.

Lime water is rendered immediately turbid, though in a ſlight degree.

Concentrated vitriolic acid produces no ſenſible diſengagement of bubbles.

Syrup of violets on ſtanding ſome hours becomes of a lively green.

Infuſion of galls produces a fine purple in a few ſeconds; and pruſſiated lime gives a fine blue, both of which colours remain for about twenty-four hours.

Nitrated ſilver gives an immediate precipitate, white at firſt, but turning blue on expoſure to light.

Muriated barytes cauſes a ſlight cloudineſs.

Oxalic acid produces ſcarcely any change.

The water renders a ſolution of ſoap in a ſlight degree turbid, but does not properly curdle it, and therefore it may be called a ſoft water.

On boiling Tunbridge water for a few minutes, it becomes turbid throughout, and when filtered, leaves an oxyd of iron, which when dried is strongly magnetical. The remaining water will no longer discolour tincture of galls or prussiated lime. During the ebullition, a small quantity of gas is given out, which, when examined in proper vessels, is found to be chiefly carbonic acid, but mixed with a small portion of azotic gas, and a little oxygen. The remaining water evaporating to dryness, yields a very small quantity of solid residuum.

The whole contents of a wine gallon of Tunbridge water, according to Dr. Babington's analysis, are the following:

	grs.
Of oxyd of iron - - - -	1.
Of common salt - - - -	0.5
Of muriated magnesia - -	2.25
Of selenite - - - - -	1.25
	5.

	cubic inches.
Of carbonic acid gas - - -	10.6
Of azotic gas - - - - -	4.
Of common air - - - -	1.4
	16.

Total—five grains for the ſolid contents, and ſixteen cubic inches for the gaſeous (*c*).

On a review of this analyſis of Tunbridge ſpring, we ſhall find that it is a very pure water, as to the quantity of ſolid matter; and the ſaline contents, (the iron excepted) are ſuch as may be found in almoſt any water that is uſed as a common drink. It is only as a chalybeate, and in the quantity of carbonic acid, that it differs from common water. Of this acid, it contains about $\frac{1}{22}$ of its bulk, a very ſmall portion compared with the Seltzer or Spa waters, but enough to be indicated by chemical teſts, though not to effervеſce with the ſtronger acids, and to give any ſtriking properties of ſmell and taſte (*d*).

(*c*) It ſhould be obſerved, however, that a completely accurate analyſis would ſhew ſome portion of a carbonated earth, to account for the change of colour produced by the ſyrup of violets. If it is carbonated lime, it will at firſt and intirely ſeparate by the ſame ebullition which procures the oxyd of iron, and mix with it ſo as to be undiſtinguiſhable by the eye. This minute obſervation might appear trifling in this place, if it did not affect the eſtimate of the quantity of iron, which it is rather intereſting to aſcertain with accuracy.

(*d*) This confirms an obſervation made by Kirwan, in his excellent treatiſe on the analyſis of mineral waters, that a very ſmall quantity of carbonic acid may be indicated by the teſt of

The quantity of iron, even at the higheſt eſtimation, is certainly very ſmall; but is more than ſufficient to give the uſual changes of colour with chemical teſts, the very decided chalybeate taſte, and (what is of more conſequence) the effects which this metal is known to produce upon the human body.

The operation of chalybeate waters in the cure of diſeaſes, is a ſubject that has occupied much of the attention of thoſe practical writers, who have taken notice of this important claſs of natural medicines. Many have attempted to introduce a good deal of refinement in the conſideration of this ſubject, and have endeavoured to lay a foundation for diſtinctions in practice, on very minute chemical differences. We may, however, with ſome degree of accuracy, point out the principal effects which the chalybeate principle alone, in the ſtate of ſolution in which it is found in mineral waters, will produce on the

litmus, when this acid is uncombined, or nearly ſo. In this water there is ſcarcely any other ſubſtance but the iron and a minute portion of a carbonated earth, that can engage the carbonic acid, and when much diluted, theſe ſubſtances are ſo eaſily ſoluble, that probably the greater part of the carbonic acid is only united with the water.

various functions; and any difference which may arise in the operation of the different chalybeates hitherto known, may be fairly traced, either to the presence of an active neutral salt, a large excess of acid, especially the carbonic, or to an increase of temperature.

In taking therefore the Tunbridge water as an example of an extremely numerous class of natural springs, the simple chalybeates, we find the effects which it produces to be decidedly of the stimulant kind: soon after taking a moderate dose, the pulse is raised in strength, the patient, if previously chilly and pale, feels a degree of glow occasioned by the increased circulation; and by persevering in the use of the water, the appetite becomes somewhat increased, and the general spirits improved. These effects are much more striking in some than others, and though it is the irritable and sanguine habit that in general feels them the most powerfully, no certain rule of expectation can be laid down previous to a trial. It is not uncommon, however, on beginning a course of these waters, for the patient to experience nausea, vomiting, and pain about the præcordia; or else a heaviness of the head, slight vertigo, and fenfe of fulnefs over the whole body. Sometimes thefe fymptoms are fo conftant as to forbid the ufe of thefe medicinal fprings; but in general they are only very tranfient, and difappear after a little ufe, and efpecially when an increafe in any of the natural excretions is eftablifhed. The fimple chalybeates produce no certain action on the bowels: when thefe are foul and loaded with bilious fordes, the water often purges pretty brifkly at firft, but this operation ceafes when the inteftines are reftored to their natural ftate. All the preparations of iron, and thefe waters among the reft, are known to tinge the fœces black, a circumftance apparently of no importance in itfelf, but of which the patient fhould be apprized, to prevent him from taking any groundlefs alarm. A long ufe of chalybeate waters is apt to bring on a coftive habit of body, unlefs prevented from time to time by proper medicines. The fecretion which thefe mineral waters more commonly excite is that of urine, and is generally in the greateft quantity where they agree beft with the habit of the patient. Now and then they bring on a more perfpirable ftate of body, efpecially where the perſon who uſes them is in a ſitu-ation to take much and regular exerciſe.

The general operation of theſe chalybeates is therefore to increaſe the power of the ſe-cretory ſyſtem, in a gradual uniform manner, and at the ſame time, by the permanency of their ſtimulus, or from ſome other cauſe with which we are not well acquainted, to impart a gentle and ſalutary increaſe to the body, of ſtrength, tone, nervous energy, and general vigour of all the functions. It is therefore chiefly in chronic diſorders, in thoſe that ariſe from ſlow beginnings, and are attended with great laxity and debility of the ſolids, but without much organic diſeaſe, that theſe wa-ters are found to be peculiarly uſeful.

Chalybeates are of eminent ſervice in an impaired or capricious appetite, and weakneſs of the aſſimilating organs, irregular digeſtion, flatulent diſtention of the abdomen, anxiety about the præcordia, difficult reſpiration from ſympathy with the ſtomach, and occaſional vomiting of viſcid mucus.

Theſe mineral waters alſo poſſeſs a very high and deſerved reputation for the cure of a variety of complaints incident to the female ſex. When from a great weakneſs and relaxation in the uterine ſyſtem, the patient is troubled with profuſe menorrhagia, or with fluor albus, diſorders that are always the cauſe of much ill health and ſuffering, ſhe will often find great relief in a water ſimilar to that of Tunbridge; and as this ſtate of local debility is a very frequent cauſe of abortion or barrenneſs, theſe mineral ſprings have often been the means of removing ſuch unpleaſant circumſtances. However, with regard to hæmorrhagy from the uterus, it is often accompanied with a good deal of general fever, pain in the back and loins, and local irritation, where every internal ſtimulant medicine only aggravates the diſorder; and therefore the uſe of chalybeate waters in theſe caſes requires much judgment and diſcrimination.

Another diſeaſe alſo, intimately connected with a derangement in the uterine ſyſtem, is chloroſis; and if we were to point out one diſorder which above all others received benefit from theſe mineral ſprings, it would probably be this; and accordingly we find in theſe watering places, a large proportion of the female patients to be ſuch who are ſuffering under this obſtruction. The great debility attending chloroſis, the diſpoſition to a cachectic ſtate of body, and to general dropſy, would ſtrongly indicate this form of chalybeate, whoſe operation is ſo much to reſtore the healthy ſtate of all the ſecretions, and along with it to invigorate the whole ſyſtem; but at the ſame time the feveriſh irritation which always ſubſiſts, the headach and frequent dyſpnœa, might ſeem to forbid its uſe. This however appears a ſtriking exception to the general rules for treating complaints attended with fever, ſince it is found that chloroſis, even in its very inveterate ſtate, where not actually accompanied with the inflammatory ſymptoms that precede any internal ſuppuration, will almoſt always bear, and be the better for every kind of chalybeate medicine, and this in particular. It is principally however to chloroſis, that this obſervation applies, for in the inflammatory ſtage of phthiſis pulmonalis, and moſt other inflammatory caſes, theſe chalybeate waters often prove much too heating and ſtimulant.

On beginning a courſe of theſe waters, it is a general practice to premiſe ſome evacuation, either a gentle emetic where the ſtomach is foul, or what is better, ſome opening medicines; and theſe by many have been held of conſequence as very good preparatives, and to prevent that diſguſt for all chalybeate waters, which perſons are apt to conceive when they have not at firſt met with the deſired ſucceſs. It is alſo a common and judicious cuſtom, where the water is not of itſelf purgative, to intermit its uſe for a day or two after it has been regularly taken for a week or ten days, and to clear the bowels during that interval by ſome proper aperient, or elſe to add a ſmall quantity of vitriolated ſoda or magneſia to the water every two or three days, and thus in fact convert it into a purgative chalybeate, a claſs of waters which will be afterwards conſidered. To perſons of a weak irritable ſtomach, and eſpecially females, the freſh drawn water is apt to prove too cold to the ſtomach, and to occaſion a nauſea or ſickneſs, which always defeats the general intention of the medicine. This inconvenience is eaſily prevented by giving the water a tepid warmth, and to do this, it is by far the beſt method to put it into a bottle closely corked, and to immerse the whole in hot water, for by this means but little of the carbonic acid escapes. Where the chalybeate water is very strong, and especially contains a large excess of carbonic acid, as is the case with the Pyrmont water, it will bear dilution with boiling water sufficient to bring the whole to a moderate temperature; but with the mild weak chalybeates, such as that of Tunbridge, the above mentioned method of warming it is by far the best.

It is frequently of eminent service during a course of these mineral waters, especially in chlorosis and other obstructions, to employ the warm bath occasionally, and the propriety of this practice, warmly recommended by Hoffman, is amply proved by daily experience.

Such are the general indications in which chalybeate waters may be safely and usefully employed; and, as powerful tonics, whose effect is general, and regularly exerted, they are perhaps superior to most of the other medicines of similar operation; but it should be remembered, that there are a great number of morbid causes that induce general debility, which this class of remedies is intirely unable to reach. Such for inftance, are thofe of derangement in the whole functions of the alimentary canal that are produced by fchirrus of any important organ, or any flow fuppurating abfcefs. It is by being employed injudicioufly in fuch cafes, that thefe waters have often difappointed the fanguine expectations that have been held out; and thereby they have frequently loft much of the regard to which they appear to be really intitled.

The prefcribed method of ufing the Tunbridge water is judicious. The whole of the quantity daily ufed, is taken at two or three intervals, beginning at about eight o'clock in the morning, and finifhing about noon. The dofe at each time varies from about one to three quarters of a pint, according to the age, fex, and general conftitution of the patient, and efpecially the duration of the courfe, for it is found that thefe waters lofe much of their effect by long habit; and in this refpect they differ much from the faline purgative waters, for the latter will continue to produce a moderate evacuation from the bowels daily for a great length of time with undiminifhed efficacy.

A fingle dofe of half a pint of thefe waters will contain, according to the analyſis which we have given, $\frac{1}{16}$ of a grain of oxyd of iron; about $\frac{1}{6}$ of a grain of muriated magneſia and common ſalt, and about $\frac{1}{12}$ of a grain of ſelenite. It will likewiſe hold in ſolution a quantity of carbonic acid, about equal in bulk to three drams of water; and $\frac{1}{3}$ of a cubic inch of air, chiefly azotic gas. Therefore, ſuppoſing a quart of the water to be the daily allowance, the patient will have taken in twenty-four hours only $\frac{1}{4}$ of a grain of oxyd of iron, $\frac{2}{3}$ of a grain of opening ſalts, $\frac{1}{3}$ of a grain of ſelenite, $1\frac{1}{2}$ ounce in bulk, or three table ſpoonsful of carbonic acid, and about half a ſpoonful of azotic gas; the whole united with two pints of water at the temperature of 50°.

The requiſite duration of a courſe of a chalybeate water may be reckoned about from one to two months. If it does not diſagree with the conſtitution, its beneficial effects in improving the appetite and digeſtive powers are ſoon felt; but if continued much longer than eight or ten weeks, without a conſiderable intermiſſion, the ſtimulant effect gradually wears off, and becomes inadequate to complete a reſtoration to ſtrength and vigour.

There is ſcarcely a county in England which does not poſſeſs ſome chalybeate water, and by far the moſt commonly it is of the claſs which I have denominated the ſimple carbonated chalybeate. Theſe are often very pure waters in every other reſpect; and ſome of them, ſuch as the Malvern chalybeate, and one or two of the Harrogate ſpaw waters, are remarkably ſimple in their compoſition, containing no foreign matters but oxyd of iron, carbonic acid, and ſlight traces of ſelenite. A little greater variety of ſalts, but ſtill either of a very inactive kind, or in very minute quantities, will give the compoſition of the Tunbridge water, and of a great number of chalybeate ſprings about this metropolis, ſuch as that of Hampſtead, Iſlington, and the like. Theſe, along with many others ſcattered over different parts of the kingdom, appear to be all full as ſtrongly impregnated with iron as that of Tunbridge, which has been given as a general example; and therefore, whenever they are uſed, the ſame directions and obſervations will apply to them all. It is merely advantage of ſituation or accidental cauſes that have given ſome of theſe a ſuperior reputation over the reſt; and where this is owing to beauty of ſite or local conveniences, it is well merited, as theſe circumſtances have no ſmall ſhare in the general plan of cure, by enabling the invalid to employ daily exerciſe, and giving that irreſiſtible charm to the ſpirits, which the ſight of a beautiful or romantic country almoſt always excites. Some ſituations are peculiarly favoured by the poſſeſſion of more than one ſpecies of mineral water, and enjoy the benefit of both ſulphureous and chalybeate ſprings, as at Harrogate; of purgative and chalybeate waters, as at Scarborough; and in many other parts of the ſea coaſt. The gradation from a very minute impregnation of ſaline ſubſtances in theſe waters, to one that is ſufficient to give very ſenſible additional properties, is almoſt imperceptible, for the infinite variety that nature gives to theſe productions, renders it ſcarcely poſſible to confine them to any arrangement ſo artificial as that of medicinal powers. We ſhall therefore at once proceed to the moſt eminent of the *highly carbonated chalybeates*, or thoſe in which the carbonic acid is obvioufly in a very great excefs, and gives very ftriking properties. *

* Since the publication of the firft edition of this work, Mr. Blifs, of Hampftead, has favoured us with a very judicious and correct analyfis of a carbonated Chalybeate long celebrated at Hampftead; his experiments are well contrived, and executed with great nicety. The following are the folid contents of a wine gallon of this water:

	grains
Of oxyd of iron	1 $\frac{50}{100}$
Of muriate of magnefia	1 $\frac{75}{100}$
Of fulphate of lime	2 $\frac{12}{100}$
Of muriate of foda, nearly.......	1
Of filex about	$\frac{38}{100}$
Total	6 $\frac{75}{100}$

And the gafeous contents of a gallon are as follows:

	cubic inches
Of carbonic acid gas.....................	10.1
Of an air fomewhat lefs pure than atmofpherical	90.9
	101

If therefore the Hampftead water be not affected by rain, it is a more powerful chalybeate than that of Tunbridge, which *contains only* one grain of oxyd of iron in a gallon of the water. *Vide Experiments and Obfervations on the Medicinal Waters of Hampftead and Kilburn. By John Blifs, Member of the Royal College of Surgeons in London.*

SPA WATER.

THE celebrated waters of Spa (which indeed have given a generic name, though improperly, to all chalybeates) differ in composition from any of our own country, chiefly in containing a very large excefs of carbonic acid, by which they acquire very confiderable fenfible properties, and probably an equal increafe in medical virtues. In other refpects, however, the Spa water is very pure and free from faline contents of any activity, and therefore this and the Pyrmont water may be confidered as the beft examples which we poffefs of the *highly carbonated chalybeate waters*. We fhall take fome notice of each.

The marquifate of Franchimont, in the principality of Liege, (*a*) contains a great variety of thefe chalybeate fprings, fcattered over a pretty extenfive diftrict, but the moft frequented of thefe are at the villages of Malmendy, and efpecially Spa, which laft is now become a confiderable place, owing to the great

(*a*) Lucas, vol. I.

refort of invalids and ftrangers of every de-fcription. The medicated fprings of this dif-trict have been known for feveral centuries, and have long conftituted much of its natural riches. The whole of this diftrict, as Dr. Lucas obferves, is compofed of rude and often uncultivated mountains, many of them, how-ever, covered with wood, and often wet and boggy. It is watered by the noble river Meufe; and affords a moft agreeable contraft to the flat rich plains of Flanders, to which it is immediately contiguous. The country abounds with iron ore, which is wrought in a number of forges and fmelting houfes that are fcattered over the country.

Of the number of fprings, not lefs than fixteen, which are enumerated by Lucas, we fhall only felect the Pouhon fpring within the town of Spa, as this is by far the moft co-pious, the moft frequented, and efpecially that which chiefly fupplies the large exportation which is made of this water for foreign con-fumption.

The Pouhon is a large flow deep fpring, which arifes from a flaty rock in the centre of the village of Spa. In cold dry weather it appears colourlefs, and perfectly tranfparent. When firft taken out of the well it fcarcely fparkles, but prefently covers the infide of the glafs with fmall air bubbles, which it alfo emits very copioufly when fhaken or poured from one glafs to another. In moift weather the water of the furface of the well appears rather turbid, and on the approach of rain, a whiftling or humming noife is heard, which the country people call the mufic of the fpring. This water has an agreeably acidulous tafte, mixed with a ftrong impreffion of a chalybeate, and this latter remains in the mouth for a confiderable time. The fpecific gravity, according to Bergam, is 1.0010.

When a glafs of the Pouhon water is expofed to a warm air, it foon parts with a number of air bubbles, throws up an iridefcent pellicle on its furface, becomes turbid throughout, and finally lofes intirely its acidulous chalybeate tafte. If it is firft corked, and then fet in a warm place, it prefently caufes the cork to fly out with an explofive noife.

The compofition of the water is well illuftrated by the feveral re-agents.

Tincture of litmus is slightly reddened, but paper tinged with this colouring liquor is rather rendered of a deeper blue (*b*).

The concentrated acids cause a considerable ebullition and disengagement of gas, and the same effect is also produced by Rhenish wine.

Syrup of violets is at first somewhat reddened, but soon becomes green, which colour is permanent.

Tincture of galls, sumach, and other vegetable astringents, soon render the water of a deep purple; and prussiated alkali gradually changes it to a blue.

The oxalic acid precipitates lime, though very sparingly.

Nitrated silver indicates a minute portion of the muriatic acid.

Acetated lead gives a white precipitate, and corrosive sublimate, yellow.

When the water is evaporated, both carbonated lime, carbonated magnesia, and oxyd of iron, are separated, and when the liquor is much reduced in bulk, it turns turmeric paper of an orange brown.

(*b*) Bergman's Essays, vol. II.

The above appearances indicate the prefence of carbonic acid, carbonated earths, and at the fame time a fmall portion of an alkali; and they likewife fhew the exiftence of iron, and a muriatic falt.

The actual contents of a wine pint of Spa water, as afcertained by Bergman, and reduced to Englifh meafure, are the following:

	grains
Of oxyd of iron - - -	.56
Of carbonated lime - -	1.47
Of carbonated magnefia -	4.46
Of carbonated foda - -	1.47
Of muriated foda - - -	.172
	8.132

Total—about eight grains of folid matter.

The gafeous fluid collected, is intirely carbonic acid, and amounts to about 45 per cent. of the bulk of the water, making 12.79 cubic inches, or about fix ounces and a half in meafure, in every wine pint.

Spa water therefore appears to be a very ftrongly acidulous chalybeate water, containing more iron, and efpecially more carbonic acid than any that we have hitherto mentioned. With regard to the other foreign contents, they are all of a very inactive kind, except the ſoda, but the quantity of this is very ſmall; enough, however, probably to counteract much of the hardneſs that the earthy ſalts would give, and to enable the water to mix very uniformly with milk and with ſoap, without much curdling. The ſoda and alkaline earths will both unite in giving antacid properties to the water, after the carbonic acid has been expelled by the heat of the ſtomach; and this may be one cauſe why its effects on the alimentary canal are, as we ſhall ſee, very uncertain.

It is a very valuable property of the Pouhon ſpring, that its water, when incloſed in bottles well corked and covered with cement, will preſerve its original ſtate nearly unaltered, even for two years. (*c*)

All the Spa waters are fatal to frogs, inſects, and ſmall fiſhes, an effect intirely depending on the carbonic acid, and always indicating a conſiderable quantity of this gas, which is ſo noxious to reſpiration.

(*c*) Rutty's Synopſis of mineral waters, page 318.

The ſenſible effects produced by this water, are ſtill more decidedly ſtimulant than thoſe of Tunbridge or the other mild chalybeates, and the operation of the carbonic acid may in ſome degree be diſtinguiſhed from that of the other principles. It has been already mentioned, that it appears to be the effect of every water, even the pureſt, to occaſion in certain habits, eſpecially the debilitated, ſome degree of vertigo and determination to the head when firſt drank; but the Spa, Pyrmont, and Seltzer waters, poſſeſs this property in a very remarkable degree, and when taken in a full draught, particularly in hot weather, or upon an empty ſtomach, they produce a ſwimming in the head, and a degree of intoxication, that ſometimes continues for half an hour, and is very ſimilar to that which ariſes from ſpirituous liquors, though without leaving the ſame debility. This kind of intoxication, as Dr. Rutty obſerves, is more remarkable in the Geronſterre water at Spa, which contains a ſlight ſulphureous impregnation when firſt drawn, ſo as ſenſibly to affect the noſe.

With regard to the operation of theſe chalybeates, upon the ſecretions and excretions, what has been ſaid of the preceding article will apply very exactly to theſe. By their general ſtimulant powers, and perhaps from the mere bulk of water, they ſometimes promote every ſecretion, and even act powerfully on the bowels; but their moſt regular determination is to the kidnies and the ſkin, and ſometimes, contrary to what is obſerved of moſt medicines, they at the ſame time promote every ſecretion.

Spa water is obſerved to quench thirſt more than common water, eſpecially in ſlight febrile complaints, attended with a foul dry ſtate of the tongue and throat, and may be uſed in theſe caſes in the ſame manner as the Seltzer water, though with more caution, as from its chalybeate property it is more ſtimulating. Ulcers in the throat, and a relaxed ſtate of the fauces, are much relieved by this application.

Theſe acidulous chalybeates appear to be particularly well calculated to afford relief in acrid diſcharges from the urinary paſſages, whether owing to ulceration of the kidnies or concretions in the bladder; and by alleviating the extreme pain of thefe diforders, they materially contribute to the reftoration of the healthy functions. (*d*)

All that has been faid under the preceding article, concerning the ufe of chalybeates, in diforders in females, arifing from derangement in the regular menftrual evacuation, applies peculiarly to the Spa waters, and efpecially in removing fterility, when arifing from fluor albus, or relaxation of the uterine fyftem; and in the other fex in preventing involuntary difcharge of femen, and the debility arifing from gonorrhæa.

In diforders of the alimentary canal, in bilious vomiting, diarrhæa and dyfentery, the Spa water is often of confiderable ufe as an auxiliary, and efpecially in reftoring the healthy action of thefe parts, and removing their debility; but as it poffeffes in itfelf no certain power in evacuating the bowels, it can feldom be trufted to intirely without the ufe of fome aperient. In the debility of ftomach, arifing from a debauch, a draught of this water is highly refrefhing and falutary.

(*d*) Hoffman—"De fontis fpadani & fchwalbacenfis convenientiâ."

Though thefe chalybeates may generally be taken without much preparation, it fhould not be forgotten, that their diffufive ftimulant properties, render them often improper in inflammatory complaints, attended with much heat, flufhing of the face, and determination to the head; and as this determination is itfelf occafioned by the water*, it may often be adviſeable in plethoric habits to employ blood-letting or other evacuations, previous to ufing this medicine. If thefe precautions apply to all chalybeates, they are particularly neceffary in the very active form in which the Spa water is conftituted; and thefe evacuations are intirely independent of thofe that may be neceffary to remove any local congeftion in the alimentary canal, and which muft often be continued during the whole courfe of this mineral water.

The dofes of this water muft principally be regulated by the experience of the individual patient, though it may be obferved, that as it produces no very powerful effect upon any of the ufual evacuations, it may be taken as largely and freely as the ftomach and bowels, or the general fyftem, can bear with convenience.

It is ſafer to begin with a moderate quantity, not more than half a pint for a doſe, which is as much in bulk of any liquid as patients can in general bear, and often more. This may be repeated three or four times in the day, and gradually increaſed till ſome effect is produced on ſome of the ſecretions. After this no further increaſe is requiſite, eſpecially as it requires ſome perſeverance to produce the full effect of this natural medicine. Many patients, eſpecially thoſe on the ſpot, are in the habit of diluting with this water the wine which forms their common drink, which makes a pleaſant and ſalutary beverage.

PYRMONT WATER.

THIS celebrated chalybeate ſpring at Pyrmont, in the province of Weſtphalia, is known over moſt parts of Europe as a water which poſſeſſes moſt remarkable ſenſible properties, and very valuable medical virtues.

The water, at the fountain head, is conſtantly ſending forth a large quantity of gas, which has a ſenſible pungency to the ſmell, and makes the water-ſervers giddy (*a*); and forms an atmoſphere which always hovers over the ſurface of the well. This gas proves fatal to fiſhes or inſects that are immerſed, and even to ducks or other ſmall birds that attempt to ſwim acroſs. The qualities of the water are ſcarcely, if at all, affected by external circumſtances.

Pyrmont water, when juſt taken up from the ſpring, is quite clear and tranſparent, and ſends forth a copious ſtream of air bubbles for a conſiderable time, in which reſpect it far exceeds any of the mineral waters that we are acquainted with.

(*a*) Rutty's Synopſis of Mineral Waters.

The taſte is highly agreeable, being ſtrongly acidulated, and poſſeſſing a pungency very ſimilar to that of briſk Champaigne wine; but it is at the ſame time ſtrongly chalybeate and a little bitteriſh. The taſte of iron it retains for a long time, even though expoſed to the open air. On account of the abundance of gas, if the freſh water be immediately bottled and well corked, and afterwards removed to a warm place, the bottles are very liable to burſt with the expanſion of the air; and hence, when they are filled for exportation, they are ſuffered to ſtand a while uncorked, to allow a paſſage for ſome of the carbonic acid gas, though enough remains to enable the water to retain all its properties.

The uſual chemical re-agents indicate the foreign contents with great exactneſs. (*b*)

Tincture of litmus is immediately and more intenſely reddened by this than even by the Spa water, indicating a great abundance of carbonic acid, much more than is neceſſary to ſaturate any alkali or alkaline earth which it may contain.

Syrup of violets is however rendered of

(*b*) Bergman's Eſſays.

a very bright green, and Brazil wood of a blue colour, but turmeric is not altered, from which the preſence of a large quantity of carbonated earth is indicated.

Any kind of acid, either the more concentrated, ſuch as the ſulphúric; or the weaker, ſuch as vinegar, lemon juice, or even Rheniſh wine, diſengage copious bubbles from the freſh water (*a*).

Tincture of galls, green tea, balauſtine flowers, and other vegetable aſtringents, ſoon render the water of a fine purple, which by ſtanding, deepens into a black colour; and this property is retained longer than in moſt of the carbonated chalybeates, and is not intirely loſt till the water has been boiled for a ſhort time.

The acid of ſugar detects a large quantity of lime.

During evaporation, the water firſt parts with much carbonic acid; it then depoſits oxyd of iron, carbonated lime and magneſia; and towards the end of the proceſs, ſome ſelenite; and leaves at laſt a reſiduum com-

(*c*) Hoffman, — " De principiis & virtutibus medicatorum Germaniæ fontium."

poſed of common ſalt and vitriolated magneſia.

Bergman's analyſis preſents the following contents:

A wine pint of Pyrmont water contains

Of oxyd of iron	.56
— carbonated lime	4.46
— carbonated magneſia . .	10.03
— ſelenite	8.58
— ſulphated magneſia . .	5.57
— muriated ſoda	1.56
	30.76

Total, thirty grains and three quarters of ſolid contents.

The quantity of gas which this water contains is much more than in any natural mineral ſpring that we are acquainted with. Bergman eſtimates it at 90 per cent. of the bulk of the water, or about 26 cubic inches in the pint: and as ſome muſt eſcape whilſt it is put in the bottles, we may fairly reckon the whole quantity to be at leaſt equal to the bulk of the water. This gas is almoſt intirely pure carbonic acid.

The ſpecific gravity of the water is eſti-mated at 1.0024, but it is difficult to aſcertain it with accuracy, on account of the conſtant eſcape of gas.

A general review of the analyſis of this water will therefore ſhew that it ſtands the firſt in rank of the highly carbonated chaly-beates, and contains ſuch an abundance of carbonic acid as not only to hold diſſolved a number of carbonic ſalts, but to ſhew all the properties of this acid, uncombined, and in its moſt active form. Pyrmont water is likewiſe a ſtrong chalybeate, with regard to the pro-portion of iron, and it is beſides a very hard water, containing much ſelenite, and earthy carbonats.

The ſenſible effects which this water oc-caſions, highly correſpond with the chemical analyſis. When freſh from the ſpring, and drank copiouſly, eſpecially on an empty ſto-mach, it ſtrikes the noſe with a very pungent vapour, and produces a kind of temporary intoxication. At all times too, it inlivens the ſpirits, and increaſes the appetite. The freſh water, ſometimes, on being freſh uſed, purges very briſkly, and always tinges the ſtools of a very dark colour; but this effect on the bowels is very uncertain, and ſeems rather to depend on the ſtate of body of the patient, and the generally ſtimulating property of the carbonated chalybeate; for when the water has loſt theſe active ſubſtances by boiling, it is no longer purgative, but rather the contrary, as Hoffman remarks. It more commonly increaſes the ſecretion of urine, and in ſome habits it ſometimes occaſions an eruption on the ſkin for a time.

The diſeaſes to which this mineral water may be advantageouſly applied, are the ſame as thoſe for which the Spa and others of the acidulated chalybeates are reſorted to; that is, all caſes of debility that require an active tonic that is not permanently heating; various diſorders in the alimentary canal, eſpecially bilious vomiting and diarrhœa; and complaints that originate from obſtructed menſtruation. The precautions required in beginning a courſe of theſe waters are ſimilar to thoſe of Spa, and the caſes in which they are contraindicated, the ſame. Pyrmont water has however been thought to be conſiderably rougher in its operation, and more active; and hence Hoffman concludes that it is peculiarly well fitted for the ufe of the Weftphalians, who are in general of a robuft conftitution, and live upon hard ftrong food. It is certain that whatever effects are produced on delicate ftomachs by a hard water, may be here apprehended from the large proportion of earthy falts; and this is one circumftance in which an artificial mineral water has a decided advantage over a natural one. Pyrmont water mixes pretty fmoothly with milk, and in this form it has been particularly recommended for gouty cafes; and as it is fo powerfully impregnated with active principles, it will bear a confiderable dilution where this may be thought neceffary, and ftill retain fo much of the iron and carbonic acid, as to be equal in ftrength to moft of the common acidulous chalybeates.

The dofe of this water is about the fame as that of Spa, under fimilar circumftances; but it may be obferved that the country people who flock to this fountain of health on all occafions, partly for a variety of complaints, and partly to enjoy the kind of intoxication which it generally produces, have in general no other idea of proportioning the dofe to their complaints, than that of drinking it as copioufly as the ftomach will bear. Where attention is paid to quantity, we may reckon about three pints as a daily allowance in common cafes, and this will contain, according to the above analyfis, about a grain and a half of oxyd of iron; fixty-nine grains of felenite and earthy carbonats; about twenty-one grains of Epfom and common falt; and feventy-eight cubic inches, or about two pints and a half in bulk, of carbonic acid, partly combined with the iron and earths, but moftly only united to the water, and very readily volatile in the heat of the ftomach.

After confidering thefe carbonated chalybeates, whofe active properties appear to be intirely confined to the iron and carbonic acid in different proportions, we may with propriety proceed to thofe which, in addition to thefe two fubftances, hold in folution a confiderable quantity of fome purgative falt, which is ſufficient to give a conſtant and decided determination to the bowels, when taken in a moderate doſe.

Some of the very briſk acidulous chalybeates, ſuch as that of Spa or Pyrmont, do indeed at times prove laxative, without the aſſiſtance of a purgative ſalt; but this effect is by no means conſtant, and appears to depend a good deal on the previous habit of the patient, and ceaſes ſoon after the uſe of theſe waters is begun; but the claſs of waters which we are going to deſcribe, operate for the moſt part very regularly and conſtantly, as long as they are continued. Some of the moſt valuable mineral ſprings belong to this claſs, which may be termed the *ſaline carbonated chalybeates*, and they contain a notable quantity of vitriolated ſoda or vitriolated magneſia, or often both. In our own country theſe waters are all cold, but on the continent, eſpecially in France and Germany, many of them are conſtantly of a high temperature; and what is rather ſingular, they almoſt all contain, along with a neutral ſalt, an exceſs of carbonated ſoda.

The only two in this country that we ſhall notice, are the waters of Cheltenham and Scarborough: thoſe of France are the thermal ſprings in the provinces of Auvergne and the Boubonnois; and in Germany the celebrated waters of Carlſbad, on the confines of Bohemia.

CHELTENHAM WATER.

Cheltenham (*a*) is a ſmall town in Glouceſterſhire, ſituated in a ſandy vale, ſurrounded by hills of a moderate height, in the midſt of a fertile well cultivated country.

The chalybeate ſaline ſpring to which this town owes its celebrity, iſſues ſlowly and in a ſcanty ſtream, from a bed of ſand, intermixed with blue clay. The well is ſunk about ſix feet deep, and excluded from communication with the external air. The ſides are covered with a yellow ochre, indicating the nature of the water. The ſupply of this chalybeate is calculated to be only about thirty-five pints in an hour, a quantity ſufficient to anſwer the demand in the height of the ſeaſon, but requires frugal management.

Cheltenham water, when freſh drawn, appears tolerably clear, but not perfectly tranſparent. It becomes more turbid by ſtanding, and ſeparates air bubbles in a ſmall quantity.

(*a*) See Dr. A. Fothergill's "Experimental inquiry concerning the Cheltenham water," 3d edit. 1788.

It gives out a ſlight but very diſtinguiſhable ſulphureous odour, which is more perceptible on the approach of rain. To the taſte it ſhews no briſkneſs or pungency, but is brackiſh, rather bitter, and chalybeate. The temperature is conſtantly from 53° to 55°.

With different re-agents it ſhews the following appearances:

Lime water produces a turbidneſs when added to the freſh water; and the ſulphuric and nitric acids diſengage a few air bubbles.

Syrup of violets is rendered green.

Tincture of galls inſtantly ſtrikes a lively purple, which grows darker by ſtanding; but this property is loſt if the water be previouſly expoſed for half an hour to the air, and it becomes thereby very turbid.

Nitrated ſilver occaſions an immediate precipitation of white clouds which ſoon become dark coloured. Acetated lead produces the ſame effect.

Soap is immediately curdled by this water.

When boiled in cloſe veſſels, a conſiderable quantity of air is extricated, which when examined, proves to be, in a large proportion, carbonic acid. A pint of the water yielded to

Dr. Fothergill, about three ounce meafures of gas, of which two-thirds were abforbed by lime water rendering it turbid, and therefore was carbonic acid, and the remainder was common air, or elfe azotic gas, united with a minute portion of fulphurated hydrogen.

During evaporation, this water at firft throws up an earthy fcum which effervefces with acids (*b*), and is therefore carbonated lime; and depofits its oxyd of iron. At the conclufion of the procefs, a large quantity of a cryftallizable falt is procured, which is a mixture of vitriolated foda, vitriolated magnefia, and common falt, and feveral uncryftallized or deliquefcent falts are alfo obtained.

A gallon of Cheltenham water, according to Dr. Fothergill's analyfis, will contain

	grs.
Of a cryftallized falt compofed of fulphated foda and fulphated magnefia - - - - - - -	480
— muriated foda - - - - - -	5
— muriated and carbonated magnefia	25
— felenite - - - - - - - -	40
— oxyd of iron, nearly - - -	5
	555

(*b*) See Rutty's Synopfis of Mineral Waters.

Together with	cubic ins.
Of carbonic acid - - - -	30.368
— an air, chiefly azot mixed with ſome hepatic - - -	15.184
	45.552

Total, one ounce, ſeventy-five grains for the ſolid contents; along with a pint and a half in bulk of the aeriform (*c*).

A general ſurvey of the component parts of this water will ſhew that it is one which

(*c*) This analyſis as given by Dr. Fothergill, is by no means complete (nor indeed is it pretended to be ſo) and is eſpecially defective in eſtimating the quantity both of the iron and the gaſes. In other reſpects it may be conſidered as ſufficiently accurate, particularly with regard to the quantity of purgative ſalts. Dr. Rutty reckons the whole reſiduum at 528 grains, and other chemiſts vary a little in this reſpect. A perfectly accurate analyſis of this water would be a work requiring conſiderable ſkill and attention, on account of the great variety of foreign contents. Allowing however that this analyſis is tolerably accurate on the whole, it will ſhew that a much leſs minute examination will ſatisfy the phyſician than the chemiſt, and that in many caſes diſtinctions may be neglected by the one, which it is the buſineſs of the other to eſtabliſh. It ſhould not be forgotten, however, that there is a wide difference between an imperfect and an inaccurate analyſis; and in a claſs of bodies, like that of mineral waters, where very ſenſible effects on the human body are aſcribed to minute quantities of active ſubſtances, the eſtimation of *thoſe* quantities ſhould be made with rigorous exactneſs.

poffeffes feveral of the moft active of thofe ingredients which give medical properties to particular waters. It is in the firft place decidedly faline, and contains much more falt than moft of the waters which we have hitherto mentioned, that of the fea excepted. By far the greater part of the falts are of a purgative kind, and therefore an action on the bowels is a conftant effect produced by this medicinal fpring, notwithftanding the confiderable quantity of felenite and earthy carbonats which may be fuppofed to have a contrary tendency. Cheltenham water is befides a chalybeate, and if the analyfis before us be at all accurate, it is one of the ftrongeft that we are acquainted with. The iron is fufpended intirely by the carbonic acid, of which gas the water contains about an eighth of its bulk, but from the abundance of earthy carbonats and oxyd of iron not much of it is uncombined. It therefore does not give indications of being very brifk, though more fo than common fpring water. It has befides a flight impregnation of fulphur, but fo little as to be fcarcely appreciable, except by very delicate chemical tefts.

Cheltenham water will not keep well, nor bear tranſporting to any diſtance, without being materially altered; for the chalybeate part is ſoon loſt by the precipitation of the iron which takes place even in the cloſeſt veſſels, after a few days. The ſalts however remain. If kept open to the air, this water both loſes its chalybeate principle, and ſometimes becomes fetid (*d*).

In order to reduce ſome of the valuable parts of this water to a more convenient form for carriage and for keeping, the purgative ſalts are procured on the ſpot by evaporation and by cryſtallizing the reſiduum, and ſold under the name of the *Cheltenham ſalts*. It is in fact nothing more than a mixture of vitriolated ſoda and vitriolated magneſia, but the proportion of each is not aſcertained; nor is it of any great importance in a medical point of view, ſince the effect of each is ſo nearly the ſame. Theſe ſalts are much uſed on the ſpot, added to the freſh water, to increaſe its operation on the bowels.

The ſenſible effects produced by this water are generally, on firſt taking it, a degree of

(*d*) Rutty.

drowfinefs, and fometimes headach, but which foon go off fpontaneoufly, even previous to the operation on the bowels. A moderate dofe acts powerfully and fpeedily as a cathartic, but, in common with many other of the largely diluted faline waters, it acts in a very gentle manner without occafioning griping, or leaving that faintnefs and languor which often follow the action of the rougher cathartics. It is principally on this account, but partly too from the falutary operation of the chalybeate, and perhaps the carbonic acid, that the Cheltenham water may be in moft cafes perfevered in for a confiderable length of time uninterruptedly, without producing any inconvenience to the body; and during its ufe the appetite will be improved, the digeftive organs ftrengthened, and the whole conftitution invigorated. I have faid that thefe good effects are principally to be afcribed to the nature and degree of dilution of the purgative falts, fince we find the fame advantage to attend the ufe of fea water, or thofe which I have termed the *fimple faline;* but it cannot be doubted that the other active ingredients of the Cheltenham water add very materially to its value, and enable it more particularly to combine a variety of ſalutary operations. A doſe of this water, too ſmall to operate directly on the bowels, will generally determine pretty powerfully to the kidnies, and thus the ſecretion of urine may be in ſome meaſure commanded, though leſs perfectly than the action of the inteſtinal canal.

Cheltenham water is uſed with conſiderable benefit in a number of diſeaſes, eſpecially of the chronic kind, and many of them highly difficult of cure (*e*). From what has been ſaid of the medicinal powers of the ſaline waters, and of the chalybeates ſeparately, ſome idea may be formed of the method in which ſuch a mixture of theſe principles, as is found in this water, may be ſuppoſed to operate, and of the caſes to which it is peculiarly applicable.

This medicinal ſpring has been found of eſſential ſervice in the cure of glandular obſtructions, and eſpecially thoſe that affect the liver, and the other organs connected with

(*e*) See a pamphlet intitled, Obſervations on the Nature, Uſe and Abuſe of the Cheltenham Water, by J. Smith, M.D. 1796.

the functions of the alimentary canal. Persons who have injured their biliary organs by a long residence in hot climates, and who are suffering under the symptoms either of excess or deficiency of bile, and an irregularity in its secretion, receive remarkable benefit from a course of this water, judiciously exhibited. Its use may be here continued even during a considerable degree of debility, and from the great determination to the bowels, it may be employed with advantage to check the incipient symptoms of dropsy and general anasarca which so often proceed from an obstruction in the liver. All the effects which mineral waters can produce in such diseases, may probably be commanded by the two springs of Cheltenham and Bath; but as the operation of these two differs very essentially, some judgment must be exercised in each individual case, to determine in what manner the use of each must be regulated. Often too it is necessary to employ the warm bath externally, during the course of Cheltenham water, and this town is very well accommodated in this respect with artificial baths of any temperature.

Among other chronic diſorders that are much relieved by the Cheltenham ſpring, we muſt enumerate a variety of ſcrophulous affections, in different parts; but as theſe often require the aſſiſtance of external application, the ſea has certainly here a very decided preference.

Another claſs of diſeaſes in which the advantage of Cheltenham water is conſtantly experienced, is in ſome of the moſt diſtreſſing and painful affections of the ſkin, of the kind uſually termed ſcorbutic eruptions; that ariſe often without any very obvious cauſe, that chiefly depend on the habit of body, and make their appearance at ſtated intervals in painful ulcerations on the ſkin, producing a copious acrid diſcharge of lymph, and an abundant deſquamation. In common with other ſaline purgative ſprings, this is found to bring relief in theſe moſt haraſſing diſorders, but it requires to be perſevered in for a conſiderable time, keeping up a conſtant determination to the bowels.

Whilſt the chalybeate ingredient of this water probably aſſiſts conſiderably in enabling the conſtitution to bear without debility a greater degree and a longer courfe of evacuation than with moft other medicines of this kind, it feems however probable that this circumftance will alter, and fomewhat impair the benefit which would arife from the iron alone; fo that the Cheltenham water cannot be ufed in every cafe where a fimple chalybeate water is indicated. There are fome conftitutions which are naturally languid or debilitated by difeafe, but which do not fhew any marks of obftruction, or thofe fymptoms that have been attributed to acrimony in the fluids; and thefe cannot bear with impunity any conftantly increafed operation on the bowels. This fhews therefore the neceffity of fome caution and judgment in the ufe of this fpring. It is likewife often a queftion of fome moment, whether the patient fhould ufe the water fo as daily to increafe in a fmall degree the natural evacuation of the bowels, or whether he fhould drink it only at intervals, and in larger dofes, fo as to be brifkly purged. Thefe are circumftances, which, I think, are not always fufficiently attended to by the greater number of invalids, and would require the judgment of a profeffional man on the fpot.

It is an advantage attending thefe faline waters, that they may be ufed at once, without any preparation; nor is any other medicine often required during their ufe, except, as has been already mentioned, the occafional addition of the cryftallized falts, where the water itfelf does not prove fufficiently active to the bowels; and likewife the ufe of the warm bath in feveral of the cafes, and more efpecially the difeafes of the fkin.

The feafon for drinking the Cheltenham water is during the whole of the fummer months, and in fuch a courfe of medicine the circumftance of feafon is probably of fome confequence. The water fhould, if poffible, be always drank at the fountain head, and never kept long expofed to the air. It might, however, be cautioufly warmed in clofe veffels, when its coldnefs would prove offenfive to the ftomach of the patient. The dofe muft vary confiderably, both from the great difference of the action of purgatives in different habits, and from the intention with which the water is given. In general, moft advantage is obtained by taking a full purgative dofe at once, fo that the ftools may be quickly procured; therefore, in ſuch caſes as the doſe of one pint will not prove purgative, ſome of the neutral ſalts ſhould be added to it; for the repetition of the diluted doſe during the day time, at diſtant periods, will not always produce ſtools, and very frequently brings on nauſea and loſs of appetite.

Since the publication of the former edition of this work, a new ſpring has been diſcovered, nearly of the ſame nature with that of the Old Spa, and producing a more abundant ſupply of water. I am favoured with the following account of it from Dr. Jamieſon.

" This ſpring is ſituated on an elevated
" airy ſpot, in the waſte lands, about three
" hundred yards diſtant from the old Spa,
" and in a ſoil conſiſting of hard blue clay,
" replete with ſhelly pyrites and chryſtals of
" ſelenite ſalts; the well is forty foot deep,
" and the water riſes to twenty feet, its
" greateſt height. In conſequence of the
" depth of the well, and the great body
" of water it always contains, it is uniform
" in its properties, and beautifully tranſ-
" parent; the temperature is from 53 to 58

" in the warmeſt ſeaſon, and two degrees " colder than the other Spas. The water, " freſh from the pump, ſparkles a little, and " taſtes ſaltiſh, like weak ſea water, imparting " to the palate the diſagreeable flavour " of the hepatic gas, inſtead of the bitter taſte. " The carbonic acid gas is not in great proportion, " but can eaſily be detected by lime " water. The hepatic gas is readily diſcovered " by inviſible words, written with a " ſolution of mercury in nitrous acid, becoming " legible when dipped in the water; " they turn immediately yellow, and afterwards " blackiſh; but the vapour of the " water does not produce the ſame effect; " the impregnation of iron ſeems ſmall in " quantity, tincture of galls, and pruſſiate of " pot-aſh, do not change the colour of the " water until a few drops of nitrous acid have " been added, it then becomes of a purple " colour. The ſaline matter of the water " conſiſts in a greater proportion of the muriate " of ſoda to the other neutral ſalts, than " is contained in the water of the other Spas, " which, with its ſulphureous gas, makes it " approximate to the nature of Harrogate

" water. The muriate of foda feems to be
" contained in the water, in a tolerable pure
" ftate, without the ufual bitter, and may
" impart to it fome peculiar medical pro-
" perties."

Upon evaporating a gallon of it which was fent me from Cheltenham, I found the grofs contents of the refiduary matter to be, about one ounce and 30 grains. Upon examining it, it was found to confift chiefly of muriate of foda, fulphate of magnefia, and fulphate of foda. The hepatic gas was foon diffipated by boiling, and from every chemical teft that was employed, the fame effects were produced, as in the old Spa; it may therefore be fafely admitted that its medical powers are the fame.

During a fhort refidence which I made at Cheltenham in the fummer of 1802, I was confulted by many invalids, and had an opportunity of converfing with others, who were under the ufe of the purgative faline waters of that place. I foon perceived that they were very indifcriminately ufed in a variety of oppofite difeafes; and that their effects were ſuch as might have been expected from ſo injudicious an application of their medical powers. The caſes in which they appear to be uſeful, are evidently connected with a turgeſcence and congeſtion of the hepatic ſyſtem in full and oppreſſed habits, where the ſecretion of bile is inconſiderable, and where the habit is coſtive. They are of more uſe in ſanguineous conſtitutions than in pallid and chlorotic habits. In diſeaſes of ſimple dyſpepſia, with flatulency and acidity, and in caſes of ſcirrhous liver, I have not perceived any uſeful operation from them.

They are chiefly uſeful when their purgative operation is ſuch, as to relieve from a ſenſe of diſtention immediately conſequent on their being taken into the ſtomach: they loſe their effect by daily repetition, and ought frequently to be alternated with other purgatives, or aided in their operation by other means.

In very delicate exſanguine chlorotic habits, I found the purgative plan univerſally improper; and in ſuch caſes recommended a chalybeate ſpring lately diſcovered at Cheltenham, from which the greateſt advantage was derived. I met with many perſons who had returned from the Eaſt and Weſt Indies, with very torpid bowels, and diminiſhed ſecretion of bile. In ſuch caſes the purgative water was uſeful, and may be proper as preparatory to the future uſe of a more tonic plan of treatment. The daily exerciſe and general habits of temperance, practiſed at Cheltenham, contribute not a little to promote the recovery of ſuch invalids.

In irritable and feveriſh habits, with thirſt and general languor, evidently ariſing from ſome local and viſceral affection, the waters of Cheltenham are leſs calculated to do good. In caſes of jaundice, from ſome reſiſtance to a free diſcharge of bile, and a ſenſe of heat, diſtention, and fullneſs, increaſed ſoon after eating, the Cheltenham water is uſeful. In caſes of jaundice from gall-ſtones alſo, it is uſeful, but ſhould be drank warm.

In calculating the number of perſons, and the variety of diſorders among the invalids at Cheltenham, I think I may fairly conclude, that one third of the whole was benefited, one third derived no advantage, and another third was evidently hurt by perſevering in the purging plan. Among the laſt caſes, ſymptoms of languor, flatulency, thirſt, and debilitated digeſtion, were induced, or much increaſed. How far the newly diſcovered chalybeate water may be employed to leſſen or remove theſe inconveniences, and under what circumſtances it may be ſafely and beneficially had recourſe to for that purpoſe, is a ſubject which has already occupied a good deal of my attention; but it is one of too much extent, and requiring too minute a reference to individual caſes, to be attempted here.

SCARBOROUGH WATER.

The town of Scarborough is ſituated at the foot of a very high cliff on the Yorkſhire coaſt, overlooking a ſpacious bay, ſurrounded by lofty rocks. The mineral ſprings iſſue from the bottom of a large cliff, about a quarter of a mile ſouth of the town. There are two ſpecies of chalybeate waters found in this ſpot, and they differ conſiderably in their compoſition, though they ariſe nearly contiguous to each other. The one is a ſimple carbonated chalybeate, ſimilar to the Tunbridge water; the other, which is better known, and more frequented, and more particularly diſtinguiſhed as Scarborough water, has, in conjunction with the iron, a conſiderable admixture of a purging ſalt, which adds much to its value.

The taſte of this water, at the fountain head, is ſtrongly chalybeate, ather briſk and pungent, and at the ſame time ſaline and ſomewhat bitter.

With the uſual re-agents it gives indication of iron, of much earthy ſalt, and when freſh, it ſhews a pretty conſiderable quantity of carbonic acid. By keeping, however, even in close bottles, it loses intirely its chalybeate property, so that it will not bear carriage with advantage. It is likewise a very hard water, curdling soap, and possessing a large portion of selenite and earthy carbonats.

When this water is evaporated to dryness, a saline residuum is obtained, much greater than from ordinary springs, but less than from that at Cheltenham. One pint of this water yields from 30 to 35 grains of solid residuum, of which about two-thirds are a soluble crystallizable salt, chiefly sulphat of soda. The remainder is mostly selenite, mixed with chalk and oxyd of iron (*a*).

Scarborough water therefore may be ranked among the purging chalybeate waters, though the quantity of aperient salt is too small to operate with activity, except an unusual and often inconvenient dose be taken.

Its general effect, however, even when taken in moderation, is to determine gently to the

(*a*) See Short, "on Mineral Waters," and Rutty's Synopsis, neither of which however present any analysis which is sufficiently accurate for the modern chemist, as from the time in which these respectable authors wrote, some of the most important parts of the analysis of mineral waters were unknown.

bowels, rather than to the kidnies, which is the uſual way in which the ſimple waters paſs off; and this circumſtance illuſtrates in a ſtriking manner the great increaſe of activity which is given to purgative ſalts, by large dilution, and probably too by the addition of the chalybeate principle.

With regard to the diſeaſes for which this water may be uſed with advantage, what has been ſaid of the preceding article, will apply here; but in many of theſe it would be adviſeable to increaſe the purgative effect of this water, by adding ſimilar ſalts, ſince there are not many ſtomachs that could bear ſo many pints of this water, as would be requiſite to command a full evacuation from the bowels. It is therefore chiefly as an alterative that the Scarborough water can be employed in its natural ſtate.

This town has an advantage belonging to its ſituation, which Cheltenham does not poſſeſs, that of affording an opportunity for ſea-bathing, the uſe of which will in many caſes much aſſiſt in the plan of cure for many of the diſorders for which the mineral water is reſorted to.

VICHY WATER.

The provinces of Auvergne and the Bourbonnois, which are ſituated nearly in the centre of France, in a mountainous diſtrict, poſſeſs, among other mineral treaſures, a great number of warm ſprings of different degrees of temperature, and various compoſition; but for the moſt part they are of the claſs of hot ſaline chalybeates, and generally with a ſmall exceſs of ſoda, ſo as to be ſenſibly alkaline in their properties. Many of theſe have long obtained a very high celebrity in the country for the cure of ſeveral diſeaſes, and their nature has been explained by ſeveral ingenious obſervers, though not quite of modern times. Of thoſe that are much frequented, we may enumerate the famous hot baths of Bourbon, in the villages of Bourbon-Lancy, and Bourbon l'Archambault, near the town of Moulins; the waters of the Mont d'Or in Auvergne, which contribute to the formation of the river Dordogne; and the baths of Vichy in the Bourbonnois, ſituated on the banks of the river Allier, a very large tributary to the Loire.

Thefe thermal waters have been frequented for a great number of years, many of them contain baths which are indifputably of Roman conftruction, and are decorated with elegant buildings that have been conftructed by feveral of the French princes. As an example of the general nature of thefe fprings, we may felect that of Vichy, which is one of the moft confpicuous.

The town of Vichy is fituated in a very fertile plain watered by the River Allier, full of vineyards and fruit trees (*a*). This plain, which is at a moderate diftance from the lofty mountains of Auvergne, abounds with fprings of very different kinds; for both hot, tepid, and cold waters, are here found almoft contiguous to each other. The hot and tepid fprings, like moft others of this clafs, iffue forth in great abundance and with impetuofity. There are fix different fources at Vichy, which vary a little in temperature, and in the proportion of the foreign contents. The

(*a*) "Traité des Eaux Minerales de Vichy," &c. par J. F. Chomel. 1738.

tafte of them all is more or lefs faline, and fomewhat bitter, and they poffefs a degree of pungency to the fmell. On the addition of any of the ftronger acids, a copious effervefcence is excited, indicating the prefence of much carbonic acid. The addition of galls caufes a flight change of colour to a rofe-purple, but this only takes place when the water is frefh. By evaporation, thefe waters depofit an earth which effervefces ftrongly with acids, and is therefore carbonat of lime, and yield at laft a refiduum, of which a part is eafily cryftallizable, gives a vivid green with fyrup of violets, effloref ces in the air, and has all the properties of carbonated foda.

The fources of thefe waters appear to be quite out of the reach of any influence from the atmofphere, for no variation is perceived in them either in winter or fummer. In their channel they leave a yellowifh mud, which is doubtlefs principally oxyd of iron.

All the waters of Vichy, therefore, are warm, chalybeate, and alkaline, probably too, mixed with fome earthy muriats, which increafe their operation on the bowels; for the refiduary falt is found to be lefs purgative in proportion to the number of times that it is waſhed and brought to a greater ſtate of purity.

The ſaline nature of theſe ſprings is ſhewn in a ſtriking manner by the great eagerneſs with which ſheep, cows, and other animals, crowd to drink theſe waters, and to lick the ſtones and ſides of the channel through which they flow. Their fondneſs for this beverage is ſo great, that at ſtated times, they croſs the Allier in numbers, ſwimming over the river, but without taſting it, as they ſo much prefer their favourite ſalt ſprings. It is found that this water firſt purges them, but increaſes their appetite, and aſſiſts in rendering them fat, and in good condition.

The immediate effects attending the internal uſe of theſe waters is an increaſe in the inteſtinal evacuation, more or leſs according to the individual ſpring. They likewiſe determine conſiderably to the kidnies, and from theſe circumſtances, added to the operation of the chalybeate and the alkaline ingredient, we may account for the very great benefit which has long been known to attend their uſe in a variety of caſes.

It will not be neceſſary again to enumerate thoſe particular ſymptoms of diſeaſe affecting various organs, in which theſe waters have been employed with advantage; it is ſufficient to obſerve, that they are highly ſerviceable in all the diſorders of the ſtomach that appear to depend on a debility of that viſcus, unconnected with organic diſeaſe, and eſpecially where the marks of acidity prevail; in the conſequences of various derangements of the hepatic organs, ſuch as the bilious colic, and bilious diarrhœa; and in a ſluggiſh torpid ſtate of bowels, inducing obſtinate coſtiveneſs, loſs of appetite, and irregularity in the functions of the whole alimentary canal. Like the Seltzer water, the thermal ſprings of Vichy and Bourbon are highly eſteemed in nephritic diſeaſes, where they very powerfully ſooth the exceſſive pain which accompanies the formation of calculus, and aſſiſt in rendering the diſcharge of ſabulous matter more eaſy, if not preventing its concretion.

The copious employment of theſe warm waters in bathing, extends their utility to a number of caſes, in which the warm bath has long been found of benefit, ſuch as rheumatifm, fciatica, gout, and the like; and in many of thefe, the internal ufe of the water very properly accompanies the external. This is particularly the cafe with many of the dif-orders peculiar to the female fex, owing to irregularity in menftruation, and a defect in the functions of the uterine organs; and hence thefe fprings have acquired great reputation for the removal of barrennefs, chlorofis, and other female complaints. The celebrated Catherine de Medicis, the mother of feveral French princes, is faid to have been much in-debted for her fertility to the waters of Bour-bon-Lancy.

As the waters of the thermal fprings of Auvergne and the Bourbonnois lofe all their chalybeate principle as well as their tempera-ture by carriage, they are not of fufficient im-portance when become merely fupercarbonated alkaline waters, to be an object of commerce like the Seltzer; and therefore, though highly interefting to the naturalift and the phyfician on the fpot, it will not be neceffary to give them here any further notice.

CARLSBAD WATERS.

THERE are few waters that have more engaged the attention of chemifts and phyficians than the very celebrated thermal chalybeate fprings at Carlfbad in Bohemia, better known by the name of THE CAROLINE BATHS. As thefe poffefs a higher temperature than any of the hot fprings in our own country, and have a peculiarity of compofition of which we can exhibit no example here, it will not be unintérefting to give fome defcription of them, for which we are furnifhed with ample materials by (*a*) Berger, Hoffman, (*b*) Bergman, and others.

The whole country on the banks of the Eger in Bohemia is rich in minerals and mineral waters of various kinds, but efpecially chalybeate; and of thefe many are highly acidulous and cold, like the waters of Spa or Pyrmont; but others are very hot, and thefe have given celebrity to the fpot in which is

(*a*) See Berger's Commentatio de Thermis Carolinis, 1709."

(*b*) Hoffman, De Thermis Carolinis.

now ſituated the village of Carlſbad. This name, as well as that of the *Caroline Waters* is attributed to their having been reſorted to and firſt brought into conſiderable notice by the emperor Charles IV. in 1370, which ſhews that theſe baths have been long held in eſtimation. Carlſbad contains ſeveral ſprings, all of which reſemble each other in height of temperature, and in chemical properties: the moſt important of theſe is one which ariſes, with great vehemence, and in a moſt copious ſtream, intolerably hot to the touch, and boiling up with violence; and on this account it has been denominated the *Prudel* or furious ſpring. This is the water which ſupplies the greater number of baths and the drinkers, and it is beſides uſed for ſeveral domeſtic purpoſes, ſuch as ſcalding fowls and hogs to looſen the feathers and hair, for which its heat is quite ſufficient. This fountain terminates directly into the little river Teply, which it renders ſenſibly warm for ſome diſtance, (the word Teply ſignifying *warm* in the Bohemian tongue) till it joins the Eger, a tributary river to the Elbe.

The temperature of the Prudel fountain, as it firſt iſſues forth, is as high as 165°, and keeps invariably to the ſame point. This is hotter than any of the mineral waters that we are acquainted with, which are employed medicinally; and indeed this water requires to be cooled before it can be uſed as a bath, or even drank. On account of the heat and quantity of water, there is always a thick vapour ſeen to hover about the mouth of the ſpring, and from the denſity of the ſteam and the tardineſs with which it diſperſes, the country people foretel the approach of rain (*c*).

The taſte of this water is ungrateful, being ſlightly alkaline, ſaline, rather bitter, and ſtrongly chalybeate. It ſcarcely gives any ſmell, except a ſlight pungency to the noſtrils, but without any thing ſulphureous or fetid. This water is remarkable for a very rapid and copious diſpoſition of a calcareous earth, which takes place always on cooling, and forms a very hard and beautiful ſtalactite, which lines the inner ſurface of any tube or channel through which it flows, and forms petrifactions around moſs, pieces of ſtraw, or

(*c*) This is likewiſe a common remark at Buxton.

any extraneous ſubſtance which is put in the ſtream for twenty-four hours. All the iron which the freſh water contains is alſo precipitated by cooling, and rather ſooner than the calcareous earth; and a very fine laminated calcareous ſtone, in variegated colours, is thus formed in large maſſes around the channel of the ſtream. This, when poliſhed, almoſt rivals the jaſper in beauty.

The various ſprings at Carlſbad give ſtrong indications of containing a large quantity of carbonic acid, and this gas ſhews itſelf both in combination with the water, and uncombined, filling ſeveral caverns that have been diſcovered in the rocks adjoining to the ſprings, and rendering them fatal to all animals that enter them incautiouſly.

The chemical compoſition of the Prudel water, as aſcertained by re-agents, is the following:

All the ſtronger acids, when added to the freſh hot water, cauſe a copious ebullition and diſengagement of carbonic acid gas; and at the ſame time they become neutralized by the ſoda and calcareous earth, which the water contains in a conſiderable quantity.

On adding a little of the gall-nut in powder, the water ſoon becomes of a faint purple, but this diſappears as ſoon as it is cooled, and when it has once loſt its temperature, it will no longer change colour with galls, nor can the power of becoming purple be renewed by reſtoring the original heat.

Syrup of violets added to the hot water ſoon becomes of a high green colour, and the red of Brazil wood is changed to purple.

Carbonated potaſh cauſes an immediate and copious white precipitation. Corroſive ſublimate gives a yellow precipitate.

The ſolid contents of this water, as aſcertained by evaporation, are eſtimated by Bergman (*b*) to be (in an Engliſh wine pint)

	grains.
Of carbonated lime - -	4.15
—ſulphated ſoda - -	41.51
—muriated ſoda - -	5.53
—carbonated ſoda (cryſtallized)	11.76
	62.95

Total, about ſixty-three grains, along with a ſmall quantity of iron.

(*b*) Bergman's Eſſays,

The gaſeous contents have not been eſtimated with any accuracy; but probably an analyſis of theſe would exhibit a conſiderable quantity of carbonic acid, and no other gas of any importance to the medical powers.

Beſides the Prudel fountain, there is another of conſiderable importance, and differing ſomewhat in compoſition, which from the circumſtance of its turning a mill, has been called the *Muhlbrunn*, and appears to have been particularly brought into notice by Hoffman. The temperature of the latter is only 114°, and it differs from the former, in containing more carbonic acid, more ſoda, and leſs calcareous earth. This occasions ſomewhat different effects on the body, which will be preſently mentioned.

The general reſult of the analyſis of theſe waters therefore is, that they are all conſiderably complex in their chemical nature, and contain ſeveral of the more active of thoſe principles which appear to give medical powers to any natural water. They are all more or leſs thermal, and poſſeſs a heat ſeveral degrees higher than the animal temperature. They are all acidulated with carbonic acid, but at the ſame time contain a very notable portion of ſoda and calcareous earth: they beſides hold in ſolution a ſenſible quantity of Glauber's ſalt. With regard to that of the iron, it is probable very minute, and not more than is contained in Bath water, as the circumſtances of precipitation with galls appear to be very ſimilar in each; but from the greater degree of temperature, the Caroline water will probably make a ſtronger chalybeate impreſſion on the taſte than even that of Bath.

From a review of the compoſition of the Caroline water, compared with that of other medicinal ſprings, we might expect it to produce powerful and various effects upon the body, when taken internally, and this is actually the caſe, as appears from the beſt authorities. (*a*) Its moſt obvious operation is that of exciting the action of the bowels, which it does in almoſt all caſes when a conſiderable doſe is taken, and it proves a purgative of great ſtrength, and very ſpeedy in its action. The more tepid and leſs earthy ſpring, the *Muhlbrunn*, is found to open the bowels with

(*a*) Hoffman, Berger, &c.

more certainty than the other; for the *Prudel* is ſomewhat various in its effects, a circumſtance which probably depends on the ſtate of the ſtomach that receives it, and on the quality which the contents of this organ may have to neutralize the calcareous earth and alkali of the water. Not unfrequently, when the ſtomach is very foul, the water excites vomiting when firſt taken. As a cathartic, the Caroline waters operate without ruffling, and leave the body cooler, and the appetite and digeſtive powers ſtronger.

The ſecretions of urine, perſpiration, and ſaliva, are likewiſe increaſed by this natural medicine, both when taken often in ſmall doſes, and even accompanying, or ſubſequent to the operation on the bowels. Whilſt this water is exerting its action on all the ſecretions, it ſhews the properties of a general ſtimulant, for it increaſes the pulſe, the heat of the body, and occaſionally brings on a headach, in plethoric and irritable habits. It is alſo remarked, that, with ſeveral perſons, after drinking the water copiouſly, many parts of the body, and eſpecially the feet, ſwell conſiderably; but this cellular effuſion ſoon diſappears after uſing the bath for a day or two. Beſides theſe ſymptoms, the common effects of determination to the head, very frequently occur, ſuch as headach, vertigo, and drowſineſs, particularly on the uſe of the hotteſt of theſe waters. Sometimes, in habits in which the ſecretions are irregular, and the ſkin irritable, a courſe of theſe waters will bring on a copious cutaneous eruption, which gradually ſubſides by a farther continuance in this natural medicine.

The diſeaſes, to the cure of which theſe celebrated thermal ſprings are applicable, are as various as the nature of their foreign contents; and from the union of ſeveral valuable qualities in one water, it may be made uſe of in caſes of very oppoſite natures, without incurring the cenſure of employing it indiſcriminately as an univerſal medicine. In common with the other purgative chalybeates, it is found to be eminently ſerviceable in dyſpepſia, and other derangements of the healthy action of the ſtomach; in obſtructions of the abdominal viſcera, not connected with great organic diſeaſe; and in defect or depravation of the biliary ſecretion; and here probably the ſoda will contribute much to the general efficacy. In thoſe diſorders of the kidnies and bladder, that are attended with a diſcharge of ſabulous concretions, and a tendency to calculus, the Carlſbad waters have long been celebrated; and their operation, like that of the other alkaline waters, is that of increaſing the flow of urine, and at the ſame time rendering it leſs painful, and giving an eaſier paſſage to the extraneous matter, which, when detained, is productive of ſo much miſchief. Owing to the activity of the chalybeate ingredient, and at the ſame time the power which this mineral ſpring poſſeſſes, of giving a ſenſible increaſe to all the ſecretions, without inducing debility, it is highly eſteemed for reſtoring a healthy ſtate to the uterine ſyſtem in females, and thereby removing ſterility. In ſhort, we may aſcribe to this thermal water the virtues that reſide in ſeveral of the mineral ſprings which we have already noticed; and its high temperature and abundant quantity, render it admirably adapted for warm bathing at any degree of heat. The ſame precautions againſt its internal uſe in plethoric and irritable habits, in thoſe who are ſubject to hemoptyſis, or liable to apoplexy, require to be obſerved here as with any of the other active thermal waters; and as its power of producing ſerious miſchief, when miſapplied, cannot be doubted, its efficacy in removing various diſeaſes, and relieving many diſtreſſing ſymptoms, is equally eſtabliſhed by long experience.

HARTFELL WATER.

The only ſpecies of chalybeate waters which remains to be mentioned, is that in which the iron is held in union with a fixed acid, and this is always the ſulphuric, in the very few of this claſs that are uſed medicinally; ſo that we are only acquainted with two ſolutions of this metal in the natural medicated waters; of which that in the carbonic acid is extremely common, and found in a great variety of combinations; that in the vitriolic acid is very rare. Among the few *vitriolated chalybeate waters* in this kingdom, that at Hartfell, near Moffat, may be ſelected as a good example.

The Hartfell chalybeate water ariſes from the baſe of a very high mountain of the ſame name, about five miles from Moffat. (*a*) The Hartfell rock contains a great abundance of iron pyrites, aluminous ſchiſtus, and argillaceous ſtone mixed with iron in different ſtates; and it is from the decompoſition of theſe materials that the ſpring becomes impregnated

(*a*) See Dr. Garnet's "Obſervations on Moffat and its Mineral Waters.—1800."

with the foreign contents, to which it owes its medicinal properties.

The water, when taken from the well, appears perfectly clear, but it gradually depofits a quantity of oxyd of iron, even when clofely corked; it ftill however retains at all times a large portion of this metal in folution. It has a ftrong aftringent and inky tafte.

With re-agents it fhews the following appearances:

Tincture of galls produces a very deep purple colour, nearly as dark as that of common ink; and this change of colour is as deep after the water has been boiled, as before, in which refpect this water differs in a ftriking manner from the common carbonated chalybeates.

Tincture of litmus is in a flight degree reddened.

Muriated barytes produces a copious white precipitation.

Lime water gives a white precipitate of aluminous earth

By boiling this water, and evaporating it gradually, a fmall quantity of gas arifes, which is not more than five cubic inches in the gallon; and at the ſame time ſome oxyd of iron is depoſited; after which the liquor remains clear, till further evaporated nearly to dryneſs.

The ſaline matter that remains is a mixture of alum and vitriolated iron.

A wine gallon of the Hartfell water, according to Dr. Garnett's analyſis, contains

		grains.
Of ſulphat of iron	- -	84
— ſulphat of alumine		12
— oxyd of iron	- -	15
		111

Total, 1 dram and a half, and 21 grains of foreign contents, of which by far the greater part is ſulphat of iron, with exceſs of metallic oxyd.

The analyſis of this water ſhews that it is very ſimple in its compoſition, poſſeſſing only two ſalts, both of which however have conſiderable power upon the human body. Contrary to the greater number of mineral waters, this ſpring is always the ſtrongeſt after heavy rains, indicating that the foreign contents are added, by being waſhed down through the ſtrata of the mountain, and not ariſing from any confiderable depth below the level of the water. All the vitriolated chalybeate waters contain alum, which is produced from the decompofition of the aluminous fulphuret, at the fame time, and in the fame manner, in which the fulphat of iron is generated. It is owing to the alum, that the water fhews, by the teft of litmus, the marks of fome uncombined acid.

The Hartfell water, if preferved in clofe bottles, will keep for a long time unimpaired in its properties, except by the depofition of the excefs of oxyd of iron, and from this depofition, the chalybeate and aftringent tafte of the falts that remain, become even more fenfible. As, however, there then appears to be nothing remarkable in the chemical compofition of this water, it is probably one that may at all times be imitated with great eafe by any artificial folution of thefe two ingredients.

This chalybeate fpring appears to be one that poffeffes no inconfiderable fhare of medicinal virtue in the cure of feveral very important and dangerous difeafes; and the daily experience of medical men, in the ufe of ſimilar preparations, confirms the opinion of the advantage to be derived from this natural medicine. The firſt effects of this water (*a*) are ſometimes giddineſs and ſickneſs, eſpecially where a larger doſe has been taken than the ſtomach can well bear. Its operation on the bowels is uncertain: it ſometimes produces gripes, and, on firſt uſing it a diarrhœa not unfrequently follows; but this is not the general conſequence, for it much oftener occaſions coſtiveneſs, and this may be ſaid to be its more natural and conſtant effect.

This water, as Dr. Horſeburgh obſerves, has been found of great ſervice in diſorders of the ſtomach and bowels, bloody flux, bloody urine, immoderate flow of the menſes, or their ſuppreſſion, fluor albus, gleet, &c. Indeed it may in general be ſaid to promiſe advantage in all caſes where there is relaxation of the ſolids, and any diſeaſe connected with general debility. The frequent uſe which practitioners of the preſent time make of chalybeate medicines in general, and the vitriolated

(*a*) See a very ſenſible and judicious paper on this ſubject by Dr. Horſeburgh, in the firſt vol. of the "Edinburgh Phyſical and Literary Obſervations."

iron in particular, in ſeveral ſtates of pulmonary conſumption, has removed much of the apprehenſion which was formerly entertained of the heating powers of the preparations of ſteel, and has enabled phyſicians to lay down with more accuracy, and confine within narrow limits, thoſe ſymptoms in which alone this metal is prejudicial. Under ſuch precautions, the Hartfell water will be found to be a very valuable medicine for theſe diſtreſſing and dangerous diſorders, and experience has confirmed its uſe.

As an external application in old and languid ulcers, where the texture of the diſeaſed parts is very lax, and the diſcharge profuſe and ill conditioned, much benefit has been derived from this vitriolated chalybeate, employed both internally as a medicine, and as an external application.

The doſe of this water is more limited than that of moſt of the mineral ſprings which are uſed medicinally. It is of importance in all caſes, and eſpecially in delicate and irritable habits, to begin with a very ſmall quantity, for an over-doſe is apt to be very ſoon rejected by the ſtomach, or to occaſion griping and diſturbance in the inteſtinal canal; and it is never as a direct purgative that this water is intended to be employed. Few patients will bear more than an Engliſh pint in the courſe of the day, but this quantity may be long continued in. It is often adviſeable to warm the water for delicate ſtomachs, and this may be done without occaſioning any very material change in its properties. The great variation in the ſtrength of this aluminous chalybeate, according to the quantity of rain that falls, muſt however cauſe ſome difficulty in proportioning the doſe to the particular diſorder, a circumſtance which is certainly productive of ſome inconvenience, though in very many caſes it is much leſs than might be imagined by the practitioner who is only converſant with the accuracy of pharmaceutical preparations.

A CHEMICAL ACCOUNT OF THE CHALYBEATE SPRING, NEAR BRIGHTON. *

"THE Chalybeate Spring, near Brighton, commonly called *The Wick*, has long been noticed as a ferruginous water. But as far as I can learn, no regular account of its chemical or medicinal properties has ever been published. The only public notice which I can trace refpecting this fpring, previous to the mention which Dr. Saunders has made of it in his work on Mineral Waters, is contained in the *Brighton Guide*, where a very curfory and imperfect account of the moft obvious properties of this water is given, firft, on the authority of Dr. Relhan, whofe obfervations are ftated to have been made a confiderable time fince, and afterwards on that of Dr. Henderfon, of Brighton. But thefe accounts, in the prefent ftate of chemiftry, can fcarcely

* This communication from Dr. MARCET, not being intended to be publifhed in any other form, would be rendered very imperfect by giving only an abftract of it, as I have done upon moft other occafions. I have therefore, with the confent of the author, printed the whole of his paper; and this I have thought the more proper, as the inquiry was undertaken at my requeft, and as I had already introduced the fubject in the former edition of this work.

be of any other ufe, than that of enabling us to obferve, that, in earlier periods, this fpring had not remained unnoticed.

§ I. *Situation of the Spring.*

The fpring iffues from the declivity of a fmall eminence, fituated about the diftance of half a mile to the weftward of Brighton, and a quarter of a mile from the fea. The afcent from the fea fhore to the fpring, is very gentle and inconfiderable; but the eminence from which it iffues, is commanded on every other fide, by a fucceffion of fmall hills, which gradually rife round it.

The hill which extends immediately to the weftward of Brighton, and over which the Horfham road paffes, confifts chiefly of lime-ftone. Extenfive lime pits are opened on the borders of this hill, and the foil for fome diftance continues calcareous. But on approaching towards the chalybeate fpring, the foil gradually becomes argillaceous, and the particular fpot on which it is fituated, appears to confift almoft intirely of clay. Befides clay, however, it was found, in clearing away the rubbifh, to form the refervoir that the ſoil in that ſpot, was intermixed with veins of a black oily combuſtible ſubſtance, ſome ſpecimens of which I have ſeen, which evidently contained a quantity of coaly and pyritic matter. * In the immediate vicinity of the ſpring, ſome fir trees and ſhrubs have been planted, which ſeem to thrive ; but except the turf, and ſome ſcanty heath, no ſpontaneous vegetation is to be ſeen for a conſiderable diſtance. On the top of the eminence, and at a very little diſtance from the well, there is a pretty large pond, apparently ſupplied by a ſpring, but which has no particular taſte or other ſtriking properties.

For the accommodation of thoſe who drink the water, a ſmall neat building has been erected immediately over the ſpot from which the ſpring iſſues, where the water is received a few feet under ground, into a baſon of Portland ſtone. This reſervoir contains only a few gallons of water, but it fills again as ſoon

* For theſe ſpecimens I was indebted to Dr. Tierney, of Brighton. Mr. Tennant, to whom I ſhewed them, told me, that he had repeatedly found on the ſea ſhore, at Brighton, ſimilar fragments of coaly pyritic matter ; a circumſtance which he thought then rather ſingular, but which ſeems now to be accounted for.

as it is emptied, and is prevented from overflowing by a drain, which conveys its superfluous contents into a contiguous pond. This bafon, I obferved, has its internal furface deeply corroded by the water, and its bottom is covered with a thick yellowifh fediment, which fhews itfelf abundantly wherever the water is allowed to ftagnate, and particularly in the fmall crevices formed by the decayed brick-work which furrounds the well.

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§ II. *External qualities of the water.*

(A)—On firft infpecting the bafon, early in the morning, and before the water had been ftirred, its furface is commonly found covered, fometimes entirely, fometimes only partially, with a very thin, iridefcent pellicle; and befides this, when the water has not been difturbed for fome hours, there is alfo often a kind of yellowifh fcum, floating in irregular patches on its furface. The fpring is at all feafons very plentiful, and does not appear to vary fenfibly in its qualities. Yet after heavy rains the water is fometimes flightly turbid.

The temperature of the well, was found to be at 54°, when the thermometer ſtood in the air at 68°. I have been told by people who live on the ſpot, that the ſpring has never been known to freeze.

(B)—The water, after the ſmall quantity of ſcum juſt mentioned has been removed, is quite clear and tranſparent, and no gas is ſeen to eſcape from it, although, if poured high from one veſſel into another, there is a ſort of ſparkling appearance, which, I believe, would be found to be common to all waters, and ought not to be miſtaken for a diſengagement of air bubbles.

(C)—The Wick water, when quite freſh, has a peculiar faint ſmell, not uncommon in ferruginous waters, and a ſtrong, though not unpleaſant, chalybeate taſte. Its ſpecific gravity is 1001.08.* It inſtantly curdles ſoap. Some of the water which had been

* The ſpecific gravity was taken twice with ſufficient care and accuracy, and with ſimilar reſults. But in both caſes the water was three or four days old, before I could have an opportunity of aſcertaining its denſity.

allowed to ſtand a whole night in a glaſs tumbler by the ſide of the well, with ſome of the ſcum above deſcribed floating on its ſurface, was found the next morning ſtill perfectly clear; but the greateſt part of the ſcum had precipitated to the bottom of the glaſs, in the form of a yellowiſh ochry ſediment, in which I could only perceive a kind of faint earthy taſte.

(D)—Having taken to my lodgings, in a glaſs bottle, a gallon of this water, free from any ſcum or ſediment, it continued perfectly clear the next day, and exhibited no appearance of precipitation or any change whatever, except perhaps that the peculiar ſmell, which, I have mentioned, was leſs perceptible. On the third day, ſome ſmall air bubbles appeared on the ſurface of the water, but I could perceive no other change. The day after however, on removing the ſtopper, I remarked a ſlight hiſſing noiſe, as if a quantity of air was making its eſcape. The bottle had been kept well ſtopped, but as it was not full, a quantity of atmoſpheric air had remained in contact with the water. At the expiration of five or six days, the water was found somewhat turbid, and small yellowish particles were seen floating in it. It had lost entirely its peculiar smell, and the chalybeate inky taste was less conspicuous. After a few weeks, a considerable yellow sediment had subsided, the water had become more turbid, and the chalybeate taste was farther diminished. Some of the same water, which had been carefully corked up in a transparent glass vessel (no air being left in contact with it, and the vessel remaining at complete rest), preserved its transparency much longer. Yet after a few weeks, this water also was found to have deposited a yellow substance all over the inside of the vessel. But the water itself, on being poured out, after standing for near two months, and when the chalybeate taste was considerably diminished, appeared quite clear, leaving behind the yellow sediment, which adhered strongly to the sides of the bottle.

§ III. *General effects produced on the water by chemical tefts.*

Having now ftated the fpontaneous changes which this water undergoes, and its moft obvious external properties, I proceed to relate the general refults obtained by the application of tefts, or chemical re-agents.

Experiment I.—Some of the water, juft brought from the well, being heated in an open veffel, and kept boiling for a few minutes, no precipitation took place, and no other obvious change was produced in the water, except a flight diminution of its tranfparency.

Exper. II.—The fame experiment being repeated in a tubulated receiver, the neck of which was immerfed in mercury, in order to prevent the accefs of air, the water, after undergoing ebullition for a few minutes, appeared as tranfparent as before.

Exper. III.—A fmall quantity of the water being quickly reduced by boiling to about one-third of its volume, continued free from precipitate, although its tranſparency appeared ſlightly impaired. On attempting to puſh the concentration farther, a yellowiſh ſubſtance began to collect at the bottom of the veſſel.

Exper. IV.—Some of the water being ſlowly heated in an open veſſel, and kept for about an hour over a lamp, without being ever allowed to boil, a yellow precipitate began to take place, before the water had undergone any ſenſible concentration.

Exper. V.—The foregoing experiments being repeated on water that had been kept for ſome time, the ſeparation of yellow matter took place more quickly; and in general, there appeared to be ſome kind of proportion, between the readineſs with which the heated water yielded this precipitate, and the time which had elapſed after it was taken from the well.

Exper. VI.—Water, quite freſh from the well, altered paper ſtained with litmus, to a reddiſh purple colour.

Exper. VII.—The ſame water, after being boiled, altered litmus exactly in the ſame manner; and the change of colour ſeemed even to take place ſomewhat more readily in the boiled than in the unboiled water.

Exper. VIII.—Paper ſtained with turmeric had not its colour any way altered by the water, whether previouſly boiled or not.

Exper. IX.—Paper ſtained with the red infuſion of Brazil wood, being moiſtened with the water, turned to a dark brown colour, with a faint purpliſh hue; and this effect took place, whether the water had been previouſly boiled or not.

Exper. X.—Pruſſiat of potaſh inſtantly produced a blue cloudineſs, and after the ſeparation of the yellow particles mentioned in Exper. 3, 4, and 5, whether by boiling, or by keeping, ſtill the clear water continued to ſtrike blue with pruſſiat of potaſh, though evidently in a fainter way than before this operation.

Exper. XI.—Tincture of galls being dropped into the water juſt brought from the well, produced, at firſt, neither cloud, nor change of colour. But on being allowed to ſtand, the mixture gradually became cloudy, and the next day it was found quite black and turbid.

Exper. XII. — Tincture of galls being mixed with ſome of the water, which had been kept for a week or two, the black precipitat took place immediately.

Exper. XIII.—The ſulphuric, nitric, and muriatic acids, produced no effervefcence, precipitation, or hepatic ſmell whatever. But on the contrary, if the water had begun to undergo the ſpontaneous precipitation before mentioned, any of theſe acids reſtored its pellucidity inſtantly.

Exper. XIV.—Oxalic acid produced no immediate precipitate; but a cloud appeared in the water after ſtanding for ſome time.

Exper. XV.—Both oxalat of ammonia and oxalat of potaſh, produced an immediate white precipitate.

Exper. XVI.—Cauſtic alkalis occaſioned a precipitation of yellowiſh flakes, and the ſame effect took place in water which had been boiled. Lime water produced ſimilar effects.

Exper. XVII. — Barytic water inſtantly produced a copious white precipitate, whether the water had been boiled or not; and this precipitate was not rediſſolved by adding muriatic acid.

Exper. XVIII.—Both muriat and nitrat of barytes, threw down a copious white precipitate.

Exper. XIX.—Nitrat of ſilver produced a whey-coloured cloud, which, on ſtanding, ſubſided, and paſſed to a grey colour.

Exper. XX.—Having previouſly added a few drops of nitric acid, and of nitrat of barytes, till no further precipitation took place, ſtill the water gave a copious precipitation with nitrat of ſilver.

Exper. XXI.—Nitrat of mercury occaſioned a white precipitate, which continued white after ſtanding for ſome days.

Exper. XXII.—Nitrat of ſtrontites produced no precipitate at firſt; but after ſtanding for a day or two, a kind of white incruſtation was formed on the ſides of the glaſs.

Exper. XXIII.—Acetite of lead only produced at firſt a ſlight cloudineſs; but after ſtanding for a day or two, a pretty purpliſh powder ſubſided.

§ IV. *Inferences drawn from the preceding experiments.*

From the preceding experiments ſome inferences preſented themſelves, reſpecting the particular ingredients contained in this mineral water, which prepared the way for a more minute inveſtigation. It was ſoon perceived, that in ſeveral of the above experiments, uſeleſs redundancies had occurred; and if I have not ſuppreſſed them here, it is becauſe I wiſhed to relate faithfully the gradual progreſs of this inquiry, and the various methods which I have ufed in profecuting it.

1ft, From experiment 1, 2, and 3, it appeared obvious, that no part of the folid ingredients of this water, was kept in folution by means of a gafeous acid; fince boiling, even to a confiderable extent, did not produce any precipitation.

2dly, From experiments 2, 3, 4, 5, it was inferred, that the accefs of air promoted in this water, the precipitation of fome metallic fubftance.

3dly, From experiment 6, it was fufpected that the water was flightly acid; but, from experiment 7, it appeared evident that this circumftance did not depend upon the prefence of an aerial acid.

4thly, It was inferred from experiment 8, that neither pure nor carbonated alkali, nor pure earth were prefent in the water. From experiment 9, a fmall quantity of carbonated earth might have been fufpected, but fuch an inference being incompatible with experiment 13, the flight change of colour alluded to, in the infufion of turmeric, was fuppofed to depend on fome other caufe.

5thly, The preſence of iron was clearly indicated by experiment 10; and it was conjectured from experiment 12, that the ſlowneſs with which tincture of galls had produced its effect in experiment 11, was owing to a want of ſufficient oxygenation. The circumſtance of a quantity of oxyd of iron being precipitated from the water by a gentle heat (exper. 4), whilſt on the contrary, no precipitation took place (exper. 3), when the water was boiled briſkly, could only be accounted for by the action of the atmoſphere, which, in the firſt inſtance, oxygenated the iron, whilſt in the latter, its acceſs was prevented by the rapid emiſſion of ſteam.

6thly, Both experiments 14 and 15, but more eſpecially the latter, indicated the preſence of lime; but from ſome of the reſults above mentioned, it was obvious, that the lime, in this inſtance, was combined with a mineral acid.

7thly, The experiment 16, confirmed the former concluſions with regard to the exiſtence of iron in the water; but did not afford ſatisfactory information as to the exiſtence of earths, as theſe might eaſily be confounded with the oxyd of iron.

8thly, The experiments 17 and 18, indicated the prefence of fulphuric acid, and it became probable that the alteration of litmus, obferved in experiment 8, depended either upon this acid, in a feparate ftate, or upon fome of its compounds, which have the fame property with regard to blue vegetable colours.

9thly, From experiments 19 and 20, it appeared extremely probable, that the water contained muriatic acid.

10thly, From the colour of the precipitate obtained in experiment 21; from the effect of the mineral acids (experiment 13); and the total abfence of hepatic fmell, it appeared fufficiently obvious, that the water was free from hepatic gas, or hepatic compounds.

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§ V. *Plan of Analyfis.*

On collecting the information derived from thefe general refults, it appeared that the only fubftances which I could pofitively expect to find in the water, by a more particular inveftigation, were iron, combined with the fulphuric, or perhaps with the muriatic acid, and lime, in the ſtate of ſelenite, or poſſibly in that of muriat. I ſuſpected the preſence of alum, Epſom, and common ſalt; but this I did from conjecture alone, and upon no other grounds, than a compariſon of this water with other mineral ſprings of an analogous compoſition. With regard to the gaſeous contents, the only ſubſtances of this claſs, which I could reaſonably expect to find, were atmoſpheric air, and carbonic acid gas; but neither the one nor the other had yet been poſitively ſhewn, and on the contrary, ſome circumſtances had occurred, which rendered the preſence of the latter rather improbable.

Theſe general notions however, enabled me to form the following plan of analyſis:

1ſt, To examine the *gaſeous contents* of the water.

2dly, To obtain by evaporation, the *fixed ingredients* of the water in a ſolid form, as a previous ſtep to their chemical examination. For the ſtate of great dilution in which theſe ingredients appeared to exiſt in the water, and the great tendency ſhewn by ſome of them to be precipitated by concentration, would have made it exceedingly inexpedient to operate on the water itſelf.

3dly, To rediſſolve a known quantity of the reſidue obtained by this evaporation, and precipitate the iron from it, by pruſſiat of potaſh.

4thly, To ſeparate the lime from the ſame ſolution by oxalat of ammonia.

5thly, To add cauſtic potaſh to the ſame ſolution, with a view to precipitate both the *magneſia* and *alumine*, if theſe earths ſhould exiſt in the water.

6thly, To boil this laſt precipitate, if any was obtained, in pure potaſh, in order to diſſolve the alumine, and thus obtain the *magneſia* in its ſeparate ſtate.

7thly, In caſe the potaſh ſhould appear to have taken up any *alumine*, to precipitate the latter by boiling the alkaline ſolution with muriat of ammonia.

8thly, To diſſolve another portion of the reſidue in nitric acid, and to add nitrat of barytes, with a view to aſcertain the quantity of *ſulphuric acid*.

9thly, To add nitrat of ſilver to the ſame ſolution, in order to precipitate the *muriatic acid.*

10thly, Laſtly, to try, by the agency of alcohol, which has the power of diſſolving certain ſalts, and of precipitating others; and by ſlow evaporation and cryſtallization, whether ſome light might not be thrown on other parts of the analyſis, and other ſubſtances diſcovered, which were not unlikely to exiſt in the water, but might have eſcaped notice, had the former method been excluſively employed.

§ VI. *Examination of the gaſeous contents.*

Exper. I.—A quantity of the water juſt brought from the well, and meaſuring exactly $5\frac{1}{4}$ cubic inches, was put into a phial, or ſmall receiver, the neck of which terminated in a bent tube, which had its extremity immerſed in a mercurial bath. The phial was not quite filled with the water, but the quantity of atmoſpheric air, contained both in the tube and the upper part of the phial, was accurately ascertained. The heat of a lamp being now applied, an elastic fluid soon began to come over, which was collected in a graduated jar. After allowing the water to boil for about a quarter of an hour, no more gas was given out; and as the water itself was now beginning to boil over, the process was stopped, and the result examined. For this purpose, the quantity of air collected in the jar, was carefully noted, and a solution of caustic alkali being introduced into it, a quantity of gas equal to $\frac{4}{10}$ths of an inch, was immediately absorbed, which, of course, was carbonic acid.

Exper. II.—With regard to the portion of air left in the jar unabsorbed, it was found, (every allowance being made for pressure and temperature), that its bulk was perfectly similar to that of the air contained in the apparatus: and this air being examined by the nitrous test, gave precisely the same result as atmospheric air. These two experiments were tried a second time with results exactly similar.

EXPER. III.—Some of the water which had been ſent from Brighton to London, and kept for five days, being tried in the ſame manner, yielded only the $\frac{17}{100}$th part of an inch, which is a little leſs than half the quantity obtained in the former experiment.

From theſe experiments it may be inferred that, the Brighton chalybeate yields, when recently taken from the ſpring, about $\frac{1}{15}$th part of its bulk of carbonic acid gas, and that it does not appear to contain any other elaſtic fluid. From the readineſs with which this gas is given out; from the obvious diminution which it ſuffers by keeping; and from other circumſtances of the analyſis, it appears extremely probable that the gas exiſts in the water free from any combination.

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§ VII. *Evaporation of the water.*

(A)—In order to prevent ſuch chemical changes as are liable to happen in operations of this kind, from too great a heat being applied, I was deſirous of carrying on this evaporation on a pretty large maſs of water at a very gentle heat. I had brought no apparatus with me for that purpofe, but Mr. Glafyer, a very intelligent and well-informed chemift and druggift, of Brighton, obligingly offered his affiftance for this tedious operation. A whole gallon of water was carefully evaporated over a water bath, and the refidue, which appeared in the form of a greenifh mafs, was allowed to dry at the fame temperature. This refidue weighed exactly 65 grains, which makes for each pint $8\frac{1}{8}$th of folid contents, dried at 212°. This refiduary matter foon gave figns of deliquefcence, and increafed in weight by expofure to the atmofphere.

(B)—After this firft trial, having often had occafion, in London, during the courfe of this analyfis, to evaporate new quantities of water, which were fent to me from Brighton, I found it much eafier and more expeditious to begin by concentrating the water brifkly to a fmall compafs, over an Argand's lamp, in a Florence flafk, and then to finifh the deficcation of the refidue over a water bath, at any defired temperature. The heat which I have generally ufed for thefe deficcations is that of 160°, and I have uniformly found that the Brighton chalybeate, whether it was taken from the well in dry or rainy weather, in fummer or winter, conftantly yielded *eight grains and a half* of folid refidue, dried at 160°, for each pint of the water, and the accidental deviations from this proportion, which have occafionally occurred, have never exceeded a quarter of a grain.

(C)—The procefs being carried on in the manner juft related, the whole mafs of folid matter prefented itfelf in the form of a greenifh incruftation, thick at the bottom, and gradually thinner towards the edges. But on clofer examination, a quantity of yellow powder, (which afterwards proved to confift chiefly of iron), appeared collected in the centre, and there was feen alfo a kind of fnow-like fubftance flightly fpread over the whole furface. Viewed through a magnifying glafs, the whole mafs offered the appearance of a confufed cryftallization; and foon afterwards figns of deliquefcence manifefted themfelves by the appearance of fmall drops of water on different parts of the furface. Thefe various appearances deferved the more notice, as they pointed out the neceffity, before proceeding any farther, of rendering the refidue homogeneous, by careful mixture and trituration, in order to obtain correfponding refults from different portions of the fame refidue.

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§ VIII. *On the modes of filtration and deficcation adopted in this analyfis.*

This part of chemical manipulation is of fuch material importance in an inquiry of this kind, and is fo intimately connected with the refults, that although I wifh to avoid enlarging upon practical details, yet I can hardly proceed farther, without giving once for all, a few explanations which the fubject feems to require.

As the difficulty of getting, in London, large fupplies of the chalybeate, in its recent ftate, made it neceffary to operate upon a fmall fcale, it became the more neceffary to guard againft the various fources of inaccuracy to which chemical manipulations are liable. And as it is principally to the different modes of *filtration* and *deficcation*, that the ftriking difcordances which frequently occur amongft experiments, in other refpects fimilarly conducted, are to be afcribed, it is only on this part of the fubject that I fhall offer a few obfervations.

(A)—With regard to filtrations, I have, after many comparative trials, adopted the following method. Two round pieces of filtering paper, of between three and four inches in diameter, and exactly fimilar in weight, are cut from the fame fheet, and applied the one over the other, in order to filter the folution through both. The refidue is then, after due deficcation, weighed, by putting the paper containing it in one fide of the balance, and the plain piece of paper, fimilarly dried, in the other. The difference gives the weight defired. In fome cafes it may be expedient to feparate the refidue, in order to weigh it by itfelf; but in general the former method is lefs liable to error. A little tedioufnefs in this mode of proceeding no doubt arifes from filtering through a double paper; but it is fometimes the only way of avoiding differences, which, however trifling, will, in a complicated analyſis, ariſe from the wetted paper remaining impregnated with various ſoluble ingredients, after the moiſture has been evaporated from it. I attempted alſo to uſe Dr. Black's ingenious method,* which conſiſts in anointing every part of the filter with wax, except a ſmall ſpot in the centre, into which the whole of the reſidue ſubſides. But this mode, owing to a variety of little inconveniences, did not appear to me to anſwer the purpoſe ſo well as the method juſt deſcribed.

(B)—With regard to deſiccations, I have uſed an apparatus, which I ſaw firſt in nurſeries, applied to the purpoſe of keeping the food of children of an uniform temperature, and which, with ſome trifling improvements, I have found extremely well adapted to chemical purpoſes. It conſiſts ſimply in a tin pan, about four inches in diameter, and three in depth, in which is placed another ſimilar veſſel, which fits the former pretty exactly,

* See the Analyſis of ſome mineral ſprings in Iceland, in the 3d Volume of the Tranſactions of the Royal Society of Edinburgh.

except that it is about half an inch ſhallower, ſo as to form a ſmall ſpace between the two. This ſpace is filled with water, and the ſubſtance to be dried being placed in the upper or ſmaller pan, the heat of a lamp is applied; and in order to prevent oſcillations in the flame, as well as to keep the pans ſuſpended over it, the lamp is incloſed in a cylindrical tin caſe, in the ſides of which there are apertures to anſwer the purpoſe of chimnies.

In placing in the apparatus, the ſubſtance to be dried, care muſt be taken, in order to prevent inaccuracies of temperature, to inſulate that ſubſtance from the apparatus itſelf. For being made of tin,* which is a good conductor of heat, the bottom and ſides of the veſſel are much more quickly heated, than the air or internal ſpace of the apparatus in which the thermometer is immerſed. This is eaſily done by placing the ſubſtance in a thin glaſs capſule, and laying this on a ſmall ſtand conſiſting of three legs of glaſs or fine wire, fixed on a flat piece of cork. Things being thus diſpoſed, and a thermometer being ſuſpended immediately

* Or *tinned iron*, as it might more properly be called.

over the capſule, a pretty accurate notion of the temperature to which the ſubſtance is expoſed, will be obtained; and this indication will be ſtill more correct, if the apparatus be covered: but this can only be done towards the end of the proceſs, when moſt of the moiſture is already volatilized.

(C)—I have only further to obſerve that the temperature which I have generally uſed in deſiccations, is that of 160°; and whenever a different degree of heat has been uſed, it has been expreſsly mentioned. It muſt be confeſſed however, that as it is only by the trimming of the lamp, that the temperature can be regulated, or by putting on, or taking off the cover, occaſional deviations of five or even ten degrees, are ſcarcely avoidable. The heat, in this apparatus, can ſcarcely be raiſed above 180°. It is in every inſtance to be underſtood, that the ſubſtance has been left expoſed to the ſtated degree of heat, until it has reached its maximum of dryneſs, under that temperature, which will ſometimes take ſeveral hours.

§ IX. *Rediſſolution of the ſolid ingredients of the water.*

Ten grains of reſidue, obtained in the manner deſcribed § VII. 2, being boiled with diſtilled water, the fluid became muddy, and a conſiderable portion of the reſidue remained undiſſolved. A few drops of muriatic acid being then added, and heat applied, the whole was immediately diſſolved, with the exception of a ſmall quantity of ſediment, which, on boiling briſkly, ſeemed for a moment to diſperſe, but ſoon reappeared and ſubſided in the form of a whitiſh powder. I tried to rediſſolve this ſubſtance by means of concentrated acids, and by long boiling and digeſting, but in vain. I therefore began to ſuſpect that the water contained ſome ſiliceous earth, an uncommon occurrence, which, till then, no circumſtance had led me to ſuſpect.

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§ X. *Silica.*

(A)—This inſoluble ſubſtance, after being repeatedly waſhed with diſtilled water, and heated to rednefs in a fmall platina crucible, weighed $\frac{1}{6}$th of a grain. This being mixed with a minute portion of alkali, and tried with the blow pipe, readily melted into a tranfparent glafs. The experiment being repeated with a different portion of the fame refidue, a fimilar refult was obtained; only the quantity of filica yielded in the latter inftance, was $\frac{1}{5}$th inftead of $\frac{1}{6}$th of a grain, a fmall difference, which gives an average of $\frac{1}{6}\frac{1}{0}$ths of a grain of ignited filica, for 10 grains of the folid refidue; or a quantity correfponding to 17 parts of filica for 1000 of the folid ingredients of the water, dried at 160°.*

(B)—Some fufpicion having arifen that the filiceous matter might have been yielded by the glafs veffels, and in the proceffes of folution and filtration, in order to afcertain

* I fhall obferve, once for all, that in giving the refults of my experiments, moft of which have been repeated feveral times, I have generally, for the fake of brevity, ftated only one refult. Whenever I have been able to trace any particular fource of error, in any individual experiment, I have repeated it, and have only ftated the refult of that which has clearly appeared to be the moft accurate. But when experiments, conducted exactly in the fame way, have prefented but very flight variations in the refults, I have, in this cafe, given the average.

this point, a quantity of water, was evaporated in a tin veſſel, and the reſidue of this was treated as in a former experiment. But the ſame reſults were obtained, and no difference could be perceived either in the quantity or nature of this inſoluble vitrifiable matter.

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§ XI. *Sulphat of iron.*

Having been led to conclude from the circumſtances before mentioned (§ IV. & V.), that a quantity of iron, moſt probably in the ſtate of ſulphat, was contained in the Brighton chalybeate, my next object was to determine in what proportion this ſalt exiſted in the water.

Exper. I.—Twenty grains of the reſidue* were diſſolved in about four ounces of water, by means of a few drops of muriatic acid, and the ſolution was gently heated, a previous ſtep which I have found effectual in facilitating the precipitation of iron by pruſſi-

* When I ſpeak ſimply of *reſidue*, I always mean the reſidue obtained from the Brighton chalybeate, in the manner deſcribed in § VIII. B.

ated alkali; probably in confequence of its bringing the metal to that ftate of uniform oxygenation which is moft favourable to its union with the pruffic acid. Having then added a folution of pruffiat of potafh, meafuring one cubic inch and a half, (a quantity known by previous trials to be fufficient for the precipitation of the whole iron), the fluid inftantly paffed to a blue colour, and a blue precipitate, darker than the folution, gradually fubfided, leaving the fupernatant fluid tranfparent and nearly colourlefs. After a few hours, the clear fluid was feparated by means of a fyphon, and the remaining muddy fluid, containing the Pruffian blue, was thrown into a filter. This pruffiat of iron, after being carefully dried, at the temperature of 160°, weighed exactly 8 grains. I repeated this experiment three times, without any fenfible variation in the refult.

Before I could draw any pofitive conclufion from the laft experiment, with regard to the real quantity of fulphat of iron, it remained to be determined by comparative trials, what quantity of pruffiat of iron my folution of pruffiated potafh, would precipitate from a known quantity of ſulphat of iron. This led me to various inquiries reſpecting the agency of the pruſſic teſt, which are too much connected with the ſubject to be paſſed over in ſilence.

Exper. II.—Ten grains of green ſulphat of iron, recently prepared and regularly cryſtallized, were diſſolved in water, and after adding a few drops of muriatic acid, the ſolution was gently heated, in order to render this experiment perfectly parallel to the former. One cubic inch and a half of the above mentioned ſolution of pruſſiat of potaſh, being then added, a quantity of Pruſſian blue was inſtantly precipitated, which dried at 160°, weighed 11.3 grains. I was thus enabled to deduce the real proportion of ſulphate of iron in the Brighton chalybeate, from this formula, 11.3: 10=8: 7.079. Therefore 20 grains of the reſidue, dried at 160°, contain according to this eſtimate, a quantity of ſulphat of iron, equal to 7.079 of this ſalt in its cryſtallized ſtate.

Exper. III.—I have hitherto confidered as a ftandard of comparifon fulphat of iron in its *cryftallized ftate*, which is not that in which it actually exifts in the refidue under examination. In order to afcertain what allowance ought to be made for this circumftance, or in other words, how much a given quantity of green fulphat of iron, in its cryftallized ftate, loft in weight by being deficcated, 20 grains of the cryftallized falt, reduced to a powder, were expofed to a heat of 160°, and weighed at different periods of the deficcation. In a quarter of an hour, the 20 grains were reduced to 17. In about half an hour longer, they were reduced to 15; and after an interval of two hours, which feemed to bring the falt to its maximum of deficcation, under that temperature, the 20 grains were reduced to 14; and the falt, in this ftate, was changed to a whitifh powder.

Exper. IV.—The fame experiment being repeated, with this difference, that the 20 grains of cryftallized fulphat were previoufly diffolved in water, and then evaporated to drynefs at the fame temperature of 160°, the 20 grains were reduced to 12, which is 2 grains lefs than in the preceding experiment.

Taking the laft of thefe experiments (which feems the moft applicable to the prefent cafe) as a ftandard of reduction, it will be found that 20 grains of the refidue contain in fact only 4.24 grains of *dried* fulphat of iron, a quantity correfponding to the 7.079 grains of *cryftallized* fulphat, which were deduced from the former eftimation. It is obvious therefore, that the mode of calculation juft propofed, would be more ftrictly correct; but the ftate of cryftallization being a much more uniform ftandard of the quantity of moifture, than any artificial procefs of deficcation, I fhould, on that account, prefer the former mode of computation.

EXPER. V. — The folution (Exper. 1) from which the iron had been precipitated by pruffiat of potafh, although quite clear at firft, and having only a greenifh caft fcarcely perceptible, was found, after ftanding for a few days, to have depofited another diftinct, though not ponderable quantity of Pruffian blue. Sufpecting from this circumftance, that fome minute portion of iron had efcaped the action of the pruffiated potafh, I heated the folution with a view to complete the precipitation. But inftead of the very fmall additional quantity of precipitate which I expected, the fluid having previoufly paffed to a muddy green, and then to a blue colour, foon depofited another copious blue precipitate, which, after the ufual filtration and deficcation, weighed no lefs than 2.8 grains.

EXPER. VI.—A fufpicion naturally arofe, that this new pruffiat, proceeded, at leaft principally, from the teft itfelf. In order to afcertain this point, one cubic inch and a half of the above mentioned folution of pruffiat of potafh (a quantity equal to that ufed in ex. 1) was boiled, firft by itfelf, which produced no change or precipitation, and afterwards, with the addition of a few drops of muriatic acid,*

* Immediately on adding concentrated muriatic acid to the cold folution of pruffiat of potafh, a denfe white precipitate appeared, which was inftantly rediffolved without any application of heat; but if a confiderable proportion of acid was added, a permanent white precipitate fubfided.

which, in a few minutes, occaſioned a copious blue precipitate, weighing, after the uſual filtration and deſiccation, 2.7 grains. It appears therefore that each cubic inch of the teſt, yielded, on being boiled with muriatic acid, 1.8 grains of pruſſiat of iron; and conſequently, that the additional precipitation of 2.8, in the experiment above mentioned, proceeded (with the exception of only $\frac{1}{10}$th of a grain) from the iron contained in the pruſſiat of potaſh, and not from the ſolution under examination.

As however the quantity of iron thus precipitated from pruſſiat of potaſh, by boiling with muriatic acid, was not the whole of the iron contained in that teſt, I do not entirely depend on the accuracy of the laſt concluſion. For, unleſs the quantities of acid uſed, and the degree of heat applied, be exactly the ſame in both experiments, correſponding reſults cannot be expected. In the preſent inſtance therefore, where theſe circumſtances were not attended to, the coincidence obtained may have been accidental. But it may be remembered, that my eſtimate of the quantity of iron in the chalybeate reſted upon a direct comparative experiment (exper. 2) on artificial ſulphat of iron, the reſult of which was afterwards confirmed by the application of ſuccinat of ammonia (exper. 7 & 8), a teſt totally different from the former. This eſtimate therefore is quite independent of the peculiarities of the pruſſic teſt above mentioned (exper. 5 & 6). But I have thought it right to ſtate them, as they point out the neceſſity, whenever there is an acceſs of acid, of boiling the ſolutions to which the pruſſic teſt has been applied, as a previous ſtep to any other part of the proceſs in which heat may be required; ſince, otherwiſe, a precipitate ariſing from the teſt itſelf, would interfere with the ſubſequent reſults. And it may be alſo obſerved, that, boiling with muriatic acid, provided it be carried to a ſufficient extent, will be, on many occaſions, a convenient mode of ſeparating entirely the iron from ſolutions in which the pruſſic teſt has been concerned; ſince, as Scheele has firſt obſerved, the mineral acids poſſeſs that power.

It may not be uſeleſs to obſerve, that the ſolution of pruſſiated alkali, which I uſed in all theſe experiments, conſiſted of one part of the pruſſiat in cryſtals, to ſixteen parts of diſtilled water; and that a ſpecimen of theſe cryſtals, burnt with a little wax, in a ſilver crucible, yielded 0.225 of brown oxyd of iron. This pruſſiat of potaſh was ſo prepared, as not to be tinged blue by the mineral acids, unleſs heat was applied.

Having thus obtained by means of the pruſſic teſt, reſults which appeared ſufficiently accurate, with regard to the quantity of ſulphat of iron contained in the water, I was deſirous to aſcertain, by ſome other proceſs totally unconnected with this, the real proportion of metallic iron, or rather of oxyd of iron, actually contained in a given quantity of this chalybeate.

For this purpoſe, and in order to obtain a ſolution of this queſtion, perfectly independent of my own experiments, I requeſted of my friend Mr. Allen, one of the lecturers of chemiſtry in the medical ſchool of Guy's Hoſpital, to examine, by any method he might think proper, a portion of reſidue procured in the ſame manner as that which had been the object of the preceding experiments.

He very obligingly complied with my requeſt, and ſoon afterwards favoured me with the following account, which I ſhall give in his own words:

Exper. VII.—" Ten grains of the precipitate from the chalybeate ſpring at Brighton, dried at the temperature of 160°, were diſſolved in diſtilled water, by the aſſiſtance of a little muriatic acid, with the exception of a minute fraction of a grain, which appears by Dr. Marcet's experiments, to be ſilex. This ſolution was exactly neutralized by ammonia. A ſolution of ſuccinat of ammonia being added, and the whole boiled, a brown precipitate was obtained. This roaſted with wax, in a ſilver crucible, gave 1. 3 grains of oxyd of iron.

" Dr. Marcet having found that the oxyd of iron in this mineral water, is combined with ſulphuric acid, the following comparative experiment was made with the green ſulphat of iron, to determine the quantity of oxyd of iron contained in it, by the teſt of ſuccinat of ammonia.

Exper. VIII.—"Five grains of cryſtallized green ſulphat of iron, were diſſolved in diſtilled water; and the iron precipitated by ſuccinat of ammonia in a boiling heat. The precipitate being treated with wax in a red heat, gave 1.8 oxyd of iron, which was of a reddiſh colour, reſembling cinnamon, but rather darker.

"Then 1.8: 5=1.3: 3.61 grains of green ſulphat of iron, in 10 grains of the precipitat procured by boiling the water down to dryneſs, in a heat not exceeding 160°.

"In employing the ſuccinat of ammonia as a teſt, care muſt be taken to ſaturate the ſolution to which it is applied, very accurately." *

On comparing theſe reſults with my own, I had the ſatisfaction to obſerve that the quan-

* In addition to this, I would obſerve, that long and repeated boiling, is alſo neceſſary to promote the action of this teſt on ſulphat of iron, upon which it acts but very ſlowly and imperfectly without it. It is evident that the effect of boiling, in this inſtance, depends merely upon a further oxydation of the iron; ſince by allowing the ſolution to ſtand for a ſufficient length of time, or by adding nitric acid, the iron becomes readily and entirely precipitable.

tity of ſulphat of iron, which I concluded to be $\frac{7079}{20}$ appeared from Mr. Allen's more direct eſtimate, to be $\frac{7.20}{20}$, a degree of coincidence which it can hardly be expected to ſurpaſs in reſearches of this nature.

In order to form an eſtimate of the actual quantity of metal or metallic iron, contained in the chalybeate, I tried the following experiment:

Exper. IX.—Five grains of iron, filed from the pureſt ſpecimen of malleable iron which I could procure, were diſſolved in diluted ſulphuric acid, by long digeſtion in a gentle heat. This ſolution being previouſly neutralized, was repeatedly boiled and filtered with ſuccinat of ammonia, and afterwards treated with pure ammonia, to precipitate a ſmall remaining portion of iron, which had eſcaped the action of the ſuccinic teſt. The whole of this precipitate being expoſed to a red heat, in an open ſilver crucible, and treated with wax, in the ſame way as in exper. 7 & 8, gave 7.4 grains of a dark red brown oxyd of iron, which was attracted by the magnet. It appears therefore that 100 grains of this oxyd, confifted of 67.6 of metal, and 32.4 of oxygen.

By combining thefe refults with thofe of the two former experiments, it will be found that the 10 grains of refidue (which, in exper. 7, yielded 1.3 grains of oxyd of iron), contained really no more than 0.87 grains of metallic iron, or 8.7 in 100 grains. And the actual proportion of metal in 5 grains of cryftallized fulphat (which, in exper. 8, yielded 1.8 grs. of oxyd), would be 1.22 grs. or 24.4 in 100; a quantity correfponding to 0.36 of the oxyd.* As however the proportion of oxyd in the falt, muft depend upon its degree of oxydation, thefe refults, even allowing them to be perfectly accurate, can only be applied to experiments made exactly under the fame circumftances as thofe juft related. But I fhould not omit to mention, that my brown oxyd of iron, had a more diftinct reddifh hue than that obtained by Mr. Allen, in the experiment to which this is compared;

* Chemical writers agree in reckoning 0.27 of oxygen in oxyd of iron at its minimum of oxydation, fuch as it is obtained from pure green fulphat; and 0.48 in the red oxyd, fuch as it exifts in the red fulphat of iron. In my experiment, the oxyd appeared to contain 0.324, which is a kind of intermediate proportion between thofe juft mentioned.

although the procefs of precipitation and calcination, was, as much as poffible, carried on in a fimilar manner. It muft be obferved, alfo, that my folution of 5 grains of iron, having not been brought to the ftate of cryftallized fulphat, fome doubts may arife as to the degree of oxydation which the metal underwent in that folution.

Before I conclude my obfervations on this part of the fubject, I fhould not omit to remark, that wherever in the courfe of this inquiry a quantity of iron has been precipitated from the water, whether merely in confequence of its being kept for fome time (as in exper. 2. D), or by means of concentration, it has never prefented itfelf in the ftate of ochre, or fimple oxyd of iron; but on the contrary, has always, upon careful examination, appeared to be combined with a portion of fulphuric acid, forming what has been called a fub-fulphat of iron.

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§ XII. *Red fulphat of iron.*

Exper. I.—Twenty grains of refidue were put in a phial, with about 150 grains of alcohol, of the ſpecific gravity of 8.10, and the mixture, after being often ſhaken and kept well corked for a few hours, was thrown into a filter. This filtered ſpirituous ſolution was of a reddiſh yellow colour. Being evaporated to dryneſs, it diſcovered a deliqueſcent browniſh reſidue, which being rediſſolved in water, imparted to it a deep yellow colour. But a ſmall portion of this reſidue (which proved to be a ſub-ſulphat of iron, formed by the action of the atmoſphere, during the proceſs of evaporation) remained undiſſolved, till a little muriatic acid was added. The reſidue which had been depoſited in the filter by a ſpirituous ſolution, was become of a paler colour, in conſequence of its being treated with alcohol, and had loſt its deliqueſcent quality. Its weight was reduced to 14.1 grains.*

Exper. II.—As it is well known that alcohol has the property of diſſolving red ſulphat of iron, whilſt on the contrary it

* Yet the reſidue of the ſolution in alcohol dried at 160°, weighed only 3.1, inſtead of 6.9 grains, which would have been the complement of the 20 grains of reſiduous matter. This muſt be owing to a loſs of moiſture, in conſequence of the action of alcohol.

precipitates the green fulphat, there could be no doubt but that the deliquefcent refidue, obtained in the former experiment, contained a quantity of red fulphat of iron. In order to form an eftimate proportion of this falt in a given quantity of the refidue, the yellow watery folution above mentioned, proceeding (exper. 1) from 20 grains of refidue, was treated with pruffiat of potafh, which occafioned a precipitation of Pruffian blue, weighing 1.45; which denotes a quantity of red fulphat of iron, equivalent to 1.3 grains of the green fulphat.

(A)—But although the prefence of red fulphat in the refiduary matter, is manifeftly fhewn by thefe experiments, yet they do not by any means prove, that the falt actually exifted in the recent chalybeate. On the contrary it appears probable, that it is the product* of the feveral operations to which

* Mr. Kirwan, in his "Effay on the Analyfis of Mineral Waters," in which he has fo much contributed to the advancement of that part of chemical fcience, expreffes a belief that the fulphat of iron, which has occafionally been difcovered in mineral waters, did not exift in thofe waters, previous to the analytic proceffes to which they were fubjected.

the water has been ſubmitted. This I think may be inferred, not only from the tincture of galls not tinging the recent chalybeate black, but alſo from the conſtant formation and precipitation of ſub-ſulphat, which happens whenever the water is expoſed to a proceſs of oxygenation. For it is reaſonable to ſuppoſe, that, whilſt on one hand, a proceſs of oxygenation, and conſequent ſeparation of oxyd of iron from the acid which held it in ſolution takes place, the portion of acid thus liberated, will unite with as much of the ſuperoxygenated oxyd, as it will be capable of combining with, and thus a quantity of the red, or ſuperoxygenated ſulphat will be generated. This queſtion however, is, in the preſent inſtance, a mere matter of curioſity, ſince it cannot affect in any material manner the former reſults obtained, either as to the abſolute quantity of iron in the chalybeate, or as to the nature of its combination.

§ XIII. *Muriat of iron.*

I have fuggefted in a former part of this paper, the poffibility of fome muriat of iron being contained in the water. This conjecture, the experiments above related, do not precifely contradict, but they render it extremely improbable.

In the firft place it muft be remembered, that if any muriated iron did exift in the water, it could only be in a very minute quantity, fince it muft have made part of the fmall portion of red fulphat of iron which was eftimated from the preceding experiments, both thefe falts being equally foluble in alcohol.

Had the fpirituous folution contained no other falts but the red fulphat or muriat of iron, the prefence or abfence of the latter would have been eafily demonftrated by nitrat of filver, or any other teft of muriatic acid. But in this cafe, as it will be proved hereafter, the muriats were difcovered, which prevented my obtaining an abfolute proof of the water being perfectly free from the prefence of muriated iron.

§ XIV. *Sulphat of lime.*

EXPER. I.—Oxalat of ammonia being added to a ſolution of 10 grains of reſidue, the iron of which had been previouſly ſeparated by ſuccinat of ammonia, a conſiderable turbidneſs inſtantly took place, and a white precipitate readily ſubſided, which, dried as uſual, weighed 4.1 grains.

Having had every reaſon to conclude from ſome of the preliminary experiments, mentioned in a former part of this paper, that the lime exiſted in the water in the ſtate of ſulphat, it remained to be determined, what quantity of ſelenite correſponded to the 4.1 grains of oxalat of lime, obtained from 10 grains of reſidue.

Not finding in any chemical works any facts from which I could immediately deduce the ſolution of this queſtion, I made the following comparative experiment:

EXPER. II.—A ſpecimen of the pureſt native ſelenite that I could procure, was pulverized and boiled to ſaturation in diſtilled water. This ſolution was decanted, and the clear fluid evaporated to dryneſs in the temperature of 160°. Five grains of the felenite thus obtained and dried, being rediffolved in water, and afterwards precipitated by oxalat of ammonia, and dried at 160°, weighed 4.25 grains; which is equivalent to 117 parts of felenite, for 100 parts of oxalat of ammonia. Confequently the following formula, $4.25:5=4.1:x$, will give 4.82 grains, as the quantity of felenite contained in 10 grains of refidue, dried at 160°*

§ XV. *Alum and Epfom falt.*

The prefence of thefe two earthy fulphats in the water, being by no means improbable, I tried to difcover them in the following manner.

* This eftimate of courfe fuppofes that felenite is the only calcareous falt prefent in the water. Muriat of lime, which is often found in mineral waters, could not be expected in this, fince its exiftence, except in extremely minute quantities, is incompatible with fulphat of iron. In confirmation of this, I tried the muriatic falts obtained from the folution in alcohol (§ XIII. exp. 1), with oxalat of ammonia, which occafioned only a very flight cloud, without any ponderable precipitat.

Exper. I.—The portion of refidue which had been left in the filter (§ XII. exper. 1), by the folution in alcohol, was diffolved in a quantity of diftilled water, not fufficient to take up any confiderable quantity of felenite, and the filtered folution was evaporated in a temperature not exceeding 80°. As the evaporation advanced, regular cubic cryftals depofited themfelves on the bottom of the veffel; and when it was completed, there appeared alfo, befides the cryftals (which formed the greateft part of this refidue), a minute quantity of a yellowifh powder, collected in the centre of the cup, and a kind of fnow-like efflorefcence flightly fpread over it. But no other cryftals but thofe juft mentioned could be difcovered. The whole of this refiduary mafs, dried as ufual, weighed precifely 5 grains. But the heat applied in the procefs of drying, was not fufficient to deprive the cryftals of their water of cryftallization. From the form of thefe cryftals, from their decrepitation on being heated, and their well known tafte, there could be no doubt but that they were muriat of foda.

Exper. II.—In order to obtain more poſitive information in this reſpect, and alſo to aſcertain the nature of the ſmall portion of uncryſtallized matter mixed with the cryſtals, the reſidue of 5 grains above mentioned, was mixed with about 2 ounces of diſtilled water, which rediſſolved the whole of it, with the exception of a very minute quantity of a yellowiſh powder. The following teſts were then tried :

(a) Pruſſiat of iron produced a pale green colour, and a precipitate weighing $\frac{6}{10}$ths of a grain.

(b) Oxalat of ammonia occaſioned a precipitate weighing 1.6 grains.

(c) Nitrat of ſilver, and muriat of barytes, both produced copious precipitates.

(d) A ſolution of platina in nitro-muriatic acid, produced no precipitate whatever.*

(e) The ſmall quantity of undiſſolved

* This teſt is exceedingly convenient and deciſive with regard to the preſence of potaſh, as it forms a diſtinct and immediate pecipitate with the ſmalleſt portion of this alkali, or any of its compounds, whilſt it is not at all affected by the mineral alkali.

yellow powder, which weighed at moſt $\frac{1}{10}$th of a grain, proved to be ſubſulphat of iron. *

(*f*) After the complete removal of the iron and lime, the remaining ſolution was tried both with pure ammonia and pure potaſh, which occaſioned no cloud or precipitate whatever; whilſt the leaſt quantity of any earthy ſalt, added to this ſolution, was readily diſcovered by the alkali.

From theſe experiments I inferred, that the 5 grains ſoluble in water conſiſted of about 2 grains of ſulphat of iron and ſelenite, and 3 grains of muriat of ſoda: and from the laſt reſult in particular, I concluded, that neither alum, nor ſulphat of magneſia, were contained in the water.

* It may be obſerved that the quantity of ſulphat of iron yet diſcovered, either in the ſpirituous or the watery ſolution, does not amount to more than 2 grains, inſtead of the 7 grains which the 20 grains of reſidue under examination ſhould contain, according to my former ſtatements. But the remaining 5 grains were found in the ſtate of ſubſulphat, in the reſidue inſoluble both in alcohol and water, which conſiſted entirely of ſelenite and ſubſulphat of iron.

§ XVI. *Muriats of Alumine and Magnesia.*

Exper. I.—Twenty grains of residue were redissolved in dilute muriatic acid, and boiled with prussiat of potash, till the iron was completely removed. The solution was afterwards neutralized, and the lime separated by oxalat of ammonia. A solution of pure potash being then added, in order to precipitate the alumine and magnesia, whitish flakes gradually subsided, which being collected on a filter, and dried at 160°, weighed 2.1 grains.

Exper. II.—This precipitate was boiled in a solution of pure potash, with a view to dissolve the alumine, and thus separate it from the magnesia, which is not soluble in alkali. This solution being allowed to cool, soon deposited a whitish powder, and the fluid, which continued somewhat turbid, being decanted off, the white powder, dried as usual, was found to have lost about half of its weight.

From these first results I naturally conjectured, that the 2.1 grains consisted of nearly equal parts of alumine and magnesia. This however, as it will ſoon appear, was contradicted by ſubſequent experiments.

Exper. III.—The whitiſh powder inſoluble in potaſh being examined, proved to be magneſia, mixed with a ſmall quantity of lime, which was readily diſcovered by the oxalic teſt. But the ſuppoſed ſolution of alumine in potaſh, being allowed to ſtand for ſome time, depoſited a further quantity of a whitiſh powder, and the clear alkaline liquor being boiled with muriat of ammonia, produced no precipitation whatever, which led me to ſuſpect that the whole of the original precipitate (exper. 1) was magneſia, with the exception of the minute quantity of lime juſt mentioned.

Exper. IV.—In hopes to obtain more deciſive reſults on this ſubject, and in order to vary the laſt experiments, I made a new ſolution of 10 grains of reſidue, from which the iron was precipitated by ſuccinat of ammonia. But from this ſolution, treated like the former with cauſtic alkali, I could obtain no earthy precipitate.

Exper. V.—This circumſtance, as it appeared afterwards, was ſimply owing to the ſtate of very great dilution in which the earthy ſalt exiſted in this ſolution; but before I was aware of this, an idea occurred to me, that the non-appearance of a precipitate in this caſe, might poſſibly ariſe from the previous application of ſuccinat of ammonia. In order to aſcertain this point, I prepared artificial ſolutions of muriat of alumine, and muriat of magneſia, and obſerved, that on pouring a few drops of ſuccinat of ammonia into the former, a copious precipitate ſubſided.

It appeared therefore uſeleſs to proſecute any farther my inquiry on the above ſolution. But this property of ſuccinat of ammonia, to precipitate alumine, ſtruck me as being new and curious, and attracted for ſome time my attention.

(A)—I ſhall not enter here into all the particulars of the inquiry and various experiments reſpecting alumine and its relations with the ſuccinic teſt, which aroſe from the circumſtance juſt related; but as the ſubject is by no means unconnected with the object of this eſſay, and as ſome explanation may be of uſe to facilitate the application of this teſt to the examination of ſolutions of alumine, I ſhall mention the following general reſults:

1ſt, That ſuccinat of ammonia precipitates alumine from its combinations, readily and entirely, provided there be no conſiderable exceſs of acid, in which caſe the ſolution muſt be previouſly neutralized.

2dly, That this teſt does not appear to have any action on magneſia or its compounds, and will therefore in many caſes afford a more convenient diſcriminating teſt, between this earth and alumine, than the boiling with potaſh, which was generally reſorted to. *

3dly, That if a ſolution of 100 parts of

* Since this was written, I have ſeen in the *Journal des Mines*, N° 70, a paper on Yttria, by Mr. Ekeberg, in which the author notices the property of ſuccinat of ammonia to precipitate glucine, which is another common feature between this earth and alumine. But I do not find that either Mr. Ekeberg or any other writer has noticed the property of this teſt with regard to alumine. On the contrary I obſerve, that the celebrated chemiſt Klaproth (Analytical Eſſays, vol. ii), in his analyſis of the Gadolinite, a mineral which contains a ſmall quantity of alumine, precipitated the iron by ſuccinat of ammonia, without remarking the property alluded to, although it could not fail to have ſome influence on the reſult.

octahedral cryftals of alum be decompofed by fuccinat of ammonia, the precipitate, calcined in a red heat, weighs exactly 12. This refult I offer with the more confidence, as it agrees perfectly with Mr. Kirwan's ftatement, a coincidence which I did not notice until I had completed my own experiments.

4thly, That if a fimilar folution be decompofed by pure ammonia, the precipitate, calcined in the fame manner, gives precifely the fame weight.

5thly, That however there is this difference between the precipitates produced from alum by fuccinat of ammonia, and thofe obtained from pure ammonia, that in the firft inftance, the precipitate, dried at 160°, is white like ftarch, and weighs 35; whilft in the latter, the precipitate, dried in the fame manner, fhrinks to a brownifh powder, fomewhat refembling glue coarfely pulverized, and weighs only 15, inftead of 35.*

* It has been fhewn by my ingenious friend Mr. Theodore De Sauffure, in his valuable paper on alumine (publifhed in the *Journal de Phyfique*, vol. 52), that this peculiar colour and fhrinking of alumine, depends on the great proportion of water in the folution from which it is precipitated; and that this appearance is entirely prevented, by ufing a concentrated folution of alum.

6thly, That if 100 parts of pure alumine prepared from alum, and brought to the confiftence of a pafte, * be diffolved in fulphuric acid, and afterwards precipitated by fuccinat of ammonia, and calcined in a red heat, the refidue will be exactly equal in weight, to that procured by calcining in the fame manner, without any previous folution and precipitation, a fimilar quantity of pure alumine taken from the fame mafs.

Exper. VI.—Being now poffeffed of a direct mode of precipitating alumine, I made a folution of 10 grains of refidue, and after precipitating the iron from it by pruffiat of potafh, and the lime by oxalat of ammonia, I added fuccinat of ammonia. But not the

* I procured this pafte by precipitating a folution of alum by pure ammonia, and afterwards wafhing the precipitate repeatedly in great quantities of diftilled water, and heating it gently once or twice with ammonia. The water at laft came off perfectly free from fulphuric acid; and a portion of the pafte thus prepared, being diffolved in muriatic acid, and a ftrong folution of muriated barytes added, a flight cloud only was produced, without any diftinct precipitate. And as nitrat of barytes produced no cloud whatever, I fufpected that the flight effect of muriated barytes might poffibly be one of thofe anomalies, fuch as Mr. Kirwan has obferved with regard to muriat of magnefia, quite independent of the prefence of any foreign fubftance.

leaſt effect was produced, although cauſtic alkali occaſioned a precipitate, and although the leaſt quantity of muriat of alumine produced an immediate cloudineſs. This experiment, which I repeated ſeveral times with the ſame reſult, appearing ſufficiently deciſive, with regard to the abſence of alumine in the Brighton chalybeate, my attention was now excluſively directed to the magneſia, the preſence of which had been proved by former experiments.*

Exper. VII.—Magneſia, in this inſtance, as it has been ſhewn before (§ XV. exper. 2. f), could only be ſuppoſed to exiſt in the state

* Whilſt this ſheet was printing, I accidentally obſerved, that muriat of alumine was decompoſed by the pruſſiat of potaſh which I uſed in my experiments, and which, I have every reaſon to ſuppoſe, had been prepared with ſufficient care and accuracy. I have ſince found upon inquiry, that this property, though not genarally known, has been noticed by ſome chemiſts, and probably belongs to all pruſſiated alkalies, in whatever manner they have been prepared. No concluſion therefore, reſpecting the non-existence of muriat of alumine, can be deduced from the above experiment, nor from any other proceſs in which the pruſſic teſt has previouſly been uſed. But from many other circumſtances, and particularly from the reſults obtained in the analyſis by alcohol, it appears ſufficiently obvious, that muriat of alumine (unleſs it be in extremely ſmall quantity), cannot exiſt in the water.

of muriat. In attempting to eftimate the quantity of this falt, I had again recourfe to alcohol. 20 grains of refidue were put into a phial, with about 120 grains of alcohol of the fpecific gravity of 810. The undiffolved part was allowed to fubfide, after fhaking the folution repeatedly, and letting it ftand for feveral hours. The clear fluid being then decanted off, and a folution of carbonat of ammonia *fully faturated* with carbonic acid, being added, the mixture became thick and turbid, and paffed to a dirty brown colour. This muddy fluid being filtered, and phofphat of foda added to the clear folution, a cloudinefs immediately appeared, and in a few minutes a white powder fubfided, which, when dried at a temperature not exceeding 100°, weighed 2.8 grains.

The precipitate obtained by this method*, being a triple falt, compofed of phofphoric

* This very eafy and valuable method of precipitating magnefia, was firft fuggefted by Dr. Wollafton. It is obvioufly founded upon the property which fully neutralifed carbonat of ammonia poffeffes, firft to diffolve the carbonat of magnefia which is formed in confequence of a double elective attraction, and afterwards to yield the earth to the phofphoric acid, with which, and the ammonia, it forms a triple falt. With

acid, magnefia and volatile alkali, (the fame combination which Mr. Fourcroy has difcovered in the bladder of a horfe, and Dr. Wollafton has shewn to compofe one of the concretions which are formed in the human bladder), my next object was to determine, by a comparative experiment, what quantity of muriat of magnefia was required to form, by the procefs above mentioned, a known quantity of this triple falt.

Exper. VIII.—For this purpofe, I evaporated to drynefs a folution of muriat of magnefia, in a heat of 160°. 5 grains of the refidue thus obtained were diffolved in water, and both

regard to the preparation of the carbonat of ammonia, Dr. Wollafton's method confifts fimply in pulverifing a quantity of the common carbonat, and expofing it for a few hours to the action of the atmofphere, thinly fpread on a piece of paper. I found that 100 grains of common carbonat of ammonia recently fublimed, being treated in this manner, were reduced to 57 grains: and a folution of falt thus prepared had no fmell whatever. But no certain inference can be drawn from this experiment, refpecting the proportions of carbonic acid and volatile alkali in the common carbonat, fince (as Mr. Davy has fhewn in his excellent treatife on the nitrous oxyd), thofe proportions vary confiderably according to the degree of heat with which this falt is fublimed.

carbonat of ammonia, and phoſphat of ſoda were ſucceſſively added, as in the former experiment. The precipitate, dried in a heat not exceeding 100°, weighed 7.8 grains; and the ſame was reduced to 7 grains, by raiſing the heat to 120°. It appeared in the form of an impalpable, and nearly taſteleſs white powder.

This reſult therefore, combined with that of the former experiment, gives 1.79 grains (78 : 5 = 28 : 179), as the quantity of muriat of magneſia contained in the 20 grains of reſidue.

Exper. IX.—In order to know what quantity of pure magneſia the above 2.8 grains of triple ſalt contained, I made the following comparative experiment: *

Five grains of magneſia, prepared by ex-

* It may be obſerved, that in the comparative experiments, I have generally uſed but ſmall quantities of the ſubſtance to be examined, though it would have been very eaſy to employ larger quantities of materials. But it appears to me, that generally ſpeaking, there is ſeldom any thing to be gained by making experiments of inquiry upon a large ſcale; whilſt on the contrary, ſmall quantities are, with proper management, more ſuſceptible of giving expeditious as well as accurate reſults, particularly when the proceſſes of filtering and drying are concerned.

pofing for about a quarter of an hour, common calcined magnefia to a red heat, fo as to be certain that all the moifture and the carbonic acid had been expelled, were diffolved in muriatic acid, and precipitated as in exper. 7. The triple falt being collected on a filter, and thoroughly dried in a heat not exceeding 100°, weighed 26.3 grains. Confequently 2.8 grains of this falt, or 1.79 grains of muriat of magnefia, contained only 0.53 grains of pure magnefia; a proportion which is equivalent to 100 grains of triple falt dried at 100°, for 19 of magnefia prepared in the manner juft defcribed. I dried the 26.3 grains of triple falt at a temperature not exceeding 100°, fearing that it might be decompofed by a greater heat; but I was rather furprifed to find, that being afterwards expofed to a heat of 160°, it loft only 2 grains.

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§ XVII. *Sulphuric acid.*

In order to afcertain the quantity of fulphuric acid in the chalybeate, a folution of nitrat of barytes was added to a pint of the water (equivalent to $8\frac{1}{2}$ grains of ſolid reſidue), which precipitated from it 6.8 grains of ſulphat of barytes*; a quantity which, ſuppoſing this ſalt to contain 0.33 of acid, according to the aſſertion of Fourcroy and Kirwan, would correſpond to 2.24 grains of ſulphuric acid in a pint, or 2.64 in 10 grains of the reſidue.

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§ XVIII. *Muriatic acid and muriat of ſoda.*

Exper. I.—Ten grains of reſidue were diſſolved in very dilute nitric acid, and nitrat of ſilver was added, in order to ſeparate the muriatic acid. The precipitate dried as uſual, weighed preciſely 6 grains; a quantity which, (if according to Mr. Kirwan,† 100 parts of muriated ſilver contain 16 parts of acid) would make 0.96 grains of muriatic acid in 10 grains of reſidue.

(A) With regard to the quantity of muriat

* Ten grains of reſidue would therefore have yielded 8 grains of ſulphated barytes dryed at 160°.

† See Kirwan on Mineral Waters, table IV. Mr. Kirwan's preciſe eſtimate is $\frac{16.54}{100}$ of acid, the ſalt being dried at 130°.

of ſoda, it will be found that if according to Dr. Black's ſtatement*, 235 grains of luna cornea are equivalent to 100 grains of common ſalt, the above 6 grains of muriated ſilver will repreſent 2.5 grains of muriat of ſoda: and by deducting from theſe 2.5 grains, 0.7 grains (which may be conſidered as an adequate allowance for the 0.89 grains of muriat of magneſia diſcovered in XVI. exper. 7 & 8), the quantity of muriat of ſoda will be reduced to 1.8 grains, in 10 grains of reſidue.

§ XIX. *Examination of the ſediment depoſited by the chalybeate, and of the changes which the water undergoes by long expoſure to the atmoſphere.*

(A) I have mentioned at the beginning of this paper a copious earthy or ochry ſediment which is formed wherever the water has been ſuffered to ſtagnate. Some of this ſubſtance

* See Tranſactions of the Royal Society of Edinburgh III. 116.

which I had collected and brought with me in a muddy ſtate, became in a few weeks hard and friable like ochre, of which it had exactly the colour and appearance. Being ſlightly examined, it appeared to contain iron, in the ſtate (partly at leaſt) of ſubſulphat; lime, chiefly in the ſtate of carbonat; and a ſmall portion of argillaceous earth. The two laſt ingredients, there is every reaſon to ſuppoſe, are merely conveyed and depoſited by the water, without having ever been chemically combined with it.

(B) With regard to the pond before mentioned, formed by the ſuperfluous water from the Wick chalybeate, I found on examination, that a pint of it contained only $3\frac{1}{2}$ grains of ſolid matter, in which I diſcovered nearly the ſame ingredients as in the freſh chalybeate, except that the whole of the iron had diſappeared. The nature of this water, however, muſt vary exceedingly according to the weather and the ſeaſon; ſince heavy rains muſt always dilute its contents, and ſometimes occaſion the introduction of various other ingredients.

§ XX. *Recapitulation, and conclufion.*

On recapitulating the various refults of this analyfis, in order to prefent them in one view, it appears, that 100 parts of the folid refidue obtained by evaporation from the Brighton chalybeate, and dried at the temperature of 160°, have given:

	GRAINS.	
Sulphat of iron -	21.2	... equal to 35.3 grs. of cryftallized green fulphat.
Sulphat of lime -	48.2	Dried at 160°
Muriat of foda -	18.	
Muriat of Magnefia	8.9	
Siliceous earth -	1.7	
Lofs - - - -	2.0	
	100	

And a pint of the water (which is equal to 8.5 grains of the folid refidue) contains:

Carbonic acid gas, about $2\frac{1}{2}$ cubic inches, or $\frac{1}{13}$th part of its volume:

	GRAINS	
Sulphat of iron -	1.80	equal to 3 grains of crystallized green sulphat.
Sulphat of lime -	4.09	
Muriat of soda -	1.53	
Muriat of magnesia	75	Dried at 160°
Siliceous earth - -	14	
Loss - - - - -	19	
	8.50.	

I shall not prolong this paper by remarks on the application of the Brighton chalybeate to the cure of diseases, as I have no personal experience of its medicinal properties. But I may be allowed to point out the considerable proportion of active ingredients, and more particularly of iron, which it contains, compared to other springs of an analogous composition. The chalybeate of Tunbridge, for instance, which has long been justly celebrated for its medicinal virtues, contains, according to Dr. Babington's analysis, no more than 1 grain of oxyd of iron in a gallon; whilst the Brighton spring holds in one pint, more than an equal quantity of the same oxyd. It is true that the chemical composition of the two springs is very different, since in the one, the iron is ſuſpended by a mineral acid, whilſt in the other, it is held in ſolution by a gaſeous menſtruum. But experience has ſhewn that the ſpecific effects of iron on the human frame, do not materially differ, whether it be taken in the ſtate of carbonat, or of ſulphat, or of plain oxyd, or in any other form, provided the metal be nearly in the ſame ſtate of oxydation; although it muſt be allowed that there may be differences in the degree of that effect, as well as in the manner in which the acid, or vehicle of the metal, affects the organs of digeſtion, in particular individuals. It may be obſerved alſo, that this ſpring contains a quantity of neutral ſalts, which may probably be of uſe in affording a gentle ſtimulus to the ſtomach and inteſtines, and thus contributing to inſure the beneficial effects of its ferruginous ingredients. It is therefore very reaſonable to ſuppoſe, that the Brighton chalybeate is likely to be of conſiderable uſe in diſeaſes which require the tonic powers of this kind of medicines; and from the peculiarly advantageous ſituation of that ſpring, there is every reaſon to expect, that at no diſtant period, its medicinal qualities will be more generally acknowledged. *

Before I conclude, I muſt beg leave to mention a circumſtance reſpecting the medicinal effect of this chalybeate, which I have learnt from Dr. Tierney. This gentleman has obſerved, that in common with moſt mineral waters of this kind, it is apt to occaſion in ſome individuals a degree of nauſea and a ſenſe of weight in the ſtomach, when taken cold; but he has found that thoſe effects generally diſappear, if the water be drank moderately warm. This remark appears to me important, and is particularly applicable to the Brighton chalybeate, as its analyſis ſhews, that no iron is precipitated, nor any other material change produced, by applying heat to it, provided it be done quickly, and in veſſels which, from their ſhape, expoſe but a ſmall ſurface of the water to the action of the atmoſphere. In

* Several practitioners at Brighton, have been for ſome years in the habit of recommending the Wick water in a variety of complaints. Both Dr. Tierney and Mr. Hall have told me, that they have had frequent opportunities of aſcertaining its beneficial effects. That ſpring, however, is yet comparatively ſpeaking, but little known, and ſeldom reſorted to.

the Tunbridge chalybeate, on the contrary, ſuch a method would be quite impracticable, ſince the water cannot be heated, without the oxyd being immediately precipitated."

OF SULPHUREOUS WATERS.

The laſt claſs of mineral waters which we ſhall mention, is the ſulphureous; or thoſe which are ſo ſtrongly impregnated with ſulphur, united either to hydrogen, or to an alkali, or to both, as thereby to acquire very ſenſible qualities of ſmell and taſte, and to become very powerful agents on the human frame.

We meet with ſeveral varieties of ſulphureous waters, ſuch as hot and cold, ſimple or ſaline, and the like; and by a happy combination of various properties, a highly valuable medicine is ſometimes compoſed.

All theſe waters are at once detected by the ſmell, which is very fetid, like the ſcouring of a foul gun-barrel, or like rotten eggs. They have beſides, a taſte which is peculiar, and rather ſweetiſh, which altogether conſtitutes a drink that is at firſt very unpalatable; but it is found that habit remarkably ſoon reconciles the drinker to this nauſeous liquor.

Sometimes the hepatic gas is ſo highly ſuperſaturated with ſulphur, as to depoſit it readily in the form of pure ſublimed ſulphur on the upper covering of wells, and other places, through which it paſſes for a conſiderable time. In all caſes, however, the quantity of this inflammable is very ſmall in any given portion of water, compared to the intenſity of the ſenſible properties. None of theſe waters will bear carriage well to any diſtance, as the ſulphureous ingredient is conſiderably decompoſed, and the ſulphur ſeparated in an inactive form, by mere reſt, even in cloſe veſſels. Some of theſe, however, are more permanently ſulphureous than others, which depends on minute chemical differences, which will be duly noticed.

As ſpecimens of the cold ſulphureous waters, the only kind which this country poſſeſſes, we ſhall give an account of the celebrated ſprings of Harrogate and Moffat: as examples of the hot waters of this ſpecies, we ſhall mention the ſtill more famous thermal fountains of Aix-la-Chapelle, and thoſe of Barèges, in the ſouth of France, and with theſe we ſhall conclude the hiſtory of the individual mineral waters.

HARROGATE WATER.

THE villages of High and Low Harrogate are ſituated in an agreeable country, in the centre of the county of York, adjoining to the town of Knareſborough. The whole of this diſtrict abounds with mineral ſprings of various qualities, but principally ſulphureous and chalybeate. Harrogate in particular has long enjoyed conſiderable reputation, by poſſeſſing very valuable ſprings of both theſe ſpecies, and ſome years ago the chalybeate was the only one that was uſed internally, whilſt the ſulphureous water was confined to external uſe. At preſent, however, the latter is employed largely as an internal medicine.

The adjacent country is ornamented with a variety of elegant ſeats, and contains the ancient foreſt of Knareſborough, now however moſtly encloſed and cultivated. The town of this name has a very beautiful and romantic ſite, and poſſeſſes a variety of natural curioſities to intereſt the obſerver.

The ſulphureous ſprings of Harrogate are four in number, and they all appear to take their riſe from a large bog at a ſhort diſtance from the wells. (*a*) This bog conſiſts of the remains of decayed vegetable matter, forming a black fetid half fluid maſs, in many places four or five feet in thickneſs, which every where reſts on a bed of clay and gravel. From hence the water appears to paſs under ground through ſtrata of ſhale; and havihg undergone a natural filtration in its paſſage, it riſes perfectly tranſparent into the wells where it is received for the uſe of the numerous invalids that frequent this place.

The four ſulphureous ſprings reſemble each other cloſely in all their properties and diſtinguiſhing characters, but as one of them is much more ſtrongly impregnated with the ſulphureous principle than the reſt, it is the only one uſed for drinking, whilſt the three others are devoted to the ſupply of the baths. An account of the properties of the drinking well, will be ſufficient for our preſent purpoſe.

This water, when firſt taken up, appears

(*a*) See a very clear and intereſting account of this water in Watſon's Chemical Eſſays, vol. 5, 1786.

perfectly clear and tranſparent ; it ſends forth a few air bubbles, but not in any remarkable quantity. It has a very ſtrong ſulphureous and fetid ſmell, preciſely like that of a damp ruſty gun-barrel, or bilge water. To the taſte it is bitter, nauſeous, and ſtrongly ſaline. It is however a remarkable inſtance of the power of habit in reconciling the palate to the moſt nauſeous taſte, that moſt perſons very ſoon come to drink this water without any diſguſt. This water loſes its tranſparency when expoſed for ſome hours to the open air, and becomes ſomewhat pearly and rather greeniſh to the eye ; and at the ſame time the ſulphureous odour abates, and at laſt the ſulphur is depoſited in the form of a thin film on the bottom and ſides of the veſſel in which it is kept.

The ſpecific gravity of the water when freſh drawn, according to Dr. Garnett's experiment, is 1.0064.

The compoſition of this water has excited the attention of ſeveral very ingenious chemiſts, and the obſervations of Short, Watſon, and others, have been fully confirmed, and the analyſis compleated, by Dr. Garnett, whoſe account we ſhall follow implicitly. (*b*)

Different re-agents give the following appearances.

Tincture of litmus ſlightly reddens the water when freſh, but not after it has been boiled.

Characters written on paper with a ſolution of acetated lead, when plunged into the freſh water, are ſoon made viſible and rendered nearly black. The ſame happens even when the paper is only held over a glaſs of the water, but it requires a longer time to produce this change. Theſe circumſtances ſhew that ſulphur is both contained in the water, and is evolved from it in a gaſeous form.

Nitrated ſilver gives a copious precipitate with the water, which is of a dirty brown when freſh from the ſpring; and white after the water has been boiled; ſhewing the preſence of ſulphur in the former caſe, and of the muriatic acid in the latter.

The acid of ſugar indicates a large quantity of calcareous earth.

A ſolution of ſoap is immediately curdled.

(*b*) See "A Treatiſe on the Mineral Waters of Harrogate, by J. Garnett, M.D. 1794"

Syrup of violets is rendered green after ftanding for fome hours.

No appearance of any thing metallic is indicated by the ufual tefts.

By boiling a quantity of the frefh water in a proper veffel, and receiving the volatile products, a mixed gas was obtained by Dr. Garnett, in the proportion of 34 cubic inches in the gallon, or about $\frac{1}{7}$ of the bulk of the water. This is compofed of carbonic acid, fulphurated hydrogen, and azotic gas. The two former might be expected to be contained, the one from the fmell, and the other from the flight alteration in the colour of litmus; but the latter can only be afcertained by experiment. The azotic gas is more loofely attached to the water than the two others; (*c*) and befides, a large quantity of it is conftantly rifing up through the water at the fpring head, precifely in the fame manner as at Buxton and Bath.

(*c*) This was afcertained by receiving the gas expelled from the fulphureous water, in fucceffive phials previoufly filled with warm water, and examining each feparately. The firft is chiefly azotic gas, but the carbonic acid and fulphurated hydrogen are not entirely expelled till the water has been boiled for fome minutes. Thefe facts are interefting in a chemical view, probably more than in a medical.

Harrogate water likewife contains feveral fixed faline fubftances which are left after evaporation; and which give it a ftrong bitter and faline tafte, and produce fenfible effects on the bowels when taken largely.

The whole contents of a wine gallon of this water are, according to Dr. Garnett, the following:

	grains
Of muriated foda —	615. 5
— muriated lime —	13.
— muriated magnefia	91.
— carbonated lime —	18. 5
— carbonated magnefia	5. 5
— fulphurated magnefia	10. 5
	754. 0

And for the gafeous contents,	cubic inches
Of carbonic acid gas —	8
— azotic gas — —	7
— fulphurated hydrogen	19
	34

Total, one ounce and a half and thirty-four grains of folid contents, and thirty-four cubic inches, or about eighteen ounces in bulk of gaſeous ſubſtances, of which, about ten are ſulphurated hydrogen.

The foregoing analyſis ſhews therefore that the Harrogate water is conſiderably compound in its conſtitution, but that it probably owes its valuable properties to the hepatic gas, of which it contains about a twelfth of its bulk, and to a number of purgative ſalts, which, when taken together, we find, from the compariſon of other waters, to be able to produce, in moſt perſons, a very ſenſible determination to the bowels.

The ſenſible effects which this water occaſions, are often head-ach or giddineſs on being firſt drank; and, as it ſhould appear, more frequently than follows a full draught of the ſimpler waters; and beſides, a purgative operation, which is mild, ſpeedy, and ſeldom attended with pain or griping. Theſe appear to be the only very ſenſible effects which are produced with any great certainty, but it is not merely from theſe that we can explain the whole of the benefit which is derived from this water in a great number of caſes. In theſe, the operation of the ſulphur, probably rendered peculiarly active by its union with the hydrogen, is the moſt conſpicuous, though the preciſe operation of this ſubſtance is little known.

The diſeaſes for which Harrogate water has long been uſed with the greateſt advantage, are indicated by a review of its contents; and though we cannot in all caſes exactly diſtinguiſh and ſeparate the operation of the different ingredients, there are certainly ſome to which the purgative ſalts are peculiarly applicable, and others that require the ſulphureous principle; and again there are ſeveral in which the union of both the active contents is of particular advantage. Like all the other ſaline waters, that of Harrogate is uſed in a number of diſorders of the alimentary canal from the ſtomach to the inteſtines, and in the derangements of the biliary ſecretion which ſo often produce theſe complaints. As this water is a ſpeedy and ſafe purgative, and as under its uſe, the general health, ſpirits, and appetite almoſt invariably improve, it may be uſed with the greateſt proſpect of advantage in correcting the obſtinately coſtive habit of body that accompanies hypochondriaſis, and this habit when removed by mineral waters, appears to be lefs likely to return, than when only the refinous and draftic cathartics are made ufe of. The purgative qualities of this water are not much impaired by keeping for a moderate length of time, but it is not improbable, that even in thefe cafes, the fulphur may contribute to its medicinal powers. The fame obfervations will apply to its ufe in fcrophula, and in various vifceral obftructions. But it is peculiarly from the cure of a number of cutaneous diforders, that the fulphureous waters of Harrogate have acquired their high celebrity, and accordingly a very large number of the patients who refort thither are of this clafs. In thefe complaints, the ufe of the water was formerly intirely confined to external application, and even then its efficacy was very fully eftablifhed. Modern practice has introduced a confiderable improvement in imploying this water largely as an internal medicine; and the union of the fulphur with the neutral falts in fuch a proportion as to determine regularly and moderately to the bowels, appears to be a plan of cure well adapted to thefe troublefome and often very obftinate difeafes. If we compare the actual quantity of ſulphur contained in this compound form, with the ſenſible properties and peculiar action which this inflammable here exerts, we ſhall find that there is no form of combination in which it is ſo active, and ſo readily diffuſible, as in that of its union with hydrogen. It cannot be doubted, but that this ingredient has a large ſhare in the cure of theſe cutaneous complaints, as we know the efficacy of ſulphur upon them when employed in other forms, though in much greater quantities. It is not my preſent purpoſe to enumerate all the varieties of cutaneous complaints that are found here; many of them are the ſmall pimply eruption ſo commonly met with, and called in popular language, though improperly, ſcorbutic; which are often produced by a ſudden application of cold, either to the ſurface of the body or the ſtomach; or elſe ſeem to belong to the habit of body and ſtate of the ſkin, and appear periodically. It is not however, merely to theſe, that the uſe of Harrogate water is confined, for it is conſiderably, though not equally ſerviceable, in many of the more obſtinate and painful diſorders of the ſkin, ſuch as the elephantiaſis, and leprous eruption. Thefe complaints receive material advantage in the ufe of the warm bath, which accordingly makes part of the plan of cure; and during its ufe, very moderate dofes of the water, warmed, and repeated at proper intervals, will materially affift in keeping up that full perfpiration which is promoted by the bathing, and always kept up for fome hours by confining the patient in bed after immerfion, wrapped up in flannel. In this refpect, however, the cold fulphureous waters are not fo advantageous as thofe which are naturally hot; for the former, in being artificially warmed. muft lofe fome of the fulphureous gas, on which part of their efficacy, even when applied externally, muft depend. For this purpofe therefore the hot fulphureous baths of Aix-la-Chapelle are certainly preferable, but we have no natural fprings of this kind in our own country.

Among thofe diforders in which both the fulphureous and faline ingredients may be fuppofed to unite their valuable properties, we may mention the piles, and fymptoms produced by feveral fpecies of worms. The advantage of fulphur, as a mild unirritating purgative, and one, perhaps, that continues its operation through the whole of the inteſtinal canal, has long eſtabliſhed its virtue in thoſe hæmorrhoidal affections that require this evacuation; and the neutral ſalts with which it is united in this mineral water, cannot but contribute to its efficacy. The effect of ſulphur in removing worms from the alimentary canal, has been ſuppoſed, with ſome probability, to be that of deſtroying the animal; and if this be a juſt explanation, the diffuſive activity of the ſulphurated hydrogen will amply counterbalance the minuteneſs of quantity. However this be, we find that Harrogate water is a ſafe and often powerful remedy againſt the round worm and aſcarides, when taken in ſuch a doſe as to prove a briſk purgative; and in the latter caſe alſo, when uſed as a glyſter, the aſcarides being chiefly confined to the rectum, and therefore within the reach of this form of medicine. (*d*)

(*d*) For further particulars concerning the uſe of Harrogate water, the reader is particularly referred to the very judicious and accurate obſervations contained in "An Eſſay on the Waters of Harrogate and Thorp Arch, by Joſhua Walker, phyſician to the Leeds Infirmary, 1784."

This water is generally taken in ſuch doſes as to produce a ſenſible effect on the bowels. For this purpoſe, it is found in general neceſſary to take in the morning, three or four glaſſes of rather more than half a pint each, at moderate intervals. To correct the nauſeous flavour, which is offenſive to thoſe who are beginning to uſe this water, ſome perſons are in the habit of taking ſome aromatic ſeeds, ſugar comfits, and the like; but Dr. Garnett judiciouſly recommends a ſmall quantity of ſea biſcuit or coarſe bread, which will remove the taſte very ſpeedily, and not cloy the ſtomach, which to an invalid is often a circumſtance of ſome importance. The water ſhould be taken freſh from the ſpring and cold, where the ſtomach can bear it, eſpecially in thoſe caſes where the ſulphureous ingredient is particularly wanted.

With regard to the actual quantity of ſubſtances contained in the uſual doſes, we find, according to the above analyſis, that half a pint will hold in ſolution about forty-five grains and a half of purgative ſalts, and one grain and a half of carbonated earth, for the ſolid contents; and for the gaſeous, about four drams in bulk of carbonic acid and azotic gas, and five of ſulphurated hydrogen. This laſt will contain, according to Kirwan's eſtimation, about one-third of a grain of ſulphur (*e*), a quantity which in every other combination, would appear, and probably would really be, quite unable to produce any effect whatever on the human body.

The duration of a courſe of Harrogate water muſt vary more than that of moſt other waters, on account of the very great diverſity in the diſeaſes to which it is applied. The worſt kind of cutaneous complaints are thoſe in which the greateſt perſeverance in its uſe is requiſite, and in theſe the patient ſhould give this medicine a trial of ſeveral months, at intervals, eſpecially if a reſidence of a few weeks produces any amendment.

(*e*) The exact quantity of ſulphurated hydrogen gas contained in half a pint of the water is 1.1875 cubic inches. Mr. Kirwan's eſtimate (*Treatiſe on Mineral Waters, page* 195) is 30 grains of ſulphur in 100 cubic inches of hepatic air, making in the above quantity .356 of a grain.

MOFFAT WATER.

The village of Moffat is ſituated at the head of a valley on the banks of the Annan, about fifty-ſix miles ſouth-weſt of Edinburgh. It is ſurrounded by hills, ſome of which are very lofty; of theſe the Hartfell mountain has been already noticed for the chalybeate water which ſprings from its baſis. The ſulphureous waters which have given much celebrity to Moffat, and have rendered it the Harrogate of North Britain, iſſue from a rock, a little below a bog, whence they probably derive their ſulphureous ingredient. The chief of theſe is contained within a ſtone building incloſing a pump, and the quantity of water is amply ſufficient for every demand.

Moffat water (*a*), even when firſt drawn, appears rather milky and blueiſh; the ſmell is preciſely the ſame as that of Harrogate; the taſte is ſimply ſaline and ſulphureous, with-

(*a*) See a very good Paper on this water by Mr. Milligin, ſurgeon at Moffat, and inſerted in the Edinburgh Medical Eſſays and Tranſactions, vol. I. 1747.

out any thing bitter. It ſparkles ſomewhat, on being poured from one glaſs to another.

When expoſed to the air, it becomes more turbid, and throws up a thin film, which is pure ſulphur, and is thereby deprived of all its diſtinguiſhing properties as a ſulphureous water. This change takes place even in cloſe veſſels, ſo that it cannot be exported with any advantage.

Dr. Garnett found the following appearances on uſing different re-agents (*b*).

Acetat of lead, added either in ſolution or traced on paper, became ſoon blackened in this water; and in the former caſe a copious brown precipitate was formed.

No change was produced by tincture of galls, acid of ſugar, and muriated barytes, and very little by litmus and lime water.

Nitrated ſilver gave a copious precipitate with the water, both before and after it had been boiled.

By boiling the water, and examining the volatile products, exactly the ſame gaſes were

(*b*) See "Garnett's Obſervations on Moffat, and its Mineral Waters, 1800," the experimental part of which is conducted with that clearneſs and preciſion which have particularly diſtinguiſhed this chemiſt in the analyſis of mineral waters.

procured as from the Harrogate water, and in proportions not very different.

A wine gallon of Moffat water contains, by Dr. Garnett's analyſis,

		grains.
Of muriated ſoda	-	36

for the whole of the ſolid contents; together with the following gaſes:

		cubic inches
Of carbonic acid gas	-	5
— azotic gas	-	4
— ſulphurated hydrogen		10
		19

Total, half a dram and ſix grains of common ſalt, and nineteen cubic inches of a gas, of which ten inches, or about five ounces and a quarter in bulk, are ſulphurated hydrogen.

Moffat water is therefore very ſimple in its compoſition, and hence it produces effects ſomewhat different from thoſe of Harrogate. It is perhaps on this account alſo, that it ſo ſoon loſes the hepatic gas, on which depends the greater part of its medicinal power.

The only particularly ſenſible effect which this water produces, is that of increafing the flow of urine. It does indeed fometimes purge, but this is by no means conftant, and can never be at all relied on, except after a very extenfive dofe, where the mere bulk of water is probably the chief caufe of the action on the bowels.

This is fo well eftablifhed, that the ufe of many of the common purgative medicines is almoft always requifite during a courfe of the water. It is not however, from the want of any obvious operation, that we can undervalue this water, fince it poffeffes a very fenfible portion of the fulphureous gas, the activity of which, in many cafes, is well known.

The difeafes for which Moffat has been, and is ftill the moft reforted to, and for the cure of which it has been almoft proverbially famous, are cutaneous eruptions of every kind, and here the external application of the water, warmed to a confiderable temperature, is very judicioufly made a very large part of the plan of cure. The fame obfervations will apply here, as concerning the employment of Harrogate water; only the latter has the property, which is often a valuable addition, of fenfibly affecting the bowels. Scrophula is another diforder in which many receive very important relief here. It is chiefly however in the earlier ftages, and flighter fymptoms of this formidable malady, that the good effects arifing from this water are the moft confpicuous; but under this ufe, glandular tumours are often difperfed without fuppuration, or any bad confequence. Frequently too, perfons who have ill conditioned and irritable ulcers, apply the water as a conftant dreffing to the part, and with great benefit. Befides thefe difeafes, the water of Moffat is now employed in a number of bilious complaints, in dyfpepfia, and general want of action in the alimentary canal; and alfo in calculous cafes.

With regard to the requifite dofe, it may be obferved in general, that this is a water which may be fafely taken at almoft all times, and by moft conftitutions. To produce much benefit, it fhould be ufed pretty freely in fuch dofes and intervals as the patient can bear. The quantity ufually prefcribed, is from one to three bottles drank every morning; but there are many perfons of a delicate ftomach to whom this allowance is much too large.

On the other hand, the common people frequently take, in one morning, from three to five Scots pints (or from ſix to ten Engliſh quarts); and one inſtance, Mr. Milligin mentions a man, who in eight hours, ſwallowed the enormous quantity of thirty-two Engliſh quarts, and without feeling any other inconvenience than a ſlight giddineſs and head-ach.

AIX-LA-CHAPELLE, OR AKEN WATER.

THE city of Aix-la-Chapelle, or Aken, as it is called by the Germans, is ſituated in a rich fertile country, lying between the Meuſe and the Rhine, ſurrounded by the dutchies of Juliers and Limbourg. This city has long enjoyed a very high diſtinction among the other towns in Flanders, for which it is conſiderably indebted to the hot ſulphureous baths that have long rendered it celebrated. Theſe have been much reſorted to for ſeveral centuries, and were in the height of their reputation in the time of Charlemagne, who for a long time made this city his reſidence, endowed it with valuable privileges, and delighted in the uſe of the waters, ſo much as frequently to hold his levee in the bath, with all his attendants (*a*).

(*a*) See Blondel's "Deſcriptio Thermarum Aquiſgranenſium & Procetanarum, 1685," & Lucas, vol. ii. on the Aken waters. The origin of the Latin term for theſe waters *Thermæ Aquiſgranenſes* is not well determined, but is of conſiderable antiquity.

There are ſeveral ſources of hot water within this city and the ſmall territory that belongs to it; the principal of theſe is incloſed within a ſtone ciſtern, always kept cloſely ſhut, whence the water flows in a large ſtream into ſeveral ſpacious and elegant baths that are diſtributed through various parts of the city, which are more in number and extent than perhaps in any place where bathing is uſed; and diſtinguiſhed by the names of the *Emperor's Bath*, the *Noble's Bath*, the *Poor's Bath*, &c.—The ſupply for all theſe is very ample, and every neceſſary apparatus is found for vapour bathing, for the *douche*, or pumping on any particular part of the body, and the like.

The water riſes within the ſprings in a large body, and with continual ſparkling; and at the ſame time, as Dr. Lucas obſerves, ſends out a conſiderable number of air bubbles, that break on the ſurface with a ſlight exploſion. It is at firſt perfectly colourleſs and pellucid, and ſends forth a large volume of ſteam, and with it a remarkably ſtrong odour of liver of ſulphur, preciſely ſimilar to that of Harrogate water, but much more powerful: this odour is ſo penetrating, that in cloſe foggy weather it ſtrikes the noſe at a conſiderable diſtance from the baths, eſpecially to ſtrangers coming from the country; for the inhabitants of the town, from long habit, ſcarcely notice it. The taſte of the freſh water is ſaline, bitteriſh, and rather alkaline, and both the taſte and ſmell are much more powerful in proportion to the heat, as it firſt iſſues from the ſpring. The temperature of theſe waters varies conſiderably, according to the diſtance from the ſource and the ſpring itſelf. In the well of the hotteſt bath, it is, according to Lucas, 136°; and in the different baths it is found at various degrees of heat from this point to 116.° Bergman, however, makes the temperature to be 62° of the Swediſh thermometer, which is equal to 143° of Fahrenheit; and probably this is more accurate, ſince the water requires to ſtand fifteen or eighteen hours in the large baths, before it is ſufficiently cooled for tepid bathing, unleſs previouſly mixed with cold water. At the fountain where it is drank, it is about 112°. On ſtanding to cool, the water gradually loſes its clearneſs, acquires a milky hue, and depoſits an earthy ſediment, which is intirely calcareous. At the ſame time it loſes much of its offenſive ſmell, and when cold, has ſcarcely any odour: this is in ſome degree renewed by heating the water, but when again cooled, the ſmell is no longer recoverable.

The chemical analyſis of Aken water preſents us with ſome intereſting appearances, and its compoſition is now aſcertained in a ſatisfactory way, aſſiſted by the knowledge which modern chemiſtry has afforded of the ſubſtance which gives the ſulphureous impregnation. With re-agents, the appearances are as follows:

Acetat of lead dropped into the freſh water, cauſes a brown precipitate; which is found to be ſulphurated lead mixed with muriated lead.

A piece of lead with a bright poliſhed ſurface ſuſpended over the vapour of the water, becomes ſoon blackened and corroded into a fine pulverulent black ſulphuret.

Nitrated ſilver, added to the water when cold, gives a white precipitate of luna cornea.

Syrup of violets changes into a pale graſs green, and the water both hot and cold, but lefs fo with the cold, owing to the previous depofition of carbonated lime.

Litmus, in like manner, is rendered of a deep violet, and infufion of rhubarb of an orange red, both by the frefh and cooled water, and ftill more when it is confiderably reduced by evaporation; and from this latter circumftance the prefence of an uncombined alkali is indicated.

No metal is difcoverable by the niceft tefts.

The folid contents left after evaporation are, a fmall quantity of carbonated lime, of muriated foda, and carbonated foda, which laft gives the lixivial tafte, and acts a confpicuous part in the chemical compofition of the whole.

But the moft ftriking feature in this mineral water, and almoft peculiar to it, is the unufual quantity of fulphur that it contains; the whole however fo far united to a gafeous bafis as to be entirely volatile by heat, fo that none is left in the refiduum after evaporation. In the common fulphureous waters, fuch as that of Harrogate, though this inflammable is indicated by every teft and fenfible property, it cannot be procured feparate and in a palpable form without the affiftance of chemical agents: whereas here it is fpontaneoufly feparated; for it is found that wherever a large quantity of the Aken water paffes hot from the fpring through a confined place, the upper covering becomes by degrees incrufted with a very fine pulverulent fublimed fulphur. This is particularly the cafe on the dome of the vault that inclofes the great fource which fupplies the emperor's bath. This is opened at times, and the fulphur brufhed off, and fold under the name of *Aix fulphur*. The hydrogen therefore, which flies off in a gafeous form from this water, is fuperfaturated with fulphur, and depofits its excefs of this fubftance in a very fhort time after it has become aeriform; but, however, the foda which the water contains, probably detains fome of the fulphurated hydrogen for a time, fince the peculiar odour of this compound is recoverable, even after the water has been once cold; but, as has been mentioned, it is entirely diffipated by the procefs of evaporation (*b*).

(*b*) The chemical reader is here referred to fome excellent obfervations on this fubject by Mr. Kirwan, in his Treatife on Mineral Waters. Hepatic air, he obferves, confifts of inflammable

The actual quantity of ſolid contents is variouſly eſtimated. Bergman gives the following, in the proportion of an Engliſh wine pint:

		grains.
Of carbonated lime	—	4.75
Of common ſalt	—	5.
Of carbonated ſoda	—	12.
		21.75

Total, twenty-one grains and three-quarters.

air combined with ſulphur, but it exiſts in very different proportions. Where each ingredient is combined merely to ſaturation, it may be called ſimply, *ſulphurated hydrogen*; but where the ſulphur is in exceſs, it is termed *ſuper-ſulphurated hydrogen*. Sulphurated hydrogen, combined with any baſis, forms a *hydro ſulphuret*, and may alſo be called an *hepatule* to diſtinguiſh it from a *hepar*, which is the union of ſulphur ſingly with a baſis. Hepatules occur ſometimes in mineral waters, as well as ſulphurated hydrogen, and ſometimes both together, but never hepars. The former are tranſparent and colourleſs, and become turbid only on expoſure to the air, whereas the hepars will become turbid by mere dilution, and depoſit their ſulphur. (See Kirwan, pages o and 30).

Aix-la-Chapelle water ſeems to be a mixture of ſuper-ſulphurated hydrogen, and hepatule of ſoda. To the former, the greater part of the hepatic odour, and eſpecially the ſublimation of the ſulphur, ſeems to be owing; on the latter probably depends the

The exact quantity of gas has not been ascertained with any degree of accuracy, nor, what is perhaps of more consequence, the proportion of the sulphur to the hydrogen in the hepatic gas. There is, besides, a quantity of carbonic acid in the water, but not more apparently than is sufficient to saturate the soda, and to hold in solution the calcareous earth.

Aken water, when taken internally, seems to possess important medical virtues, and is used in a variety of cases. Its sensible effects are but few. In general it produces some degree of chearfulness and gaiety of spirits, but, if taken largely, it slightly affects the head with some degree of vertigo and sleepiness, and this is the more as the heat is greater. It sometimes excites nausea, from the powerfulness of its sensible qualities, till the patients are used to the taste and smell, which soon happens. After this, it seldom produces sickness, except the stomach is foul. It often determines to the bowels, and proves mildly laxative, if liberally

circumstance of the degree of adhesion of the sulphureous smell, which may be at first somewhat renewed by heating the water, after it has once cooled.

taken; but this effect is in a good meaſure regulated by the acidity of the patients ſtomach, and the weakneſs of the digeſtive organs. It more certainly determines to the kidnies, increaſes the flow of urine, and likewiſe eminently promotes perſpiration, and a ſoft moiſt ſtate of the ſkin, highly favourable to thoſe diſorders that are affected by the ſtate of this excretion.

During a courſe of the water, even uſed only internally, the body acquires a ſulphureous ſmell, and ſilver worn in the pockets becomes tarniſhed (*c*).

Theſe thermal waters are much reſorted to on the continent for a variety of complaints. They are found eſſentially ſerviceable in the numerous ſymptoms of diſorders in the ſtomach and biliary organs, that follow a life of high indulgence in the luxuries of the table. In theſe caſes, the ſoda that the water contains probably contributes much to its efficacy. Hence its uſe in acidity and indigeſtion in the primæ viæ from accidental cauſes, and in jaundice. Aken water alſo much relieves painful affections of the kidnies and bladder, which

(*c*) Lucas, vol. II. page 148.

produce pain in the loins, and thick mucous urine with difficult micturition. As the heating qualities of this water are as decided as in any of the mineral ſprings, it ſhould be avoided in caſes of a general inflammatory tendency, in hectic fever, and ulceration of the lungs, and in a diſpoſition to active hemorrhagy.

As a hot bath, this water is even more valuable, and more extenſively employed than as an internal remedy. The baths of Aix may be ſaid to be more particularly medicated than any other that we are acquainted with. They poſſeſs both temperature of any degree that can be borne, and a ſtrong impregnation with ſulphur in its moſt active form, and a quantity of alkali which is ſufficient to give it a very ſoft ſoapy feel, and to render it more detergent than common water. This quality is even made uſe of, both here and at Borſet in the neighbourhood, where the water is applied to waſhing linen and other ſubſtances. From theſe circumſtances, theſe baths will be found of particular ſervice in ſtiffneſs and rigidity of the joints and ligaments, which is left by the inflammation of gout and rheumatiſm; and in the debility of palſy, where the higheſt degree of heat which the ſkin can bear is required. The ſulphureous ingredient renders it highly active in almoſt every cutaneous eruption, and in general, in every foulneſs of the ſkin (*d*); and here the internal uſe of the water ſhould attend that of the bath. Theſe waters are alſo much employed in the diſtreſſing debility which follows a long courſe of mercury, and exceſſive ſalivation.

Aken water is one of the few natural ſprings that are hot enough to be employed as a vapour bath without the addition of artificial heat, and for this purpoſe the vapour is detained as it paſſes through the channels that ſupply the common baths where the heat is the greateſt. This is a mixture of ſteam with hydrogen gas ſtrongly ſulphureous, and it is applied by a ſuitable apparatus either generally or partially to the body, as occaſion may require. This vapour bath is much more liable to affect the head, and cauſe fluſhing in the face and turgeſcency of the veſſels, than the ſimple hot bath, and therefore muſt be uſed

(*d*) Hoffman.

more cautiously. It is employed both in the cafes in which the hot bath is ufed, and more efpecially as a fudorific to excite a full perfpiration, which is afterwards kept up by removing the patient to a warm bed for fome hours. This is found to be a remarkably powerful auxiliary in curing fome of the worft fpecies of cutaneous diforders.

In ufing this water internally, the patient fhould begin with not more than half a pint for a dofe, and repeat it more or lefs often according to the effects on the head, and the intention of drinking it. For producing a purgative operation, it is neceffary to take from a quart to a gallon, a quantity which fometimes cannot be borne by the ftomach; and in that cafe fome of the faline medicines of this kind muft be reforted to. By fuffering the water to ftand in an open glafs for fome time, its activity abates as the fulphur evaporates, and thus its action may be moderated, whilft the whole of the alkali is retained.

The town of Aix likewife poffeffes the advantage of being near to feveral chalybeate waters, which often are of great ufe in reftoring to perfect health thofe patients who have received all the benefit from the ſulphureous waters which their caſes will admit; and as it is only twenty-four miles diſtant from Spa, invalids frequently viſit both theſe celebrated fountains during their cure.

BORSET WATER.

Contiguous to the city of Aix-la-Chapelle, a quarter of a mile to the ſouth, is the village of Borſet or Bordſcheit, alſo enriched with ſeveral thermal ſprings, which however on account of their proximity to Aken, are but little frequented by invalids, but are principally made uſe of by fullers and cloth workers, on account of the convenience of procuring, without expence, plenty of hot water, a little alkaline, which is well adapted for the cleanſing of cloth (*a*).

One of the ſprings of Borſet reſembles thoſe of Aix in all its conſtituent parts, but the impregnation with ſulphur is much weaker. It depoſits, however, ſome ſulphur in its courſe through any confined channel on its upper part, but not ſufficient to be worth collecting. It is pretty ſtrongly alkaline. Its temperature is 132°, which is nearly as high as the hotteſt baths at Aix.

The other hot ſpring differs conſiderably

(*a*) Lucas.

from the former, in containing no ſulphur in any form; it therefore has no odour, nor does it blacken the ſolutions of ſilver or lead. It is however equally alkaline, and the heat is as high as 152°, and therefore much exceeds the hotteſt of the Aken waters. In this ſpring there is a large quantity of earth ſuſpended, which is depoſited as the water cools, and forms hard incruſtations to a conſiderable thickneſs round every ſubſtance that may lay in its way, and will ſerve as a nucleus. Notwithſtanding this circumſtance, it is found highly uſeful in ſcouring wool and cloth, boiling vegetables for the table, and in thoſe domeſtic purpoſes for which a ſoft water is required. The alkali which they contain corrects therefore the hardneſs which the abundance of earth would otherwiſe give.

This curious ſpring alſo contains ſome carbonic acid, which is conſtantly eſcaping from the freſh water, and is in ſufficient quantity to corrode in a ſhort time the leaden covering which is uſed for the vapour baths, and any iron which may happen to be within its reach.

The ſtream flows from the ſeveral baths into a large fiſh-pond where it is of a blood heat. Here carp and tench multiply very faſt, and grow to an enormous ſize, but their fleſh is flabby and without flavour, till they have been removed into a pond of cold water, and kept there for about ſix months, when they become perfectly firm, and good for the table.

Borſet water, when uſed medicinally, is chiefly employed externally, and the great heat which it poſſeſſes, allows of every convenience for the vapour, hot, warm, and tepid bathing.

BAREGE WATER.

The ſmall village of Barege, celebrated for its thermal waters, is ſituated on the French ſide of the Pyrenees, about half way between the Mediterranean and the Bay of Biſcay, near the ſource of the Adour, which takes its riſe in theſe wild regions, and falls into the ſea at Bayonne. Barege is compoſed of two ſmall hamlets, the principal of which, lower Barege, contains about fifty houſes, along with the baths. Cloſe to the village runs the little ſtream of the Baſtan, which flows in a rapid courſe to join the Gave, one of the tributaries to the Adour.

The ſituation of the Barege is highly wild and romantic. The valley of the Baſtan is on all ſides encloſed by lofty crags, the ſides of which are arid, ſcarcely admitting of cultivation, and interſected by deep perpendicular ravines, the channels of large torrents, when the winter ſnow begins to melt from the mountains. To defend the village and baths of Barege from the ravages of the waters, a large ſtone dyke was erected by

M. Louvois, which bears his name, and protects the centre of the town, where are situated the hot ſprings, whilſt the whole place is overhung by a wood of oak and aſh trees that cover the lower part of the mountain (*a*).

The hot ſprings that have given celebrity to the village of Barege are four in number. They have all the ſame component parts, but differ ſomewhat in their temperature, and in the quantity of ſulphur, the hotteſt being the moſt ſtrongly penetrated with this active ingredient. The cooleſt of theſe waters raiſes Reaumur's thermometer to 27°, (about 73 Fahr.); the hotteſt is 39°, (120 Fahr.). They are all very light, almoſt equally ſo with diſtilled water, and have a ſlight taſte and ſmell of liver of ſulphur. The three cooleſt are chiefly uſed for ſupplying the baths, the hotteſt for drinking and topical applications.

The analyſis of the Source Royale will ſerve as a ſpecimen of the whole.

Tincture of litmus is not altered, but ſyrup of violets is turned ſlightly green.

(*a*) See "Voyages Phyſiques dans les Pyrenées en 1788 & 1789, par F. Pazumer, Ingenieur Geographique:" and in this work, an analyſis of Barege-waters by Meſſrs. Montaut and Pagez.

Sulphuric acid, much diluted, produces no change, but when much concentrated, it occasions a flight fulphureous odour. This continues fome days, but without any apparent precipitate being formed.

The alkalies, fixed or volatile, occafion no alteration.

All the metallic falts are decompofed by the water. Nitrated filver immediately renders it turbid, and a brown precipitate gradually fubfides. As foon as this metallic folution is added, the water lofes the fmell of liver of fulphur, and acquires that of fulphur fingly. The nitrated mercury and acetated lead produce the fame effect.

This water, as well as the other three fprings, lofes its fulphureous principle by cooling and by contact of air, or even in well clofed bottles, if kept for fome days.

A quantity of this water, flowly evaporated, foon lofes the odour of the fulphur, and when dry, left a refiduum, which was grey, acrid, and faline. Diftilled water diffolved the greater part. This folution contained muriated foda, and an excefs of foda, which it was neceſſary to ſaturate by adding ſulphuric acid, before the whole would cryſtallize. It likewiſe held diſſolved a ſmall portion of an oily matter of a peculiar nature. This latter, when ſeparated from the ſalts, and diſtilled *per ſe*, gave a ſmell like that of animal lymph, and yielded a ſmall quantity of ammonia, and therefore is probably a bituminous ſubſtance, that in the ſtate in which it exiſts in the water appears to form a kind of ſoap with part of the ſoda. This ſubſtance is alſo depoſited ſpontaneouſly in the channel of the water, forming a black unctuous mud that yields ammonia by diſtillation. The ſulphur was not ſeparable in a ſolid form from the water by mere heat, but when the brown precipitate yielded by nitrated ſilver was ſublimed, a true cinnabar was produced; and when butter of arſenic was ſubſtituted for the nitrated mercury, an orpiment was ſublimed. This laſt, mixed with lime, gave a calcareous hepar, from which, by means of diſtilled vinegar, ſulphur was ſeparated in its pureſt form.

From this analyſis we find, that the Source Royale at Barege is a thermal water of the heat of 102°, containing a ſmall proportion of ſulphurated hydrogen, probably united to the ſoda, in the form of an hepatule; (*b*) beſides holding in ſolution an exceſs of ſoda, a little common ſalt, an earth which is a mixture of carbonated lime and alumine, and a ſmall portion of a bituminous ſubſtance of a nature but little known, and alſo united with the ſoda. None of the foreign ingredients however are in any conſiderable quantity, and hence the lightneſs and comparative purity of this water.

The proportion of the different contents it is not eaſy to aſcertain preciſely from the particulars of the analyſis. We ſhall be tolerable exact, if we allow an Engliſh wine pint to contain about three quarters of a grain of earth and bituminous matter, half a grain of common ſalt, and two grains and a half of carbonated ſoda, or at leaſt of ſoda which, if fully carbonated and cryſtallized, would amount to that quantity; for it is by no means certain that the whole of the alkali here exiſts in union with carbonic acid. The

(*b*) See Note (*b*) to the laſt article.

proportion of this ſubſtance is eſtimated (after Mr. Kirwan's calculations) from that of ſulphat of ſoda, which, as has been mentioned, was procured by ſaturating the alkali with ſulphuric acid.

The waters of Barege are remarkable for a very ſmooth ſoapy feel, they render ſkin that is immerſed in them very ſupple and pliable, and diſſolve perfectly well ſoap and animal lymph. For this property they are doubtleſs indebted to the ſoda, and bituminous matter which they contain.

Barege is chiefly reſorted to as a bath, and from the highly detergent powers of its waters, joined to the degree of heat, they have been ſuppoſed to poſſeſs peculiar powers as diſcutients in reſolving tumours of various kinds, rigidities, and contractions of the tendons, ſtiffneſs of the joints left by rheumatic and gouty complaints, and likewiſe they are highly ſerviceable in cutaneous eruptions. (*c*) The warm bath is uſed both generally, and in the form of *douche*. Internally taken, this water gives conſiderable relief in diſorders of the

(*c*) Rutty's Synopſis.

ſtomach, eſpecially attended with acidity and heart-burn, in obſtinate cholics, jaundice, and in gravel and other affections of the urinary organs.

The vallies adjoining to Barege alſo abound with hot ſprings, equally ſulphureous and alkaline, and uſed for medical purpoſes. Of this kind are the baths of St. Sauveur and Cautères. Some of theſe latter raiſe Fahrenheit's thermometer as high as 131°.

At a ſmall diſtance from the valley of the Baſtan, at the village of Bagnères, on the banks of the Adour, there are alſo found a vaſt number of hot ſprings of various temperatures, from 88° to 135°. Theſe all reſemble each other in chemical compoſition, but differ ſtrikingly from thoſe of Barege, in containing no ſulphureous ingredient, nor any exceſs of ſoda, but are hard to the touch, and highly ſelenitic.

They are much reſorted to from the ſouth of France, and uſed chiefly externally, as ſimple thermal waters.

CHAPTER V.

ON THE INTERNAL USE OF WATER AS AN ARTICLE OF DIET.

In the foregoing chapter, I have laid before the reader the account of thofe particular mineral waters which appeared to me to be the moft deferving of notice, and to prefent a fair fpecimen of very extenfive claffes. In treating of thefe, care has been taken to fubjoin to each, fuch an account of their medicinal efficacy as has been found to be eftablifhed by long experience, and to be more peculiarly appropriate to the individual fubject. The reader muft, however, in many inftances be ftruck with the general fimilarity in the virtues afcribed to each, even where the chemical compofition appears to be the moft diftant; and as there is no reafon to doubt of the accuracy of the fact refpecting the actual exiftence of thefe valuable properties, which in moft cafes will be confirmed by the experience of every phyfician who has had opportunities of trying thefe remedies, it will not, I truft, be a ſuperfluous taſk to make ſome obſervations upon the effects of mere water upon the human body, conſidered abſtractedly from all the foreign ingredients with which it is generally found in combination.

A ſubſtance which forms ſo large a portion of the ingeſta, muſt have a powerful and conſtant agency upon the animal machine at all times; and from its conſtant and regular operation on the healthy body, may be in part deduced of its effect in relieving or aggravating certain ſymptoms of diſeaſe.

The ſhare which water has in aſſiſting the proceſs of digeſtion, claims the firſt attention. The obvious uſe of this fluid as an aliment, is that of holding in ſolution, and conveying in a proper form, the other materials which conſtitute the ſolid food of animals.

Water, therefore, ſhould be the fluid of all others the moſt eminently fitted for ſuſpending in a liquid ſtate, all the varieties of animal and vegetable matter; and this is actually the caſe, as we mentioned in the introductory part of this work. But beſides being ſubſervient to the preparation of food within the ſtomach, water is itſelf an aliment, highly neceſſary as ſuch, in order to preſerve that due proportion of fluid to ſolid matter, on which depend the preſervation of life, and the proper performance of all the functions.

The proceſs of digeſtion we know is a complex operation, but principally performed by the ſolvent power of the gaſtric juice, and the action of the ſtomach itſelf upon its contents. The gaſtric ſecretion depends chiefly on the healthy action of the ſtomach; and this again is kept up by the ſtimulus of the gaſtric liquor, by the particular nature of the alimentary contents, and by the circumſtance of diſtention ariſing from mere quantity. As far as the preparation of food within the ſtomach is concerned, it would appear, that in a vigorous healthy organ, any more water than is neceſſary to give a due conſiſtence to the food, will retard digeſtion. This it will do, by weakening the activity of the gaſtric liquor, by diminiſhing the ſtimulating quality of the food, and therefore its action upon the ſtomach; and, if the water be cold, by ſuddenly abſtracting part of that temperature which appears to be ſo neceſſary to the complicated proceſs of digeſtion, and the regular evolution of which cannot be difturbed with impunity. The retardment thus produced, will only be counteracted by an increafe in the ftimulus arifing from mere diftention. But if no more aqueous dilution were employed than what was folely neceffary as a folvent for the folid part of the aliment, the additions thus thrown into the circulating mafs by the chylopoietic organs, would probably be too ftimulating in their nature, and perhaps too foon *animalized;* and hence a ftrong tendency to plethora and an inflammatory ftate of body would be produced, and various diforders of the fyftem would follow. On the other hand, if the powers of the ftomach are naturally weak, fo that digeftion is a very flow procefs, the fpontaneous chemical changes that the food would take on out of the body, begin within the ftomach before they can be prevented by the proper action of that organ and its fecreted liquor; hence the acidity of ftomach, heart-burn, and eructations, and all the train of fymptoms iucluded under the general term of dyfpeptic. But thefe again will be prevented in a great meafure by proper dilution; as the fimple addition of water will moderate the ftimulus of high food when too ſtrong for the action of the ſtomach, and at the ſame time will haſten the propulſion of its contents into the inteſtines by aſſiſting in the change requiſite to be produced on the food previous to its entering theſe organs. Hence it is, that there appears to be good reaſon to expect benefit from aqueous dilution to a certain degree in very different ſtates of body; that is, both when the circulating fluid is too ſtimulating, owing to an abundance of ſtrongly nutritious aliment, and a rapid digeſtion; and alſo, in that ſtate which is a conſequence of the former, a debilitated ſtomach and defective nutrition, owing to the inability in the digeſtive organs to aſſimilate common food in merely its uſual ſtate of dilution with watery liquid.

It is not merely, however, as an auxiliary to the proceſs of digeſtion, that the neceſſity of taking in a due quantity of liquid ariſes; water itſelf is certainly a moſt important article of aliment, and as ſuch enters largely into the compoſition of the animal body, aſſiſting in evolution of the ſolids, and compoſing the greater part of the fluid ſecretions. Hence, as the well-being of the animal frame depends much on the fecretions and excretions, the quantity and ftate of thefe, as regulated by that of the watery ingefta, becomes of high importance. During the whole courfe of circulation, the fluids are becoming gradually unfit to remain a healthy part of the living animal, and are regularly removed, when become detrimental, by the excretories of the lungs, the fkin, and the kidnies; and this removal of noxious matter appears to be full as neceffary to the conftant health of the animal, as the daily fupply of food by the mouth. A proper degree of dilution favours this falutary procefs; and what ftrongly proves its ufe, and the neceffity of removing out of the fyftem the circulating fluid when it has performed its office, is the well-authenticated circumftance of perfons having lived long on water alone, in fituations where they were prevented from receiving any fupply of folid aliment from without.

Now as there is here no new fucceffion of circulating fluid that is properly nutritious, that which is already contained within the veffels, muft be perpetually acquiring properties which render it more and more injurious;

and from this circumftance alone, a conftant wearing out of the vital powers will be produced. This however is much checked by taking in water, which will carry noxious matter out of the fyftem, and likewife affift in the nutrition of the body, by promoting the abforption of fat.

As the action of the ftomach, in digefting folid aliment, appears to engage a good deal of the powers of the body at the time, we may probably conclude that it is in general a falutary action; and therefore, that a diet may be too watery, even though the fame quantity of nutritive matter were conveyed into the body in a given time, as when a more folid aliment was employed. The effort attending the procefs of digeftion is very ftrikingly fhewn in a variety of cafes independent of difeafe; as, for inftance, where a perfon has been long kept without food, in a fituation where little external ftimulus has been applied, and therefore where fimple debility, without difeafe, has reached its utmoft height. Perfons unfortunately buried in the fnow, or miners fhut up from the air, by the falling in of the earth, whilft at work under ground, have lived for many days without food, and have ſurvived ſuch an accident; but it is invariably found neceſſary, on firſt breaking their faſt, that the action of the ſtomach ſhould be reſumed in the gentleſt manner, and with the leaſt poſſible ſtimulus, avoiding both irritating aliment, and any but the ſmalleſt degree of diſtention of ſtomach from mere quantity. An invalid, recovering from a long and debilitating ſickneſs, is nearly in the ſame ſituation; and hence he muſt be fed with ſoft, eaſily digeſtible food, taking care not to overload his ſtomach with any exceſs of quantity, and at the ſame time guarding againſt emptineſs of that organ, by food taken often and in ſmall portions. The caſe is much the ſame with new-born infants, whoſe natural food, milk, is highly nutritious, and little ſtimulating either in form or contents, and at the ſame time much diluted.

The circumſtances, therefore, which will indicate the quantity of aqueous dilution neceſſary, depend immediately on the nature of the food, and the ſtate of the ſtomach to prepare that food for the ſupport of the body. If the aliment be naturally watery, and little ſtimulating, leſs dilution will be required, and vice verſa. Animal food likewiſe ſeems to require to be accompanied with more water, on account of the readineſs with which it is aſſimilated, and its ſuperior liability to thoſe ſpontaneous changes within the body, which rapidly nouriſh, but at the ſame time as readily become noxious, and require removal. On the other hand, ſeveral animals that feed entirely on ſucculent herbage, ſeldom require any drink. If however, the powers of the ſtomach itſelf are not ſufficiently vigorous to receive ſolid food, and to extract the nutritious part, the proceſs of digeſtion muſt be, as it were, begun out of the body; as far at leaſt, as to preſent to the ſtomach the truly alimentary part, ſeparated as much as poſſible from that which would be excrementitious, and already in ſolution in a ſufficient quantity of water. This is done by the various kinds of ſoups, broths, gellies, and decoctions, that form ſo great a part of the diet of the invalid; and the proper regulation of which forms no unimportant part of the buſineſs of his medical adviſer.

A defect in the powers of digeſtion, may or may not have its origin in the ſtomach, and perhaps ſome important diſtinctions in practice may ariſe from this circumſtance. That it may occur independently of diſeaſe in this organ, is evident from the weakneſs of digeſtion produced by mere bodily or even mental fatigue, or by ſimple abſtinence; but the ſtomach is at all times ſo ſenſible to any great diſturbance of any of the animal functions, as to have its own proper actions at once thereby diſordered. In by far the greater number of acute diſeaſes, the diminiſhed force and irregular actions of the ſtomach, are merely ſymptomatic; but in the chronic affections of this organ, the true dyſpeptic ſymptoms which we ſo conſtantly meet with in perſons who have led a life of high indulgence in the luxuries of the table, appear to be for the moſt part ſeated in the ſtomach itſelf, and the biliary organs that are ſo cloſely connected with the buſineſs of digeſtion. The advantage to be derived in theſe caſes from an aqueous diet, or water, taken as it were medicinally, are very great, and will preſently be mentioned.

ON THE INTERNAL USE OF WATER AS A MEDICINE.

We now proceed to confider the ufe of water as a medicine, in the various acute and chronic difeafes, to which, under one form or other, it is conftantly applied.

Writers on the materia medica have juftly made a diftinct order of diluents, as medicines differing in their operation from that of all other fubftances. I mean now to make fome obfervations on this clafs of medicines, only I muft reduce the catalogue of *diluentia* to a fingle article, namely, pure water, employed however at different temperatures, according to the indications pointed out by different fymptoms which will be noticed as they occur.

The employment of water as a diluent in *acute difeafes*, is one of the moft important of its ufes confidered as a medicine, and it will not be uninterefting to inquire on what grounds are founded thofe beneficial confequences that attend its ufe in thefe cafes.

It appears to me that many phyficians who have been in the habit of prefcribing particular forms of diluents, either as ptifans or decoctions of fome demulcent vegetable, neutral falts largely diluted with water, or vegetable and mineral acids in a grateful form, have not always laid due ftrefs on the moft important ingredient in all thefe prepared drinks, the watery diluent itfelf. This may be partly owing to the familiar ufe which we make of water in diet, rather than as a medicine; and yet, important as this article of the ingefta is at all times, it might be thought peculiarly fo at the time of acute difeafe, when none of the circumftances that ufually affect the ftate of the body are inactive in producing changes, good or bad, upon the difordered frame. The little activity too fhewn by moft of the impregnating matters of thefe drinks, when taken feparately, compared with the effential benefit which they produce when in the form of the greateft dilution, would alone direct the attention of the medical inquirer, to that part of the diluent medicine, the powers of which it is my prefent object to illuftrate.

The inftinctive defires or averfions of perfons labouring under any fpecies of difordered functions, have been juftly confidered as de-ferving the higheft attention from the phy-fician, and in moft cafes, when prefent, will furnifh him with ufeful hints for his treatment of the patient. In acute difeafes, the thirft after water is peculiarly remarked as a cha-racteriftic fymptom, and one that is fufficiently conftant to be a bafis of nofological defcrip-tion; and it is to be obferved, that here the wifhes of the patient are directed towards water alone, and that too of the moft icy coldnefs that can be procured. Thirft, there-fore, is a direct inftinctive indication of in-creafed heat and want of dilution, and this is fo uniform, that the degree of fever may often be pretty well eftimated by the eagernefs of the fufferer after cold drink. In like manner, I have often obferved it to be an unpromifing fymptom in fever, when the fenfation of thirft is only relieved for an inftant by taking large draughts of cold liquid; as it fhews that the furface of the body is ftill unable to receive the great benefits which are to be derived from fimple dilution. The feeling of thirft may however be in fome meafure relieved without general dilution, by topical applications, ſuch as graceful acids ſwallowed ſlowly, and the like. The relief given by theſe, is however but tranſient, as they act merely by producing a flow of ſaliva, and thus taking off the dryneſs and conſtriction upon which the ſenſation of thirſt immediately depends; but they do not ſupply the veſſels with that quantity of fluid which is neceſſary to keep up this ſecretion. It is the peculiar advantage of ſimple water taken as a drink, that we know it to be perfectly void of any noxious quality in itſelf, and therefore, in giving this fluid as a remedy in diſeaſe, the attention of the phyſician is only to be directed to the circumſtances of quantity and temperature.

The benefits ariſing from large dilution in acute diſeaſes, are not confined to the mere quenching of thirſt, though this is in itſelf highly advantageous; but it is after ſo much liquid is added to the circulating maſs, that the truly diluent effects are produced. To be fully aware of the importance of dilution in that ſtate of increaſed impetus of circulation, parching thirſt, and general irritation that conſtitute acute fever, we muſt recollect that it appears probable from the refearches of the beft phyfiologifts, that the blood is not merely a peculiar chemical mixt, but a living part of the animal economy, fubject to difeafe, equally capable of acting and being acted on, in a way which appears to be no more that of a mere chemical compound, than is the cafe with any other organized part of the body while performing the functions of life. One effential alteration which the blood undergoes during inflammation, and which is almoft characteriftic of inflamed blood, is a diminifhed tendency to fpontaneous coagulation. This, as the late ingenious Mr. Hewfon has clearly pointed out, is the immediate caufe of the fize or buffy coat of inflamed blood, and is produced by the circumftance of the red globular part fubfiding at the ufual time after the blood is drawn, but not accompanied by the gluten, which laft coagulates at a later period; and being now no longer mixed with the colouring globules, affumes a purer form, and its natural grey colour. This change of the coagulability of the blood is of itfelf probably a great advantage in enabling it to circulate more freely through the minuter veffels, and thus in ſome degree to counteract the effects of increaſed force of circulation.

But, on the other hand, there are other tendencies to derangement of functions, which the mere chance of mixture in the blood will not prevent. The greater rapidity of circulation cauſes this fluid to receive an unuſual degree of action; and if we can ſuppoſe it to be ſimilarly affected by this circumſtance, as the ſolids of the body are, this will increaſe the ſtate of fever, which is itſelf an exceſs of action in almoſt every part of the body. Another, and more unqueſtionable effect produced by increaſed circulation, is a correſponding increaſe in the quantity of heat given out by the aſſiſtance of the proceſs of reſpiration, as the circulation through the lungs affords a conſtant ſupply of combuſtible matter to keep up the animal temperature. In caſes of mere increaſed rapidity in the flow of blood, unattended with fever, the cooling proceſs of perſpiration carries off the exceſs of heat generated in the vaſcular ſyſtem; but in fever, as the exhalents on the ſurface of the body will not admit of a free paſſage to the perſpirable fluid, the only way to prevent the great accumulation of heat, is to leſſen the ſource of combuſtible matter in the blood. This is peculiarly well performed by ſimple aqueous dilution, which, whilſt it changes as little as poſſible the compoſition of the blood, ſimply increaſes its bulk, by the addition of a fluid not in itſelf liable to combuſtion by acceſs of air. Thus therefore, ſimple dilution diminiſhes the quantity of heat evolved from the lungs in a given time, by leſſening the actual proportion of combuſtible matter; and it poſſibly may have the ſame effect, by rendering that part of the blood which undergoes chemical change during the proceſs of reſpiration, leſs eaſily acted on by the air of the lungs when united with a large portion of water. There are certainly ſeveral analogies out of the body, which ſhew that a mixed fluid, compounded of active and inactive matter for chemical change, becomes more difficult of decompoſition in proportion as the inactive ingredient is increaſed beyond a certain point.

Again, as the blood re-acts on the veſſels in which it is contained, there can be little doubt but that this force of action muſt be increafed to a great degree by the circumftance of the blood being in a more active ftate than ufual, and probably evolving an uncommon quantity of heat during the whole of its courfe: this again is checked by aqueous dilution, which, as it were, quenches the flame and abates the unufual ftimulus arifing from the ftate of the inflamed blood.

Another fource of the advantage derived from introducing a greater quantity of pure water into the mafs of febrile blood, is in diminifhing the tendency to effufion of coagulable lymph from the ferous arteries. It is well known that one of the moft common terminations of inflammation of membranes is a copious effufion of gluten, or coagulable lymph, which, by affuming a folid form, occafions painful and dangerous adhefions; or elfe it is the production of true pus, the prefence of which brings on a variety of unpleafant fymptoms. Thefe confequences of increafed action in membranous parts, and of preternatural effufion, muft be much leffened by diluting the contents of the circulating fluid, which will diminifh the increafed ftimulus on the exhalent veffels, in the fame manner as it does that on the blood veſſels; and thus the ſerous effuſion will be brought back to its natural ſtate, in which it is readily and copiouſly taken up by the abſorbents in proportion to its production.

The whole lymphatic ſyſtem alſo ſeems equally to feel the benefit ariſing from dilution in acute diſeaſes. The eaſe with which fluids of all kinds are abſorbed, where the powers of theſe veſſels themſelves have not been impaired by diſeaſe, appears to be in ſome degree proportionate to their want of ſtimulating properties. The abſorbent veſſels appear to poſſeſs a power of ſelection out of the various ſubſtances preſented to them; this we know to be the caſe with the lacteals, and we may conclude it to be pretty true of the other veſſels of this order. Now, the fluids the moſt ſpeedily and largely abſorbed, are thoſe which moiſten the different cavities of the body, which in health are compoſed only of water mixed with a very minute portion of ſaline, and ſtill leſs of animal matter. In acute fever, therefore, the activity of the abſorbents will be probably increaſed by watery dilution; and whilſt water exerts ſo much power in augmenting the liquid ſecretions and excretions of the body, and therefore abundantly promoting the tranſmiſſion of fluid through the exhalents, I have never obſerved it to increaſe effuſion to a morbid degree, either in the cellular membrane, or cavities of the body. In this reſpect, therefore, this method of moderating febrile action by diluting the contents of the veſſels, ſeems to have a preference over actual evacuation by the lancet, though there are numerous caſes in which it is indiſpenſibly requiſite to have recourſe to this more powerful and ſpeedy mode of relief.

In all theſe great and obvious changes produced by increaſing the quantity of water in the fluids of the body, we find that it is to this liquid alone, that we can aſcribe thoſe great benefits of diminiſhing the ſtimulus of the circulating fluid in the whole vaſcular ſyſtem during acute diſeaſe, and thereby moderating the heat, thirſt, and violence of re-action in the ſolids; of preſerving all the ſecretory organs in a previous ſtate; and of checking that tendency to ſpontaneous change, which renders them poſitively noxious to the veſſels in which they are contained, and unfit to perform thoſe functions on which the health of the body ſo eſſentially depends. All theſe advantages depend, I ſay, on the mere quantity of watery dilution, and not on the ſaline, or vegetable, or animal matter which give a name and ſome ſenſible properties to the liquid in the form in which we uſually take it as a diluent. Theſe ſubſtances have, however, conſiderable uſe, both by giving that gentle ſupply of aliment in the leaſt ſtimulating, and moſt eaſily aſſimilated ſtate; and by applying ſaline medicines, the effect of which is great, in the form in which of all others their activity is the moſt favourably educed, that of ſolution in a large quantity of watery menſtruum. We accordingly find, that a mere increaſe of their doſes will not ſupply the deficiency of proper dilution, in which ſtate only does ſaline matter of almoſt every kind act the moſt favourably. It ſhould however be kept in mind, that nothing can add to the proper diluent power of ſimple water; and this diſtinction is certainly important, inaſmuch as it is always of conſequence to ſimplify our ideas with reſpect to the application of remedies, and to introduce precifion in terms where the things themfelves admit of accurate diftinction.

Simple dilution in active fever may, however, be carried to excefs, though not, I apprehend, in the way which would appear the moft obvious, that of increafing effufion to a morbid degree into the cavities of the body. But, an excefs of watery liquid thrown in fafter than the emunctories can carry it off, muft induce a temporary plethora in the blood veffels. It is certainly not improbable that the abforbents of the ftomach may be active, and tranfmit a fluid fo eafily taken up as water is, with great facility, whilft at the fame time the exhalents or the fecretory veffels, which are the extremities of the arterial fyftem, are comparatively inactive or morbidly conftricted, and the fecretion of urine equally defective. We know that, in health, the circumftance which induces us to take an unufual quantity of liquid, is a previous increafe of the action of the exhalents by means of exercife; and whilft this and the fecretion from the kidnies are kept up in full force, there can be little danger of plethora in the circulating veſſels. So, labourers in a hot ſummer's day, kept in conſtant exerciſe, and perſpiring profuſely at every pore, will take a quantity of liquid which any other time of health could not be borne by the ſtomach. But in fever, even when the neceſſity for copious dilution is urgent, and the thirſt and deſire for drink exceſſive, and yet the urine very ſcanty, and the ſkin dry and hot, it is often ſafer to take liquid in very divided quantities, and by conſtant ſipping; and thus the mere ſenſation of thirſt as far as it depends on want of moiſture in the mouth, will be conſtantly relieved, and yet the arterial ſyſtem not overloaded with liquid contents, till its exhalent extremities are brought into a more favourable ſtate for the tranſmiſſion of fluids. Diluents therefore, may in certain caſes give tenſion and plenitude; and it is probable that from this cauſe ariſes the ſudden determination to the head, which in languid habits, and in the debilitated invalids that reſort to watering places, ſometimes follows a full draught of water, even when there is no fever preſent. (*a*)

(*a*) See note on Malvern waters.

In the uſe of water in acute diſeaſes, much regard is to be had to temperature. The point to be aſcertaind is, the degree of cold that can ſafely be borne; for cold liquid fulfills the double intention of diminiſhing heat, eſpecially that of the mouth and fauces, and introducing aqueous dilution. In ſome ſtates of fever, however, theſe two purpoſes are incompatible; for where the re-action produced by the application of cold is too languid, abſorption by the ſtomach is diminiſhed; ſo that for this latter object tepid water will be the moſt favourable.

The circumſtances to which the uſe of cold water either internal or external are to be confined, are treated of in a very able manner in Dr. Currie's valuable work on " The Effects of Water, as a Remedy in Fever," a work which is well worthy of the attention of every medical practitioner, and of the great reputation which it has already acquired. It appears from the experiments of this acute obſerver, that the degree of cold to which water, uſed either as a drink or a bath, may be ſafely carried, is in direct proportion to the degree of animal temperature above the natural ſtandard which ſteadily prevails; and this again is proportionate to the vigour of the body and the ſtrength of the diſeaſe. Where the re-action of the ſtomach is ſtrong, advantage may be taken of this circumſtance to apply as it were a cold bath to this organ; and from the great ſympathy which exiſts between it and the ſkin, the ſame effect will often be produced as if the whole body were immerſed; that is, a relaxation of the febrile reſiſtance on the extreme veſſels will be produced, and a free perſpiration will follow. It is to be obſerved likewiſe, that in proportion to the coldneſs of the water as a drink, attention muſt be paid to the period of fever in which it is applied. In the cold ſtage, as Dr. Currie remarks, it is to be always avoided, for, if taken at this time, it increaſes the chillineſs at the ſurface, the oppreſſion at the præcordia, and renders the pulſe more frequent and feeble. It is during the violence of the hot ſtage, that cold drink may be the moſt liberally allowed; eſpecially where the heat, as indicated by the thermometer, is ſteadily higher than natural. But, again, when the ſubſequent perſpiration to which it largely contributes is fully eſtabliſhed, and the natural cooling proceſs is going forward, cold drink is then to be withheld, as it might check this ſalutary ſecretion; and indeed the deſires of the patient ſeldom call for it at this period. The temperature of drink therefore, at the different periods of a cold, hot, and ſweating ſtage of a ſimple febrile paroxyſm, ſhould be, in general hot in the firſt caſe, cold in the ſecond, and tepid in the third; and it is chiefly in the ſecond ſtage that the quantity may be the moſt liberal.

Part of this ſubject however, is intimately connected with the external application of cold water in fevers, and we ſhall therefore reſume it in the following chapter.

WHAT has been ſaid of the employment of water as an article of food, and as a medicine in acute diſeaſes will, in a conſiderable degree, apply to the uſe of this liquid in *chronic diſorders*, and in relieving particular ſymptoms. There are however ſome circumſtances relating to an habitual ufe of water, which require fome notice, as they are intimately connected with the fubject of mineral waters.

Much has been faid by eminent writers concerning a proper felection of the water which is to be ufed in various forms as our common drink; and an attention to this object, has been as ftrenuoufly infifted on in recommending a place of refidence, as the more obvious circumftances of air and fituation. There certainly appears to be fome ground for this caution, for any confiderable impurity in a liquid which makes fo large a part of our diet, muft be felt, in fome way or other, in the general functions of the animal economy. Dr. Heberden, an accurate obferver, and moft judicious practitioner, has particularly infifted upon this point, and has recommended as a fair fubject of experiment, a courfe of diftilled water to be ufed medicinally in thofe cafes which have been thought peculiarly expofed to receive injury from the hard fprings in common ufe (*a*). It is to be regretted however, that we have not fuch authentic facts and obfervations conducted on a fufficiently

(*a*) Medical Tranfactions, vol. I.

large ſcale, as to enable us to tell with preciſion, what are the inconveniences really produced by uſing a water loaded with foreign ingredients. It is certain that the ſalts which give the quality of hardneſs to ſpring water, are always to be found in one form or other in the fluids of the body in the ſtate of the beſt health, and they appear to be neceſſary to the conſtitution of theſe fluids. Thus we find the component parts of ſelenite and common ſalt, in the ſerum of the blood, in the urine, and other ſecreted fluids; and even if theſe ſalts be conſidered as merely excrementitious, it would appear that in common caſes and in a healthy ſtate of body, the uſual courſe of circulation is ſufficient to throw them off into the excretions. Hard and impure waters have long lain under the imputation of producing calculous complaints, and have therefore been ſtrictly forbidden to perſons labouring under theſe diſorders; and it is unqueſtionable that in many inſtances they increaſe the painful ſymptoms of this moſt diſtreſſing complaint. It muſt however, be confeſſed, that the chemical analyſis of theſe concretions throws but very little light at preſent on their formation, except to render it certain, that it is by no means to a ſimple depoſition of the earthy ſalts which form the impurities of common pump water, that we can attribute the origin of calculi. Soft waters have however a poſitive advantage over the hard, in poſſeſſing greater powers of ſolution over animal, vegetable, and ſaline matter; and this is ſhewn by experiments made out of the body. Therefore, ſince a pure ſoft water taken largely in diet, adds nothing that is capable of diſordering the ſyſtem, but on the contrary, is introducing into the circulation a liquid, which, from its being itſelf void of earthy and ſaline matter, poſſeſſes a greater ſolvent power than water already impregnated with foreign ſubſtances, this circumſtance appears to me to go a good way to explain the great benefit produced in calculous complaints, by a water like that of Malvern (as Dr. Wall has ſuggeſted), which contains ſcarcely a notable proportion of ſalt of any kind; and on the other hand, the inconvenience ariſing from uſing a water already almoſt ſaturated with an earthy ſalt, ſuch as the hard ſpring water which forms the commoneſt of all aqueous drinks. Sometimes however, hard water appears to be pofitively noxious, and this is chiefly with very irritable ftomachs where it produces fymptoms of dyfpepfia. Invalids and young children are the moft likely to fuffer from this caufe; for the great importance of a healthy and regular performance of the functions of the ftomach and bowels in infants is well known, and a hard aftringent water taken into their tender organs, may very probably induce a faulty digeftion, coftivenefs, and diforder in the whole alimentary canal, which in infants is always dangerous, and fometimes fatal.

Another, and more decidedly beneficial ufe of water as a medicine, is in relieving thofe deranged functions of the ftomach and bowels, and biliary organs, occafioned by the moft frequent of all caufes of difeafe, efpecially with men of a middle age, and in eafy circumftances, a long and habitual indulgence in high food, ftrong drink, and all the luxuries of the table. In fuch cafes there are three direct caufes of difeafe, which operate at once in producing the morbid changes; they are, too large a quantity of food for the wants of the body, too great a proportion of ſolid to fluid aliment, and all the ingeſta of too ſtimulating a kind.

The ſtomach, being here in a conſtant ſtate of high excitement and over-diſtention, becomes gradually debilitated, and unable to perform duly the office of digeſtion; hence ariſe heart-burn, flatulence, and ſour eructations, the effect of the ſpontaneous changes produced in the maſs of food when not entirely checked by the digeſtive proceſs; hence too a great irregularity in the ſecretion of bile, either on the one hand highly acrid, ſo as to increaſe the morbid ſtimulus on the ſtomach by regurgitation into that cavity; or elſe ſcantily ſupplied, and therefore unable to complete the ſeparation of chyle, and producing obſtinate coſtiveneſs from the abſence of the neceſſary and healthy ſtimulus on the inteſtines. At length too, comes on an alarming defect of nervous energy, and a dangerous determination to the head, and palſy or apoplexy often compleat the derangement of the animal frame.

With all or any of theſe ſymptoms to combat, it muſt ſuggeſt itſelf to a prudent phyſician, that next to relieving ſuch of them as are very urgent, it becomes of the higheſt importance to endeavour to come at the fountain head of theſe diſorders, and to reſtore the healthy function of the ſtomach, that organ the diſeaſed ſtate of which had been the cauſe of all this miſchief. To fulfil this intention, which can only be done very gradually, no general plan of cure ſeems to be ſo ſtrongly indicated, as a conſtant and habitual addition of a conſiderable quantity of water in divided doſes to the daily ingeſta. This ſimple remedy will of itſelf remove the defect of an over proportion of ſolid aliment, will render every kind of food leſs ſtimulating, leſſen the irritation in the primæ viæ, dilute the bile when acrid, moderate its ſtimulus on the bowels, and render the diſcharge of the excrementitious part of the food more regular and eaſy. This I am convinced is the true ſource of *part* of the relief given in dyſpeptic complaints, by all our moſt celebrated mineral waters; and of *the whole*, in ſeveral waters of high reputation (allowing for the circumſtance of temperature). I am far from aſſerting however that mere aqueous dilution is of itſelf equal to reſtore the healthy functions of thofe digefting organs that have been deranged by a long continuance in the habits which produce dyfpepfia. Every practitioner is acquainted with thofe valuable and more active remedies, which it is neceffary to ufe in fuch cafes; but thefe it is not my intention to enlarge upon.

In the ufe of water as a medicine in chronic as well as acute difeafes, regard is alfo to be had to the circumftance of temperature.—The fimple diluent effect will be perhaps the moft powerful at a temperature approaching to the animal heat, or nearly that of Briftol water; it is however, lefs grateful at this degree than that of 45° to 60°, the ufual heat of our ordinary fprings. The common idea of the debilitating effect of tepid water, feems to be but ill founded, except we go to a height of temperature much above that of the animal body. The tepid waters of Briftol or Bath are never obferved to produce any weakening effect on the ftomach, but, on the contrary, the appetite and general health are improved under the ufe of them; and it does not appear that in any of the thermal mineral fprings that we are in the habit of ufing medicinally, their high temperature counteracts the invigorating qualities of their foreign ingredients. Delicate and very irritable ſtomachs often require a tepid warmth to be given to their drink; for the proceſs of digeſtion may in theſe habits be ſuddenly diſturbed by a draught of cold water, and ſickneſs may immediately follow. Warm water has often a remarkable effect in abating that diſtreſſing and gnawing pain ariſing from acrimony in the undigeſted food, commonly known by the term, heart-burn. A draught of water, taken as warm as it can be drank, will often give very ſudden relief in this complaint. (*a*)

Water drinkers are in general longer livers, are leſs ſubject to decay of the faculties, have better teeth, more regular appetites, and leſs acrid evacuations, than thoſe who indulge in a more ſtimulating diluent for their common drink. It is not my intention to give a catalogue of all the diſorders that have been, or may be more or leſs relieved by a judicious

(*a*) For further particulars on the treatment of dyſpepſia ariſing from a diſeaſed liver, and on the uſe of the aqueous regimen, I beg leave to refer the reader to my Treatiſe on the Structure, Economy, and Diſeaſes of the Liver. 3d. Edition.

uſe of this liquid; nor do I mean to aſſert that it is applicable in every caſe of dyſpepſia indiſcriminately. Every phyſician muſt be aware of the great difficulty of treating a diſeaſe, which is ſo varying in its ſymptoms, ſo obſtinate in adhering to debilitated ſtomachs, and eſpecially ſo expoſed to be affected by accidental circumſtances, by having its ſeat in that organ, which of all others receives the greateſt variety of impreſſions from external cauſes. It is ſufficient to have enlarged upon one of the various remedies which art makes uſe of; and which, from its ſimplicity, from its gradual and powerful operation, and from the eaſe with which it may be always procured, deſerves the higheſt attention from the medical practitioner.

CHAPTER VI.

ON THE EXTERNAL USE OF WATER.

WE have hitherto confidered the ufe of water as an article of diet, and as an internal diluent in acute and chronic difeafes; there is another very important application of this liquid which deferves attention, its employment externally as a bath, either general or partial, and at any temperature, from ice-cold, to a degree of heat as great as the fkin can bear it.

The circumftance of the animal temperature being about a medium degree between thefe extremes, the great effect that immerfion has upon that temperature, and the powers of the body that produce and regulate it, have caufed an effential difference in the phyfiological and medical view of this fubject, according to the degree of heat at which immerfion is employed; and therefore, it will be neceffary to confider feparately the fubject of bathing, in a heat much under that of the animal, and in one that nearly equals, or is above it. We fhall find that in proportion as theſe two extremes of temperature approach each other, they become leſs powerful, each in their particular mode of action; ſo that, although the diſtinction of the cold from the warm bath be very decided, the tepid bath partakes in ſome degree of the properties of each.

On the Cold Bath.

Immerſion in water at a conſiderable degree below the animal temperature, is an agent capable of producing very powerful effects upon the whole ſyſtem, on account of the extent of ſentient ſurface to which it is applied; which is much greater than that of any other curative application that we are in the habit of uſing. All the important facts that belong to this ſubject, or nearly ſo, regard merely the circumſtance of the *temperature* of the liquid which is employed for the purpoſe of immerſion; (taking into conſideration its capacity for receiving and tranſmitting heat) and it is therefore to the habitudes of the body with mediums of different temperature, that we are principally to look for an explanation of the various phenomena that occur.

When a healthy perfon is immerfed in cold water, the following occurrences are well known to take place: firft, there is a general fenfation of cold, forming that fudden fhock to the whole fyftem, which is one of the moft important effects of the cold bath. This is almoft immediately fucceeded by an equally univerfal fenfe of warmth, which increafes rapidly to a certain point, fo as to caufe the furrounding water, though actually cold, to feel of a comfortable warmth; and this feeling is fooner produced, and continues longer, in proportion as the perfon is in full health, and naturally poffeffing a vigorous circulation. By degrees, however, if the body continues immerfed, it becomes chilled; violent fhivering comes on, the extremities grow numb and pale, fometimes ficknefs takes place, and at laft, the animal powers are exhaufted by cold and fatigue. In this procefs, the moft remarkable effects are thofe which occur firft, and are directly confequent to the fhock of immerfion; and thefe require particular attention in a medical view, as it is only to the production of thefe that the cold bathing fhould be fuffered to proceed.

The fenfations of returning warmth which take place directly after the cold of the firft immerfion, conftitute what has been called the *reaction* of the fyftem; and this is certainly a proper and characteriftic term, as it imports an action produced in the body itfelf, to refift an external impreffion. Reaction in this place, feems to be a peculiar effort of the living power, and to be excited in a degree proportionate to the force of that power, and to the intenfity of the caufe which called it into action. It implies not merely an increafe of the production of animal heat, but, fuperadded to this, a fudden effort within the body, and the whole arterial fyftem, to overcome an impreffion on the extremities as fudden and powerful. Hence it is, that a mere abftraction of heat, by a cold medium, will not produce that which is precifely meant by reaction, except the external cold be applied fuddenly, and to a large furface. Thefe two conditions are fulfilled by fudden immerfion into cold water.

The fuperior power of conducting heat, which water poffeffes over air, is alfo a circumftance that is always to be kept in mind in applying cold externally. This is particularly ſhewn where a perſon continues long in this cold medium, beyond the firſt effects of reaction. On account of the high conducting power of water, the body muſt be conſtantly employed in producing an unuſual quantity of heat; and this appears to be a great effort in the conſtitution, which, if carried too far, goes directly to deſtroy the animal powers.

Thus, the exerciſe of ſwimming, to thoſe that are accuſtomed to it, is one which in itſelf requires comparatively but little muſcular exertion; but, being performed under circumſtances that highly exhauſt the animal ſtrength, it proves more fatiguing than almoſt any other kind of motion of the limbs. This too is increaſed by a ſuperior coldneſs in the medium, and the permeability of the ſkin to heat; and therefore, inhabitants of hot climates, protected by the greater unctuoſity of their ſkin, and favoured by the warmth of their ſeas and rivers, are enabled to lead almoſt an amphibious life. The uniform and gradual exhauſtion of the vital energy, by being kept in a cold medium with great conducting powers, produces a ftrong tendency to fleep, provided the exhauftion be gradual, and does not proceed at once fo far as to produce fhivering and quicknefs of pulfe, and that derangement of the functions, which refembles the cold fit of an intermittent.

The peculiar fenfibility of the fkin to the impreffion of fudden cold, as produced by the cold bath, may often occafion effects fomewhat different in degree from what might be expected from the mere circumftances of the coldnefs of the water, and the general vigour of the body.

This fenfibility may probably be in fome cafes more, in others lefs, than the general balance with the arterial fyftem; and thus the effects of cold immerfion will not, with all perfons, be followed by a reaction precifely proportioned to the coldnefs of the fluid which determines the actual force of impreffion, and the ftrength of the conftitution to regulate the reaction. To a diminifhed fenfibility of the fkin, occafioned by long habit, we may probably attribute the eafe with which the attendants on the cold and fea baths, remain for fome hours in a medium, which, from its low temperature, would exhauſt and benumb thoſe who are not accuſtomed to this practice.

Another very important circumſtance which regards the ſubject of cold bathing is, the great ſympathy which exiſts between the ſkin, on the one hand, and the ſtomach and diaphragm, on the other. This is ſhewn in a variety of inſtances, and is mutual, ſince either part may be affected by an impreſſion made on the other. A ſtriking inſtance of it is ſeen in the effects of gradual immerſion in a very cold bath, on perſons of a highly delicate and irritable habit, where, as ſoon as the ſurface of the water reaches the level of the ſtomach and diaphragm, violent ſobbing, ſhivering, and often ſickneſs, are the conſequence. On the other hand it is well known, that in acute fever, a glaſs of cold water taken into the ſtomach will ſometimes relieve a dry burning ſkin, by inducing copious perſpiration. Likewiſe, as Dr. Currie has obſerved, the ſhivering and numbneſs of limbs conſequent on long expoſure to cold and wet, is ſooneſt removed by a bladder full of hot water applied to the pit of the ſtomach. It is often neceſſary to advert to this ſympathy of parts, in regulating ſeveral circumſtances that may occur when the cold bath is uſed medicinally, as whether it ſhould be employed when the ſtomach is full, or when empty, and the like.

The difference that often occurs between the ſenſations of heat and cold, and the real ſtate of the animal temperature as taken by the thermometer, muſt alſo be attended to. This is ſhewn in a ſtriking manner during the whole proceſs of immerſion in very cold water, in an experiment related by Dr. Currie, to whoſe excellent work we ſhall often refer. When a healthy perſon was expoſed to this ſituation, the firſt ſenſation was that of ſevere cold, ariſing from the great ſhock and ſudden change of temperature; to this ſucceeded a ſenſe of warmth, owing to the commencement of reaction which continued for a while, and then gradually gave place to a great degree of chillineſs and exhauſtion: but the degree of animal heat, (as indicated by the thermometer placed under the tongue), which was the loweſt juſt after immerſion, continued to riſe very ſteadily and ſlowly, long after the glow from the firſt reaction was paſt, and whilſt the ſenſations were thofe of lofing heat. The fenfation of heat likewife is at times equally fallacious. The touch of frozen mercury is like that of a red hot iron.

The effects produced by the cold bath on the pulfe, are often very ftriking; but it is neceffary to be aware of the increafed frequency produced in perfons not in the leaft feverifh, by the mere apprehenfion of plunging into very cold water. This natural, and in many perfons infuperable alarm, may very materially retard the falutary reaction in delicate habits, efpecially where the degree of cold is carried to the utmoft extent which the conftitution is at all able to overcome. To fuch, much advantage will be derived from a tepid bath, where the fhock is more moderate, as for example, that of Buxton; and even the idea and name of a tepid bath, has fome effect in reconciling the mind as well as the body in fome degree to the impreffion of fudden cold. When the fhock of immerfion is fully over, and the reaction eftablifhed, the pulfe becomes flow, regular, and in general, fmall; and fo continues till the body begins to be chilled, if the immerfion be perfevered in. This change of pulfe from being hurried and irregular, to a flow and fteady heat, is moft ftrikingly fhewn in immerfion or affufion of cold water during ardent fever, and is one of its moft falutary effects.

Much has been alledged in favour of the advantage of falt over frefh water ufed as a bath. Where the fkin is particularly irritable, and efpecially where any cutaneous difeafe is prefent, there is no doubt but that the faline ingredients of fea-water may have confiderable effect: the fame may be faid when a perfon is immerfed for a confiderable length of time, as in long fwimming in the fea; but where the immerfion is but momentary, as is the cafe with by far the greater number of invalids who ufe this powerful remedy, and where the moifture that adheres to the fkin is wiped off carefully as foon as the patient comes out of the water, it is difficult to conceive how fea-water fhould here have any action different from frefh water at the fame temperature, and in the fame circumftances of agitation and expofure.

The difeafes and morbid fymptoms for

which the cold bath, under one form or another, may be applied with advantage, are very numerous, and ſome of them deſerve particular attention. One of the moſt important of its uſes is in *ardent fever;* and, under proper management, it forms a highly valuable remedy in this dangerous diſorder. The evolution of an uncommon quantity of heat, and a temperature ſeveral degrees above the natural ſtandard, attended with a dry unperſpirable ſtate of the ſkin and extreme veſſels, are characteriſtic of ardent fever; and theſe ſymptoms are more or leſs accompanied with a hurried unſteady pulſe, and wandering of the thoughts or complete delirium. Whatever be the proximate cauſe of fever, the moſt obvious and moſt urgent indication is to get rid of this exceſs of heat which certainly aggravates all the other morbid ſymptoms, and which nature is not at that time able to effect by the cooling proceſs of increaſed perſpiration. By whatever means this proceſs could be brought on, the end of cooling the body would be anſwered; for we find that in health, it is abundantly ſufficient to counteract an external temperature much higher even than that of a tropical ſun: but in fever, the morbid ſtate of the extreme veſſels is difficult to be overcome, except by the actual application to the ſkin of a cold medium, whoſe power of conducting heat is conſiderable. We poſſeſs ſeveral methods of performing this ſalutary operation, which act with different degrees of energy. Cool air, the free circulation of which is always aimed at in the preſent mode of treating acute fever, we may conſider as the loweſt in the degree of conducting power, and yet the effects ariſing from this ſimple application are highly ſenſible and ſalutary. Air, when at reſt, is known to be a very bad conductor of heat; and therefore its *circulation* through the chamber, and around the body of the patient, is to be particularly attended to. A more powerful method of cooling the body is that of waſhing the ſkin, on every part ſucceſſively, with cold water or cold vinegar; and as this operation always admits the play of air upon the feveriſh body, the ſpeedy evaporation which is thus produced, forms a cooling proceſs that acts with great energy. This, however, yields in force to the bold and vigorous practice which has occasionally been adopted, of plunging the whole body into cold water, or, (what amounts to the same, and is more convenient of application) that of dashing a sufficient quantity of water over the naked body. This custom, which is a common remedy in hot climates, and has been practised by a daring and often successful empiricism among several uncultivated nations who follow only the dictates of nature, has been lately recommended to the world under such judicious directions, as to be made a remedy capable of being adopted to a very great extent, and with nearly as much safety as confidence.(*b*)

It is highly important, however, to attend to the precautions which the use of this vigorous remedial process requires. "Affusion with cold water," as Dr. Currie observes, "may be used, whenever the heat "of the body is steadily above the natural "standard, when there is no sense of chilliness, and especially when there is no general nor profuse perspiration. If used "during the cold stage of fever, even though

(*b*) This forms the most interesting part of Dr. Currie's valuable work, which we have before referred to.

" the heat be higher than natural, it brings
" on interruption of refpiration, a fluttering,
" weak, and extremely quick pulfe, and cer-
" tainly might be carried fo far as to extin-
" guifh animation intirely." The moft falutary confequence which follows the proper ufe of this powerful remedy, is the production of profufe and general perfpiration; and this is a confequence, partly, perhaps, of the fudden reduction of the animal heat to its natural ftandard, but principally of the great reaction produced throughout the whole of the circulating fyftem by means of the violence of the fhock. It is this circumftance that appears to give fo much advantage to a *general* effufion of cold water in fevers, in preference to any partial application.

It has been faid by fome medical obfervers, that the procefs of perfpiration is diminifhed by a higher degree of animal temperature than is natural, as much as by one that is too low; or, in other words, that there is a precife point of temperature which is the moft favorable to the flow of this excretion; and therefore, when too high, it may be often neceffary to bring down the animal heat to the perfpirable point. Perſpiration, however, is ſo powerful a cooling proceſs, that we can hardly conceive a caſe where it ſhould not of itſelf prevent any conſiderable increaſe in animal heat, when it has been able to flow freely and fully; and therefore, when ſuch an accumulation of heat has taken place, it only ſeems to indicate a deficiency of perſpiration in the firſt inſtance, and this deficiency to have been brought on by the peculiar ſtate of the exhalent veſſels. So that, whether any addition of heat be made to the body from external cauſes, or from an augmented force of circulation, and more rapid combuſtion within the body, it ſeems, I think, neceſſary in all caſes that the power of exhalation ſhould be checked from ſome cauſe or other exiſting in thoſe veſſels and the ſentient extremities, before the accumulation of animal heat can be produced.

The application of cold in any way to the ſkin during ardent fever, whilſt it diminiſhes the animal temperature, takes off the parching thirſt, leſſens the frequency and hurried beat of the pulſe, and renders it ſlow, full, and regular. It likewiſe removes that reſtleſſneſs and wandering of ideas which precede a complete delirium, and occafions a found and eafy fleep. If an intire immerfion in cold water be employed, and the body be in a fit ftate to produce reaction, a full and general perfpiration will follow; and this is much more complete than where no previous fhock of cold had been given; and in the earlier ftages of fever it will often intirely put an end to the complaint.*

Thefe circumftances, therefore, are decidedly in favour of univerfal ablution, over that which is only partial; and as that reaction which brings on a perfpirable ftate of the fkin will be produced with the former, by ufing water even of a tepid warmth, it may be fo regulated to the ftrength of the patient as to be applicable to almoft every cafe of increafed animal temperature. There are many particular fymptoms which receive much relief from applying cold water to the parts affected. So, I have

* See Dr. Currie's farther illuftration of this fubject, in a fecond volume lately publifhed, of his Medical Reports, on the effects of water, &c. &c. in which there is a very interefting letter from Dr. Gregory, on the falubrious effects of cold bathing, in the *Scarlatina*.——See likewife a very ingenious treatife concerning Sea Bathing, by A. P. Buchan, M.D.

often found, that the dry burning heat of the palms of the hands which attends hectic fever, is relieved in a remarkable manner by making the patient hold in his hands a cloth wetted with cold water; and I have even feen the pulfe made flower and more regular, by this topical application.

The cold bath is better known, efpecially in this country, as a general tonic remedy in various *chronic difeafes*, and under thefe circumftances fome precautions are neceffary, different from thofe required in acute fever.

In chronic difeafes it is to be obferved, that the cooling power of cold water is not the object in view; nor is it at all requifite or falutary, except as being the medium through which the reaction is excited. The general circumftances of diforder for which cold bathing appears to be here of fervice, are, a languor and weaknefs of circulation, accompanied with profufe fweating and fatigue on very moderate exertion, tremors on the limbs, and many of thofe fymptoms ufually called nervous; where the moving powers are weak, and the mind liftlefs and indolent, but at the fame time where no permanent morbid obftruction, or viſceral diſeaſe is preſent. Such a ſtate of body is often the conſequence of a long and debilitating ſickneſs, or of a ſedentary life, without uſing the exerciſe requiſite to keep up the activity of the bodily powers.

In all theſe caſes, the great object to be fulfilled is to produce a conſiderable reaction from the ſhock of cold water, at the expence of as little heat as poſſible ; and when cold bathing does harm, it is preciſely where the powers of the body are too languid to bring on reaction, and the chilling effects remain unoppoſed. When the patient feels the ſhock of immerſion very ſeverely, and from experience of its pain, has acquired an almoſt inſuperable dread of this application ; when he has felt little or no friendly glow to ſucceed the firſt ſhock, but, on coming out of the bath, remains cold, ſhivering, ſick at ſtomach, oppreſſed with head-ach, languid, drowſy, and liſtleſs, and averſe to food and exerciſe during the whole day, we may be ſure that the bath has been too cold, the ſhock too ſevere, and no reaction produced at all adequate to the contrary impreſſion on the ſurface of the body.

In acute fever, therefore, the object of the cold bath is to leſſen the permanent heat of the body, to bring on univerſal perſpiration, to diminiſh action over the whole circulating ſyſtem, and thereby to occaſion a ſtate of repoſe of body and mind, and ſound ſleep. In chronic diſorders, on the other hand, the intention of this remedy is, finally to increaſe the animal temperature through the medium of powerful reaction, to ſtrengthen the moving powers, excite the nervous energy, and render the whole frame more active and alert; and to this too, the circumſtance of exerciſe, taken as fully as the ſtrength will bear, will highly contribute. In both caſes, however, a reaction on the ſurface, by means of excitement in the circulating ſyſtem, is the means through which the deſired effect is ſought for; only in the former caſe, this is fulfilled merely by eſtabliſhing the perſpiratory excretion in the fulleſt manner; in the latter, the operation appears more univerſal and more permanent.

There is a kind of ſlow irregular fever, or rather *febricula*, in which I have often found the cold bath of ſingular ſervice. This diſorder principally affects perſons naturally of a found conſtitution, but who lead a ſedentary life, and at the ſame time are employed in ſome occupation which ſtrongly engages their attention, requires much exertion of thought, and excites a degree of anxiety. Such perſons have conſtantly a pulſe rather quicker than natural, hot hands, reſtleſs nights, and an impaired appetite, but without any conſiderable derangement in the digeſtive organs. This diſorder will continue for a long time, in an irregular way, never intirely preventing their ordinary occupation, but rendering it more than uſually anxious and fatiguing, and often preparing the way for confirmed hypochondriaſis.

Perſons in this ſituation are remarkably relieved by the cold bath, and for the moſt part bear it well; and its uſe ſhould alſo, if poſſible, be aided by that relaxation from buſineſs and that diverſion of the mind from its ordinary train of thinking, which are obtained by attending a watering place.

There are ſome diſorders that require a tonic and ſtimulant plan of cure, which, from ſome peculiarity that we cannot well explain, are almoſt always hurt by cold bathing. Of this kind is the chlorofis, a diforder often extremely obftinate, and from the age at which it ufually affects females, always exciting a good deal of anxiety. Although in moft difeafes not attended with a determination of blood to particular vital parts, where a general tonic plan is indicated, the cold bath forms an ufeful auxiliary, yet I have here almoft invariably found it to be detrimental, and to increafe the head-ach, chillinefs, and languor, which at all times attend this diforder.

Cold bathing is likewife feldom admiffible in thofe cafes of difeafe in the ftomach, with defect in the powers of affimilating food, which are brought on by high living, and conftitute what may be termed the true dyfpepfia. The healthy ftate of this organ is fo intimately connected with the general power in the body of producing reaction on the fkin, that, where the former is much debilitated, will almoft conftantly fympathize with any difturbance produced by an exceffive and unufual impreffion on the latter. Befides, the procefs of digeftion feems to require a pretty uniform ftate of animal temperature; and therefore where the ſtomach is weak, this ſtate cannot be interrupted with impunity.

The effects of total immerſion in cold water, in diminiſhing the animal temperature, and occaſioning univerſal reaction on the ſkin, will ſometimes be produced in a degree, though imperfectly, on particular parts of the body, by topical cold bathing; which may therefore be employed, either in local inflammation to leſſen the heat directly, or in caſes of partial debility, to rouſe the languid circulation by exciting reaction.

The characteriſtic marks of active local inflammation, are, pain, ſwelling, redneſs, and increaſed heat in the part affected; and this laſt is both obvious to the hand and ſenſible to the thermometer. A topical application of cold water, or of a cold ſaturnine lotion, has become an eſtabliſhed practice, the efficacy of which is daily experienced. Some difference in the applicability of cold to topical inflammation, may be eſtabliſhed, according to the degree in which the whole ſyſtem is likely to be affected. There are ſome kinds of inflammation which ariſe without any very obvious caufe, and which fhew a remarkable fympathy with internal organs, efpecially the head and ftomach; of this kind is the febrile eryfipelas, preceded by naufea, rigor, and head-ach. In thefe the ufe of cold to the inflamed parts is always doubtful, and requires the utmoft caution. Another kind of inflammation is that which comes on fo far fpontaneoufly, as not to be produced by actual external injury, but yet arifes from predifpofing caufes that affect the whole fyftem; of this kind are many of the phlegmonous inflammations that follow a general expofure of the body to cold, wet, and fatigue; or that fucceed to gouty inflammation, and the refolution of fever: in fuch cafes, the employment of topical cold may produce much benefit, but generally requires much judgment and precaution. There are, however, other topical inflammations which arife from a fimple and direct morbid caufe, and in which the general fyftem is not at all affected, till the external difeafe, from violent and long-continued irritation, becomes itfelf the caufe of derangement to the whole conftitution. Thefe are the cafes that receive peculiar benefit from cold applications, which appear to extinguiſh the diſorder in its origin, and by ſo doing, prevent all the miſchief that ariſes from converting a local diſeaſe into a general one. Of this latter kind of topical inflammation, is that which ariſes from burns of every deſcription, and which, in by far the greater number of caſes, will bear a moſt liberal uſe of cold water, or even of ice; and this may be applied to a very extenſive inflamed ſurface, without even producing the ordinary effects of general chilling, which would be brought on from the ſame application to a ſound and healthy ſkin. This practice of employing ice, and ice-cold water, to burns, has ſucceeded perfectly with me in ſeveral caſes that have come under my care: one was that of a young lady, who was terribly burnt over the whole of the breaſt, by her handkerchief taking fire. In this inſtance I principally employed ice, which was kept conſtantly melting on the inflamed parts; and by this method, the ſuppuratory proceſs was prevented, as well as the great trouble which generally attends the cicatrizing of a wound from this cauſe, and the disfiguring ſcar which is always left for life, when the cure has been conducted in the common way. (*a*)

There are feveral cafes in which we find that irritation and heat of the fkin, produced by local inflammation, will be much relieved by cold water; and in thefe too we find that no bad confequence arifes to the general health by cold and wet upon the furface of the body. It is a common practice for thofe who frequent Malvern and fimilar mineral fprings for the cure of herpetic eruptions, or ulcerations of any kind, to wet their linen with the water, and drefs with it in that ftate, without receiving any injury. Another very diftreffing fymptom, remarkably relieved by cold water topically applied, is that intolerable itching of the vagina, which women fometimes experience, intirely unconnected with any general caufe, and which appears to be a kind of herpes confined to that part.

Cold water has alfo been ufed topically to parts that have become debilitated by being long

(*a*) I am happy to fee the ufe of ice and cold water in burns, which has of late been much employed by feveral practitioners, particularly recommended by Sir James Earle, in an "Effay on the Means of leffening the Effects of Fire upon the Human Body," lately publifhed by this eminent furgeon.

the ſeat of inflammation; and where, from a diſuſe of their natural actions, they have, in a great degree, loſt the power of voluntary motion. Such are the various caſes of ſtrains, bruiſes, and ſimilar injuries, in tendinous and ligamentous parts; and of rigidity of muſcles, that have been long kept at reſt, in order to favour the union of bone, where there appears to have been no organic injury, but only a deficiency in nervous energy, and in mobility of parts, or at moſt, only ſlight adheſions which would give way to a regular exerciſe of the weakened limb. The peculiar uſe of cold water here is to excite a reaction upon the debilitated limb, as appears from the increaſed warmth, and ſenſibility, and redneſs of the ſurface which follow this application when ſucceſsful. As however a partial reaction is more difficult to excite than one that is general, this may be materially aſſiſted by cauſing the water to daſh upon the affected part from a conſiderable height.

Another very ſtriking inſtance of the powerful effects of topical cold in ſtimulating a part to action, is ſhewn in the uſe of cold, or even iced water, to the vagina of parturient women, during the dangerous hemorrhagies that take place from the uterus on the partial ſeparation of the placenta. It is now generally allowed, that the uſe of cold here is not to produce any coagulum of blood, (ſince Mr. Hewſon has fully proved that blood coagulates ſooner at the animal heat than at any other) but to excite the uterus to action, and thus to propell its contents, the partial ſeparation of which had occaſioned the hemorrhage.

To conclude the ſubject of cold bathing, we may conſider this as one of the moſt powerful remedies that we poſſeſs againſt ſeveral highly dangerous and troubleſome diſorders; and one, the uſe of which may probably be extended with great advantage to a greater number of diſeaſes than thoſe in which we are now in the habit of uſing it: but for this purpoſe much judgment will often be required, and eſpecially more accuracy of diſtinction between different temperatures. We know that there are many invalids that receive much benefit from the comparatively high temperature of the Matlock and Buxton baths, who would be much injured by ſea-bathing. The great extent of ſurface to which this application is uſed, renders ſlight differences of *temperature* in the water (the only circumſtance in this liquid that appears to be of any importance when uſed as a bath) of conſiderable moment; and, whilſt we are able to regulate this temperature with ſo much accuracy by the thermometer, and at the ſame time, in febrile caſes, to determine the ſtate of the patient, and the propriety of uſing this remedy, we ought not to neglect to adopt this moſt uſeful inſtrument, as one of the few helps which phyſicians can command, whereby to increaſe their means of information, and to direct their judgment. In acute fever, the circumſtances that forbid the uſe of the cold bath, have been already mentioned; in chronic caſes, this remedy is chiefly *hazardous* in perſons, who are liable to a ſtrong determination of blood to the head, and ſtill more the lungs; and is capable of producing miſchief in weak and irritable conſtitutions, when the cold is carried to any great extent. People in active health, but addicted to the luxuries of the table, to a highly ſtimulant diet, and to a free uſe of wine, frequently ſuffer from the ſtrong reaction conſequent on immerſion; and on the other hand, weak habits, and children that poſſeſs a delicate frame of body, and a tendency to rickets, are often injured by an indiſcriminate uſe of this powerful remedy.

I cannot diſmiſs this ſubject without noticing the cuſtom, now become univerſally prevalent in this country, for perſons of all ranks to reſort annually to the ſea-coaſt, for the purpoſe of bathing, and thereby leaving behind them all the diſorders and irregularities in the body, that have been contracted during the colder ſeaſon. Cold bathing is no doubt a very ſalutary and refreſhing cuſtom to the perſon in health, and the exerciſe of ſwimming highly uſeful and pleaſant; but when immerſion in cold water is to be employed medicinally, we have ſeen that it is far too powerful a remedy not to be able to produce much miſchief when miſapplied. If we conſider the great difference that always exiſts between the ſummer atmoſphere and the heat of the ſea, the bleak expoſed aſpect of many even of our moſt favourite watering places, and the keen winds to which the bather muſt often be expoſed, I cannot but think that there are a great number of invalids, of young and puny children, and delicate females, who have been often materially injured in their health by an indiſcriminate uſe of this powerful application of cold; and are thereby diſappointed of the advantages of a more genial climate, and of country air, exerciſe, and amuſement, which altogether form a very valuable remedial proceſs, and give the great charm to a ſummer excurſion.

On the Warm and Tepid Bath.

We ſhall now proceed to make ſome obſervations on the *warm bath*, meaning thereby, the external application of water of ſuch a temperature as will at once give that ſenſation of warmth to the ſkin, which will remain permanently during the time of immerſion. It is to be remarked, that the animal temperature is aſcertained by inſerting the bulb of a thermometer under the tongue, with the mouth ſhut, ſo as to exclude the operation of the ſurrounding atmoſphere; and here it is almoſt exactly at the ſame height as it would be, if the inſtrument were introduced within an inciſion in the fleſh, or in any of the cavities of the body; that is, when the perſon is in health, at about 96° to 98° with little variation. But as the ſurface of the body is both expoſed to the external air, which is generally much lower than the animal heat, and as the ſkin is the ſeat of the great cooling proceſs, the excretion of perſpiration; the conſtant evaporation which is there going on, renders it always ſome degrees lower than the proper animal temperature. Hence it is found that the ſkin receives the ſenſation of warmth, and communicates this impreſſion, when in contact with water a few degrees lower than the animal heat; and this too gives riſe to ſome little uncertainty with regard to the preciſe degree at which the warm bath may be ſaid to commence. We may however reckon this to begin at about 92°, and to riſe as high as can be borne by the ſkin without pain.

The impreſſion of a heat greater than that of the part of the body which receives it, is probably, a direct ſtimulus, and as ſuch, it increafes the force and activity of circulation in the veffels to which it is applied, renders them full and turgid, and, according to the force of this ftimulus, occafions pain, rednefs, inflammation, ferous effufion, or intire dif-organization. As the furface of the body is readily fenfible to the impreffion of heat as well as cold, a comparatively fmall force of ftimulus in any heated medium, will produce confiderable effects, directly, from the extent of furface that receives the impreffion, and in-directly, by checking the conftant flow of heat out of the body into the atmofphere. This laft fource of accumulation of heat is, however, foon obviated by an increafe of the cooling procefs of perfpiration, when the body is in health; but in acute fever, when the ftate of the ex-treme veffels is fuch as not to admit of this procefs, a very little unufual heat in the fur-rounding medium is very fenfibly felt in the whole body. This was very apparent in the old method of treating the fmall-pox, and fuch febrile diforders, by what was called the hot regimen; which confifted in carefully ex-cluding the cool external air, and heating that of the patient's chamber to an almoft intolerable degree. The increafe in frequency of the pulfe, feverifh heat, thirft, and tendency to delirium, experienced under this treatment, has now caufed it to be almoft univerfally dif-ufed in this country.

Water being a much better conductor of heat than air, we fhould expect the general ftimulating effects of warm water to be greater than thofe of warm air; and it is certain that the body can bear a degree of heat in air, as a medium, much greater than in water. But thefe effects are in a remarkable degree coun-teracted by the great relaxation and perfpira-bility of the fkin which warm water occafions; and hence it may be ufed both with impunity and even advantage, in many cafes where the animal heat is already too high; for, by relaxing the fkin, the great cooling procefs of perfpiration will more readily follow, and the general effect will be that of diminifhing heat. In this view, therefore, it appears, that the operation of the warm bath to the dry hot fkin of a perfon labouring under acute fever and general accumulation of heat, may, in the end, be the fame as that of the cold bath; that is, by inducing general perfpiration, to bring down the animal heat to the natural ſtandard; and we actually find that this method is often employed with ſuccefs.

The warm bath has a peculiar tendency to bring on a ſtate of repoſe, to alleviate any local irritation, and thereby to induce ſleep. It is, upon the whole, a ſafer remedy than the cold bath, and more peculiarly applicable to very weak and irritable conſtitutions, whom the ſhock produced by cold immerſion would overpower, and who have not ſufficient vigour of circulation for an adequate reaction. In caſes of topical inflammation, connected with a phlogiſtic ſtate of body, preceded by rigor and general fever, and where the local formation of matter is the ſolution of the general inflammatory ſymptoms, experience directs us to the uſe of the warm relaxing applications, rather than to thoſe which, by exciting a general reaction, would increaſe the local complaint. This object is particularly to be conſulted when the part affected is one that is eſſential to life. Hence it is, that in fever, where there is a great determination to the lungs, and the reſpiration appears to be locally affected, independently of the oppreffion produced by mere febrile increafe of circulation, practitioners have avoided the external ufe of cold, in order to promote the folution of the fever; and have trufted to the general antiphlogiftic treatment, along with the topically relaxing application of warm vapour inhaled by the lungs.

Warm bathing appears to be peculiarly well calculated to relieve thofe complaints in the bowels that feem to depend on an irregular or diminifhed action of any part of the alimentary canal; and the ftate of the fkin produced by immerfion in warm water, feems highly favourable to the healthy action of the ftomach and bowels. Hence we find that the natural thermal fprings, when ufed as a bath, have all acquired a high and juft reputation for relieving colics and obftructions in the bowels, when they depend either on a defect of the bilious fecretion, or on a directly fedative and paralyfing caufe, fuch as the poifon of lead, and fimilar complaints; and the fame effect is produced, though in a lefs degree, by warm fomentations to the abdomen.

Another very important ufe of the warm bath is in thofe herpetic eruptions, where there appears a great deficiency of perſpirability in the ſkin; when it cracks, and leaves deep and painful fiſſures, which diſcharge a thin ſerous fluid; or elſe where there is a conſtant deſquamation of cuticle in dry bran-like ſcales. The warm bath is here highly advantageous in relaxing the ſkin, and rendering it more pervious, and prepares it admirably for receiving the ſtimulant applications of tar ointment, mercurials, and the like, that are intended to reſtore it to a healthy ſtate. Theſe complaints, however, require only a low temperature of the warm bath, ſo as to be merely relaxing, and not riſing to any great degree of ſtimulus from heat.

The conſtitutions of children ſeem to be more extenſively relieved by the warm bath than thoſe of adults; and this remedy ſeems more generally applicable to acute fever in them, than in perſons of a more advanced age. This is probably owing to the greater degree of irritability in the habits of children, a greater tendency to irritation in the alimentary canal, and the very ſtrong ſympathy with the ſtate of the ſkin, which it always ſhews. Where the warm bath produces its ſalutary operation, it is almoſt always, in children, followed by an eaſy and profound ſleep.

I cannot omit this opportunity of giving a caution with regard to the uſe of the cold bath in the true menorrhagia of females, and inſtead of it, to recommend that of tepid warmth, or even higher. From the great degree of pain and uneaſy ſenſation about the loins, and the general feveriſh irritation which attends this diſcharge, it requires in almoſt all caſes to be conſidered as an active hemorrhagy, produced by a determination of blood in the uterus, in the ſame way that hemoptyſis is brought on by a determination to the lungs. The cold bath commonly does harm in theſe caſes, and increaſes the pain of the loins and general fever; but I have often experienced much benefit by a bath of a tepid or warm temperature, applied as a ſemicupium.

The powerful and extenſive ſtimulus of heated water is uſed to very great advantage in paralytic affections of particular parts; whether the conſequence of general derangement in the circulation, and the alarming relics of apoplexy, or ariſing from local injury on the fpine or the origin of the nerves. In fuch a lofs of nervous energy, where there is already a want of due animal heat in the part affected, and a languid circulation, all external cold is prejudicial, as it will not excite any adequate reaction. But the direct ftimulus of heat, as applied by the hot bath, and elicited by friction, is here found materially to affift in the reftoration of the difeafed part to a ftate of health and vigour. Of all the morbid affections of particular parts, there is none that bears and requires a greater degree of external heat than paralytic affections; and here too the effect may be affifted by any thing that will increafe the ftimulating properties of the water; as, for inftance, by the addition of falt, which will have full opportunity of exercifing its powers, both from the length of time in which the patient or the difeafed part continues immerfed, and the greater fenfibility of the fkin, when warm and moift. Here therefore we may expect particular benefit from the warm fea-baths which have been eftablifhed in a few parts of this kingdom, or in the natural faline thermal fprings of Carlfbad or Aix.

The warm bath is ſometimes applied in the form of ſteam, either generally or partially, and the effects which it produces are nearly the ſame as in the form of water. Water, whilſt in the gaſeous form, is a bad conductor of heat, and yields it much leſs eaſily to the ſurrounding bodies; but the actual temperature of ſteam is much higher than that of any watery application that the ſkin would bear, and the quantity of combined caloric which it gives out when condenſing, is well known to be very great. Hence it applies the ſtimulus of heat to the ſurface of the body with very conſiderable intenſity; and by uniting the two circumſtances of a large quantity of heat with moiſture, it occaſions a great relaxation of the extreme veſſels; and where the circulation has been previouſly increaſed, it brings on a copious perſpiration. The vapour bath, though not much employed in England, forms a very valuable remedy in a variety of caſes, and from the comparative eaſe with which it might be employed, it deſerves, I think, ſomewhat more attention from the medical practitioner. In moſt of the hot natural waters on the continent, the vapour bath forms a regular part of the bathing apparatus, and is there highly valued. In no country, however, is this application carried to ſo great an extent as in Ruſſia, where it both forms the principal, and almoſt daily luxury of all the people in every rank, and it is employed as a ſovereign remedy for a great variety of diſorders. (*a*) In the management

(*a*) A ſhort account of this curious practice may not be unintereſting to the reader. " The baths are conſtructed as near as poſſible to a plentiful ſupply of water and wood, theſe two being the moſt neceſſary articles for their conſumption. When the ground is marked out, two parallel trenches are dug, and lined with brick or ſtone, in order to carry off the waſte water. Then the walls of the bath are raiſed, which muſt be between the two trenches: the length of each wall being about eighteen feet (Engliſh) and the height from the roof to the cieling about ten or eleven feet.

Within the building is placed a furnace, ſupplied by wood, and vaulted like an oven, which is lined with ſtones that become red hot by the heat of the furnace, and thoroughly heat the air on the inſide. Two or three ſtages are placed one above the other around the room, three or four feet diſtant from the furnace upon which the bathers lie, to become heated by the ſtove. The floor of the bath is conſtructed on an inclined plane, at the bottom of which there is a ſmall pipe that carries off the water when it has been uſed, into the ſoughs which were before mentioned. The private baths are conſtructed on the ſame principle, but with greater conveniences for the ſick, and with a chamber adjoining, where the bather may repoſe after uſing the bath.

of thefe baths, the bather is firft expofed naked to a dry heated room, which ftrongly

The baths are entered when the wood, which has fupplied the furnace, is nearly burnt to afhes; and then the chimney is clofed, fo as to render the heat within the room almoft fuffocating to thofe that are not ufed to it. The bathers go into the room quite naked. In the private baths fome water is generally poured upon the ftones before entering them, but the common people expofe themfelves to the burning heat, lying on the ftages where it is the moft intenfe. This often at firft produces a violent pain in the head, and great thirft, which leads fome of them to drink large draughts of cold water, to the great injury of their conftitution.

When the room is fufficiently heated, and the warmth becomes troublefome, cold water is poured upon the hot flints around the furnace: this is inftantly converted into vapour, and fills the whole room, and the water is renewed whenever the vapour begins to clear away. This excites a moft copious fweat upon the bathers, which they keep up by renewing the fteam, and by friction of the whole body with the downy leaves of the lime tree rubbed over with foap. The frictions being finifhed, the bathers cool themfelves with pouring buckets of cold or lukewarm water over their bodies, or often by plunging into fome pond which is always near the baths, or elfe by rolling in the fnow. They then drefs, and return to their refpective occupations. In the private baths, the fame general management is purfued, only they are furnifhed with a fmaller room adjoining to the bath, with beds in it, where the bather, after his various operations, retires till the fweating be over, which often terminates in a profound fleep." *See a paper, "on the Ruffian baths, and their utility in preferving health" &c. by M. Aulaine Ribero Sanches, firft phyfician to the Emprefs of all the Ruffias, Journal de Phyfique, Tom.* 25.

raiſes the arterial circulation, and ſometimes cauſes headach and great thirſt: a copious atmoſphere of ſteam is then raiſed, by which the former ſymptoms are removed, and violent perſpiration brought on; and the whole proceſs (when employed medicinally) is completed by frictions on the body, when adviſeable, and by encouraging a full perſpiration in bed. The vapour bath is uſed, particularly in that country, in many ſymptoms of diſorder ſeated in the ſtomach and bowels, ſuch as loſs of appetite, flatulence, vomiting, colic, and obſtinate conſtipation. In theſe, the bath is often uſed daily for a month or ſix weeks, employing at the ſame time a temperate diet. In the ſymptoms of incipient fever, attended with rigor, headach, thirſt, and burning heat, wandering pains, and a hard belly, the vapour bath is alſo made uſe of, but without the previous heating proceſs, or the ſubſequent friction. (*b*)

(*b*) It is a little remarkable that this cuſtom of applying exceſſive heat to the body, and afterwards ſuddenly bathing in cold water, is found among a great number of uncivilized nations, and is uſed by them as an univerſal remedy in almoſt every kind of feveriſh attack as well as in other diſeaſes: and certainly it is

The warm bath, as well as the cold, is alſo employed as a topical application, either to particular parts that require the ſtimulus of heat, and a perſpirable ſkin, or in order to produce a more general effect. For this laſt purpoſe, no mode of applying warm water is ſo ſtriking in its operation, as fomentations to the feet, in caſes where, from any general febrile irritation not attended with much accumulation of animal heat, and particularly connected with diſturbance in the alimentary canal, the patient remains reſtleſs, agitated, and unable to compoſe himſelf to ſleep. Theſe ſymptoms are often moſt completely relieved by warm pediluvia, which, though applied only to a ſmall part of the body, often produce moſt powerful effects in quieting the

one of the moſt vigorous, and often, moſt efficacious modes of cure that could be ſuggeſted, but capable of being much miſuſed. The inhabitants of the South Sea Iſlands dig a hole in the ſand, and fill it with red hot ſtones and ſand; and when the latter has become quite hot, they cover the patient up to his neck with it. When he is in a violent perſpiration, they take him out and plunge him into the ſea; after which, he lies down, well covered, and drinks abundance of hot liquors to encourage perſpiration, and often riſes quite cured of a feveriſh attack. This likewiſe is the method which they chiefly truſt to for the cure of the lues venerea.

irritation of fever, and bringing on a ſound and refreſhing repoſe. This application is likewiſe of eminent ſervice in promoting the ſedative operation of opium, which, when taken alone during a feveriſh heat, and a parched unperſpirable ſkin, is well known often to increaſe the irritation which it was intended to remove.

The caſes in which the warm bath is likely to be attended with danger, are particularly thoſe where there exiſts a ſtrong tendency to a determination of blood to the head, and apoplexy has ſometimes been thus brought on. In all caſes a hot bath will be apt to bring on headach and turgeſcency of the face, and ſometimes a ſwelling in the limbs, as happens with the Caroline waters where employed too hot. With regard to the regulation of the temperature, it may be in general obſerved, that the vapour bath may always be made much hotter than the water bath; that, where this latter is uſed, the loweſt temperature is ſuch as is required for cutaneous complaints, and to bring on a relaxation in the ſkin during febrile irritation; the warmer will be neceſſary where the water is to act as a local ſtimulus, as in paralyſis; more heat ſhould be employed to act on a deep ſeated part, than one that is ſuperficial; and, in general, the topical and partial application of fomentations will bear being raiſed to a higher temperature, but on a granulating ſurface of a ſore too much heat is often prejudicial by giving great relaxation, and a looſe ſpongy texture to the newly formed parts. Where warm water is uſed as a direct ſtimulus, its effect is much aſſiſted by ſubſequent friction; but, when employed as a ſedative and relaxing application, this ſhould carefully be avoided. In ſhort, by conſidering the ſpecific intention for which this powerful remedy is uſed, we ſhall ſeldom be at a loſs to direct the mode in which its excellent properties may be ſecured with the greateſt proſpect of ſucceſs.

THE range of temperature from the loweſt degree of the warm bath, to the higheſt of the cold bath, forms what may be termed the tepid bath. As the point at which the one ends, and the other begins, is uncertain, and varies according to the temperature of the individual, it is not poffible to fix any exact limits to this term; only it may in general be remarked, that the tepid bath is that which gives the leaft poffible fenfation to the fkin, and therefore its effects principally depend on the nature of the medium, and lefs on the circumftance of temperature, than in the hot or cold bath. In general, the heat of water which we fhould term tepid, is about 90°; a heat in which the healthy body will bear immerfion for a long time without experiencing any confiderable general effect on the fyftem. The ftate in which this degree of cold (compared with the animal heat) produces the greateft effect, is in ardent fever, where the temperature is a little above that of health, but the powers of the body weak, and not able to bear the vigorous application of cold immerfion. In this inftance, even tepid water poured upon the body of the patient, will prove a very falutary and fafe remedy, and its operation will be fimilar, though in a much lefs degree to that of the cold bath. There are, befides, fome diforders in which the warm bath is more advifeable in fome of its ſtages, but the cure will be the ſooner completed by cold immerſion. Of this kind is the rheumatiſm, in which the requiſite heat of the warm bath, when uſed, is never ſo great as in palſy; and where the cold bath, when it can be borne, is of the greateſt advantage to reſtore a perfect ſoundneſs to the affected limb. Here the temperature of immerſion may often be begun with, even as low as about 90°, and the patient may be carried gradually from this (which is about the cooleſt ſtate of Bath water) to that of Buxton, Matlock, and finally to the ſea, or any other of our coldeſt baths. In the treatment of chorea, as far as regards the uſe of bathing, it may often be adviſeable to follow this rule, for in inveterate caſes of this diſorder, the limbs acquire almoſt a degree of paralyſis, and the complaint is frequently rendered much more obſtinate by a haſty and injudicious uſe of cold bathing.

In cutaneous diſeaſes (which ſeldom require a hot bath) a tepid temperature is often quite ſufficient to produce a ſalutary relaxation and perſpirability of the ſkin; and the operation of the water as a ſimple detergent appears to be of no ſmall conſequence in the plan of cure. Much has been ſaid on the detergent powers of different waters, or their fitneſs for cleanſing the ſkin both from any thing that will accidentally adhere to it, and alſo from the groſſer parts of the perſpirable matter which is always flying off. Several waters, from their hardneſs and the great quantity of earthy ſalts which they contain, are evidently inferior as detergents to others. To the great purity of ſome waters we may attribute all the particular cleanſing power which they have the reputation of poſſeſſing, and which ſome perſons have thought proper to explain, by ſuppoſing a kind of "oily balſamic matter," a ſubſtance which in almoſt every inſtance appears to be merely the creature of the imagination. In a few waters, however, we find an exceſs of alkali, ſuch as at Aix and Barege, and in theſe, the ſmoothneſs which they give to the touch, and the ſuperior cleanſing properties which they poſſeſs, (aſſiſted by their high temperature) is thereby explained in an obvious and ſimple manner, as ſuch is known to be the property of all alkaline ſolutions. Among all the waters whoſe analyſis is at all certain, there is only one, that of Barege, which appears to contain a particle of any thing unctuous or bituminous; and in theſe it is ſo combined with the alkali as to give ſuperior powers as a detergent, over any that we are acquainted with, ſo little impregnated with foreign contents.

CHAPTER VII.

GENERAL REMARKS ON THE CONTENTS OF MINERAL WATERS, AND THEIR OPERATION.

In perufing the moft popular treatifes on particular mineral waters, efpecially on thofe of high and juftly acquired reputation, written by practitioners long refident on the fpot, we fhall find in many of them a great fund of accurate chemical knowledge, and excellent medical obfervations; but we fhall alfo, in the greater number of thefe works, meet with certain modes of treating the fubject, which may fairly be brought under candid criticifm. Some of thefe writers (efpecially thofe who have fhewn themfelves fkilful and zealous chemifts) have, I think, fometimes refined too much on the fcience, and have endeavoured to transfer the fame accuracy of difcrimination which experimental chemiftry affords, to the explanation of minute effects produced on the living body by various fubftances during their ftay in its complicated organs. Others again, have endeavoured to throw a veil of myftery over the whole fubject, and, profeffing to difregard all the information which chemiftry affords, they have ftudioufly avoided any attempt to explain the effects produced by certain mineral waters from a review of their contents, and have ftrongly favoured the idea of their being *fpecifics*, prepared by the hand of nature, againft fome of the moft formidable and obftinate difeafes with which the human race is afflicted. Among this clafs we find, however, many who from long and attentive obfervation have made themfelves mafters of all the practical information which prefents itfelf in the variety of cafes which refort to mineral fprings; and certainly, if a phyfician could not be at the fame time a found practitioner, and attached to theoretical reafoning, there would be little hefitation in chufing the moft ufeful walk, in preference to that which is perhaps the moft engaging; but fortunately this is not the cafe, for on the contrary, we find the perfuit of a collateral fcience, efpecially one founded on experiment, materially to advance the knowledge of the healing art.

It is urged by fome of the merely practical writers on particular mineral waters, that the mode in which their active contents operate, is equally myfterious with that of fome of our moft powerful medicines, fuch as mercury and opium, and probably likely always to remain fo; and therefore that accurate chemical examination is little elfe than philofophical trifling. But it fhould be remembered, that every medicated water is a compound, at leaft of the water itfelf, and of that which gives it its fenfible properties, and thefe it is the peculiar object of chemiftry to feparate, and to eftimate their refpective proportions. Now, no practitioner will deny, that it is of confequence to know the proportional quantity of each ingredient in a compound form of medicine, that he may at leaft endeavour to afcribe to each its particular operation, although he does not pretend to explain how that operation is to be brought about.

If then we fuppofe a phyfician to employ in different cafes, a great variety of compound medicines, in which however there was one ingredient common to all; and if among the various changes produced by thefe medicines, there were certain effects common to every cafe, he would naturally be led to fuppofe, that thefe were produced by that ingredient which entered into each of his formulæ, and he would be thereby led to try it alone, and obferve its operation, unconnected with that of every other active fubftance.

This appears to be the cafe with all the variety of mineral waters that are ufed medicinally. They have only one ingredient in common, the water itfelf; they all produce effects on the human conftitution in fome degree fimilar, which I would chiefly attribute to the watery vehicle; but, befides, there are feveral that act very powerfully on the body in different ways, and thefe effects are fuch as water alone cannot produce, but depend on the very active contents which entitle thefe fprings to the appellation of *mineral*, and in which they differ from the generality of waters ufed for common purpofes.

In the preceding chapters I have endeavoured to explain in general what are the effects produced by fimple water ufed internally and externally, at high and low temperatures; and thefe therefore are fuch as, under fimilar circumftances in the animal body, may be expected from all mineral waters, allowing however for any effect of an oppofite tendency which the foreign ingredients may produce; as, for inftance, where a large quantity of an aftringent and earthy falt may in fome degree counteract the detergent power of pure water.

As an example of this fimilarity of operation, in very different waters, and which may certainly in a good meafure be afcribed to the mere liquid, we may mention that tranfient determination to the head, often produced in delicate habits by the firft exhibition of any of thefe waters. We find this circumftance noticed in the pureft fprings, and thofe that are the moft free from foreign contents, as well as in every other water. So, in explaining the operation of the Malvern water, Dr. Wall fays, "I cannot clofe this treatife "without mentioning one effect of the water, "that at firft it frequently makes perfons "drowfy, and fometimes give them a dull "pain in the head. Symptoms like thefe are "common upon the ufe of chalybeate waters, "but there is no metallic principle in this "fpring. I think thefe effects muft be owing

" to the ready and eafy admiffion of the water
" in the blood, whereby a plethora is brought
" on *pro tempore*." To confirm this rational conjecture, the fame writer adds, (what is alfo generally obferved by others) that as foon as the urinary paffages are open, thefe complaints go off immediately. In beginning a courfe of Briftol water, Dr. Nott obferves, that the immediate fenfible effects are generally,
" drowfinefs, vertigo, and fometimes an ob-
" tufe pain of the head, which gentle eva-
" cuants relieve." Among the confequences produced by the ufe of the chalybeate waters of Lauchftadt, Hoffman enumerates the following, " Non raro contigit, ut aqua noftra
" (*fc. Lauchftadienfis*) primùm maximè ab
" infuetis pota, naufeam, vomitum, inflationes,
" dolores circa præcordia, *capitis graviditatem*,
" *fomnolentiam* . . . fufcitat; fed . . . . conti-
" nuato ufu, & pervadente aquâ, omnia fponte
" evanefcunt." It is not uncommon for the Harrogate water, as Dr. Walker obferves,
" to produce a fenfe of heat and univerfal
" fullnefs in thofe unaccuftomed to drink it.
" The giddinefs which fome have experienced,
" is in almoft every inftance caufed by an

" over-dofe of the water, when it fails in its
" purgative operation." The hot faline Caroline baths in Germany, have a fimilar effect, for Hoffman obferves that, on ufing them, " Alii torporem capitis perfentiunt, inclina-" tionem ad fomnum, vertiginem, ...
" & hujus generis alia experiuntur, ob lenti-" orem aquæ per capitis tubulos & glandulas
" colli commeatum."

It is of confequence, therefore, in eftimating the effects of the foreign ingredients of mineral waters, to be aware of thofe occafioned by the water itfelf, though it is often difficult to eftimate the exact degree, where other fubftances combine with the fimple fluid to produce a general operation. So, we almoft invariably find that, during a courfe of any mineral water, where it does not pofitively difagree with the conftitution, the appetite is improved, and the digeftive powers ftrengthened. This, I have endeavoured to fhew, may, in many inftances, be the direct confequence of adding fo much water to the daily ingefta; but it is often the joint effect produced by this liquid, by a chalybeate in an active form, by a gentle dofe of a purgative ſalt, which will render the action of the bowels regular and vigorous, and by the great advantages of a moderate and corrected diet, and daily exerciſe, which it is the buſineſs of the invalid to ſecure to himſelf. The uſe of ſuch a mineral water as that of Scarborough, and a reſidence at this place as an invalid, would combine all theſe advantages.

Having, in a preceding chapter, laid before the reader a general view of the effects on the human body which may be expected from the watery ingredient in mineral ſprings, I ſhall make a few obſervations on the foreign contents, eſpecially thoſe which are generally conſidered as the truly medicinal part of theſe ſubſtances. The chemical analyſis of mineral waters, amongſt ſeveral ſubſtances which appear to have but little effect on the human body preſent us with a few, whoſe efficacy in the uſe of diſeaſe is undoubted, and which ſtand high in value on the liſt of materia medica. Every one, however, who compares theſe natural medicines with thoſe that are compounded by art, muſt be ſtruck with the ſmallneſs of the doſes that are employed of the former, compared with the benefits which are produced during their uſe; and he might hence be apt to put a wrong value on their real efficacy, if he were not aware of ſome circumſtances which increaſe, to an unuſual degree, the activity of theſe ſubſtances. One, which appears to me of no ſmall conſequence, is the extent of their dilution with water; for thereby, any medicine highly active in all ſtates, is diffuſed equally over the extenſive ſurface of the ſtomach, and is enabled to act all at once in the moſt advantageous manner poſſible. It is true that the force of impreſſion on any particular part, is hereby leſſened, and therefore dilution may be carried to exceſs; but the circumſtance of extent of ſentient ſurface acted on at once, will probably in moſt caſes, more than counterbalance this, and eſpecially, as the action is milder, the ſtomach may receive it much oftener. Another advantage derived from this natural formula, is, that the very degree of dilution, as we have already mentioned, promotes, in many caſes, the general curative intention, as in the very weak ſolution of a purging ſalt, which occurs in Cheltenham or ſea water. Beſides theſe, we ſhall find that ſome of the foreign ſubſtances in mineral ſprings, though highly active in themſelves, are never uſed under the ſame form of compoſition elſewhere than in theſe waters. This gives, in ſome caſes, a ſuperiority peculiar to theſe natural medicines. Of this kind is the carbonated iron, held in ſolution by carbonic acid, and the ſulphur, by hydrogen gas. Theſe active medicines likewiſe, happen ſometimes to be found in a very fortunate ſtate of combination to fulfil a complicated curative intention, as in the waters of Cheltenham or Aix.

In aſcertaining the comparative effect of the different contents of a mineral water, the gaſeous ſubſtances that are combined with it deſerve much conſideration. For an accurate knowledge of theſe bodies, we are principally indebted to modern chemiſtry; but it ſtill remains for future inquirers to explain the preciſe operation of theſe ſubtile agents. Some conſiderations on this ſubject I would ſuggeſt to the medical obſerver.

It appears to me, that by far the greater part of the action of theſe ſubſtances is that which is exerted directly upon the ſtomach, and only through the medium of this ſenſible organ, upon the fyftem in general. A gafeous water appears to act more powerfully in proportion to the fuddennefs of the expulfion of the air, and therefore to the loofenefs of its adhefion to the water with which it is combined. Hence, the great relief found by taking mixtures in the act of effervefcence, where the carbonic acid is applied fuddenly, and in the gafeous ftate, to a large furface of the ftomach. Hence too, the fudden effects fimilar to intoxication, caufed in many perfons by a large draught of highly carbonated water, fuch as that of Seltzer and Pyrmont.

The force of action which fubftances exert upon the living fibre, as well as on a fimple chemical mixt, depends upon the degree of divifion of its parts; for this, the fenfible properties and active powers of every particle are brought into action at the fame time, and are capable of being extended over a large furface. This divifion of parts is brought about, either by mechanical means or by folution; by the latter it is effected more completely, but then the affinities of the folvent often oppofe the combinations which would otherwife be formed by the fubftance held in ſolution. This we know to be the caſe with the moſt ſubtile ſtate of diviſion that we are acquainted with, that of the ſolution of a body in the matter of heat, or what is ſuppoſed to conſtitute a gas; for in this ſtate, the baſis of the gas, though moſt intimately divided, is often held by too ſtrong an attraction for the caloric, to be ſo ready to enter into a new combination as if it were in a liquid form. But again, chemiſtry furniſhes many examples of the activity of combination being the greateſt, juſt at the time when a body has quitted its union with a ſolid or liquid, and is beginning to aſſume the aeriform ſtate, or is in what has been called the *naſcent* ſtate of gas. If then we ſuppoſe that the force of impreſſion which any agent exerciſes on a living body, holds any relation with its eagerneſs for chemical affinity, it will not perhaps appear improbable, that we may partly attribute to the above cauſe the energy with which many of the gaſeous mineral waters act upon the ſtomach: for water, impregnated with the baſis of any gas, is conſtantly giving off this foreign ingredient in the aeriform ſtate as ſoon as extraordinary preſſure is taken off;

and eſpecially, when a heat, like that of the ſtomach, is ſuperadded. The actual quantity of the baſis of any gas (the carbonic acid for inſtance) contained in any mineral water, does not appear to be of ſo much conſequence to its powers as a medicine, as that which will be ſpontaneouſly given off in the gaſeous form when it enters the ſtomach. Many ſubſtances, ſuch as lime, magneſia, and the alkalies will detain a large quantity of carbonic acid, and thus leſſen the proportion of that which is uncombined, and diminiſh the medicinal powers of the whole, as far as they depend on this acid. On the other hand, a very pure water, ſuch as that of Briſtol, holding little in ſolution that can detain carbonic acid, will give out in the ſtomach almoſt the whole of this ſubſtance which it poſſeſſed, and thus be in fact equivalent in medicinal powers to an impure water much more ſtrongly carbonated.

I have juſt mentioned, that it appears to me probable, that by far the greater part of the operation of the gaſeous bodies is confined to the ſtomach, and acts only indirectly upon the whole ſyſtem. This is particularly ſo with the carbonic acid, the moft common and the moft important of thefe fubftances in a medical view. Many of its effects are obvioufly fuch as concern the ftomach only, fuch as that of checking a tendency to vomiting, for which an effervefcent draught has been found remarkably efficacious. The giddinefs and fpecies of intoxication from Pyrmont and Seltzer water, is probably produced through the medium of the ftomach; as thefe effects are particularly felt when this cavity is empty, and come on very fuddenly, even before the vertigo and head-ach, which, as we have mentioned, alfo frequently follow a full dofe of this water. A good deal too of the gas that is emitted copioufly from the water when in the ftomach, paffes up through the mouth in troublefome eructations. It cannot be doubted however, but that part of thefe gafes are abforbed into the circulating fyftem, along with the water that conveys them into the ftomach; and, by entering the circulation, may prove very important remedies, according to the nature of the fubftance abforbed. (*a*) The

(*a*) The effect of the carbonic acid in relieving calculous complaints, has been thought by fome to indicate the abforption ſulphurated hydrogen appears to be very extenſively circulated through the minute veſſels of the body, and to perform a longer courſe unaltered, than the carbonic acid. At leaſt we have more direct evidence of its penetrating nature and great effuſion, from the odour of ſulphur which exhales through the pores of the ſkin, and its effects in blackening ſilver worn about the perſon, even when the ſulphureous water is only uſed internally, but long perſiſted in. Theſe medicines are, however, alſo locally uſeful in the ſtomach, as is found from long experience.

Some ingenious writers have endeavoured to explain on mechanical grounds part of the *modus operandi* of the gaſeous portion of mineral waters. The tenuity and ſubtlety of the gaſſes they ſuppoſe to be admirably fitted for penetrating minute veſſels, and removing every obſtruction. Thus we meet with the following explanation of the operation of

of the gaſeous acid. The uſe of this remedy has now been eſtabliſhed for a conſiderable time, and I may feel ſome ſatisfaction in having firſt introduced it to the attention of the profeſſion in a letter to Dr. Percival of Mancheſter, noticed in the Medical Eſſays of that ingenious phyſician.

Briftol water: "Its fubtile gafes, and active "aeriform impregnations, adapt it to pervade "the minuteft canals of the human frame, "even thofe undifcovered fuppofed paffages "in the nervous fyftem. Hence it refolves "obftructions of the moft remote exiftence, "it dilates the capacities of the finer veffels, "and overcomes their fpaftic conftrictions." In anfwer to fuch and to all fimilar reafoning, we may obferve, firft, that it is highly improbable that thofe fubftances circulate in the form of gafes; as the water which conveyed them to the ftomach muft have parted with moft of its excefs of gas in this organ; and confined as they are within the tubes of the circulating veffels, which ftrongly oppofe their affuming the aerifoım ftate, till they pafs out of the body through the exhalents. Secondly, it does not appear that an increafed tenuity of the circulating fluid could be brought about by impregnating it with air of any kind, provided its bafis was held in true folution; as the fpecific gravity of water is increafed by faturation with any gas: and thirdly, even making the extravagant fuppofition that the circulating fluid could be brought in any degree to refemble in form Briftol or even Seltzer water, it is not eafy to conceive how the minute veffels would be thereby rendered more pervious, or that any mechanical impulfe could be given to a gas to make it circulate more readily through capillary veffels than water will. In all probability, the contrary affertion would be better founded, for water will penetrate through inorganic pores fo clofe as to detain air. The celebrated Aftruc attempted to explain the operation of mercury in refolving obftructions and producing falivation, from the increafed momentum which the blood would acquire when mixed with fo ponderous a fluid as quickfilver; and this hypothefis was only objected to from the vaft difproportion between the minute quantity of metal introduced, and the great effects which often followed. But furely no mechanical advantage to the freedom of circulation could be gained, by fubftituting an elaftic for a non-elaftic fluid; a gas, for a liquid.

A review of fome of the moft celebrated mineral waters, prefents us with feveral facts that at firft appear highly difficult of explanation. I mean chiefly the powerful effects produced by some waters, which, from their chemical analysis, present but a very minute portion of foreign matter; effects that cannot be intirely ascribed to the mere circumstances of dilution. Of these, the Bath water is a striking instance; for the determination to the head, the quickness of pulse, and general stimulus occasioned by these celebrated waters, are far more than the mere quantity of active contents would indicate; and render precautions requisite in using this medicinal spring, which a mere inspection of its ingredients would seem to make unnecessary. We can only have recourse to two methods of explaining this difficulty; the one, that we are not yet sufficiently masters of its analysis; the other, that its component parts, as we are already acquainted with them, possess from their mode of combination, powers on the human body, superior to those which mere quantity would indicate. When treating particularly on this water, I mentioned all the facts which we possess concerning its analysis, both for solid and gaseous bodies; and it appears to me, that though a complete and accurate examination may be ſtill wanting, there is no probability that it would give any very material difference in the reſults of the experiments hitherto made. These have not been few in number, and have been varied in ſeveral ways; many of the ſubſtances, the quantities of which are not exactly known, have no apparent concern in producing the more ſtriking effects; but theſe may, I think, be in a great meaſure explained from what we do know concerning the analyſis of this water.

Every one who has attended to the ſenſible properties of this water, muſt have remarked the very penetrating chalybeate taſte which it poſſeſſes when freſh drawn, and with its natural warmth; a taſte which diffuſes itſelf over the whole mouth, and, though not nauſeous from its intenſity, gives the idea of a ſmall quantity of iron in the moſt active ſtate.

Another remarkable circumſtance attending this water, is the great rapidity with which it loſes its chalybeate taſte as ſoon as it cools; even though confined in cloſe veſſels, and before any perceptible depoſition of the iron takes place: and when cold, it appears to have intirely loſt all its medicinal along with its ſenſible properties. May we not, therefore, conclude, that Bath water is indebted for its powers on the human body, (independently of thoſe of mere water at a high temperature) principally to the circumſtance of a chalybeate impregnation, minute in itſelf, but much exalted in all its properties by a heat ſuperior to that of moſt chalybeate ſprings? and as the natural heat which it poſſeſſes, is probably given to it under confinement and preſſure, it does not cauſe the evolution of the carbonic acid which holds the iron in ſolution, till the water be expoſed to the air. Hence as it flows from the pump, it is then in the moſt active ſtate for producing the ſtimulant powers which chalybeate waters exhibit upon the human conſtitution.

To aſcertain the effect of temperature on the carbonated chalybeates, the following experiments were made:

Exper. 1*ſt.*—To a very highly acidulated chalybeate water, (artificially made) in which, however, the quantity of iron was very ſmall, were added, in ſeparate phials, equal parts of hot and cold water. The undiluted water tafted extremely brifk and fubacid, and fent forth copious bubbles, but the tafte of the iron was fcarcely perceived till the impreffion from the acid had gone off. By the dilution, the chalybeate was made fo weak in each phial, as only to become purple with galls after ftanding a quarter of an hour. The hot, as well as the cold liquor, ftill tafted acidulous, but, (as might be imagined, from the greater lofs of carbonic acid) this flavour was lefs in the former than in the latter. The tafte of the iron was however ftronger, and more permanent in the hot folution, while it was fcarcely perceptible in the cold.

Exper. 2d.—An artificial chalybeate was made by digefting iron filings in water, moderately impregnated with carbonic acid. This was much lefs brifk and carbonated to the tafte than in the firft experiment, but much ftronger of the iron. Equal quantities of this water were put into feparate glaffes, and to one was added the fame proportion of hot water, and to the other, cold water. Thefe diluted liquors ftill gave a full purple with gall in about a minute, and the firft change of colour began in a few ſeconds. They both remained without ſparkling in the glaſs, and the cold ſolution had all the ſenſible properties of the ſimple chalybeates that are ſo abundant in this country, ſuch as that of Tunbridge. There was however a very decided difference in the taſte of the two ſolutions, the hot having a great intenſity of chalybeate taſte, and more diffuſed, as it were, over the whole fauces.

Theſe experiments, made with as much accuracy as the compariſon of taſtes will allow of, ſeem to ſhew, that mere heat will much increaſe the impreſſion of a chalybeate taſte on the tongue; and, therefore, as I apprehend, will equally augment the ſtimulating properties of the iron upon the ſtomach, when exhibited in this form. They likewiſe ſhew that a loſs of carbonic acid will not diminiſh, but rather increaſe the ſimple chalybeate taſte; provided enough of this acid be left to hold the oxyd of iron in ſolution. This is not the caſe, however, with Bath water; for as it gives indications of containing very little carbonic acid, it readily parts with even that portion which ſuſpended the iron; and therefore I cannot confider this water, when cold, and efpecially tranfported to a diftance, as any thing elfe than a common hard water. To confirm the fuperior effects of a heated liquor over one that is cold, upon the ftomach and nervous power, we may add, that it is well known that the intoxicating property of vinous and fpirituous liquors is much increafed by heat.

If the idea of the fuperiour efficacy of warm, over cold chalybeates be juft, it will likewife follow that the cuftom of warming the cold waters of Tunbridge and fimilar fprings is judicious, not only to prevent the chill on the ftomach, which is fometimes inconvenient to delicate perfons, but alfo to increafe thereby their ftimulant properties. They are beft heated by being put into a bottle, well corked, and immerfed in hot water; but the ftrong waters of this kind will bear being lowered by the addition of boiling water, fo as to bring them to a refemblance of Bath water.

Befides the carbonic acid, and the fulphurated hydrogen, which we may certainly confider as the moft important of the gafeous bodies that are contained in mineral waters, there are others which are found in ſmall quantities. The moſt important of theſe is probably azotic gas, which, as we have already mentioned, is diſcoverable in many ſprings, partly mixed with the water, but chiefly riſing through it in large bubbles at the fountain head. Several of the thermal ſprings give out much of this gas, and probably indeed it might be detected in them all, if the ſubject were examined with ſufficient accuracy; but as this branch of inquiry is comparatively new, we have not much information as to the extent to which this gas is found. Some remarks on the operation to be expected from this ſubſtance, the reader will find in the note (*r*)* to the account of the Bath water, but it is ſtill an object for inquiry to determine the preoperation of this gaſeous body.

The ſaline and metallic contents of mineral waters are ſuch, as often to act in a very decided manner upon the conſtitution, either from their actual quantity, or their mode of combination. The only metal that is uſed medicinally in any natural water, is iron; and its ſolvent, in by far the greater number of

* Page 181.

inſtances, is the carbonic acid. In comparing the activity of operation of the different preparations of this metal, ſo valuable in every ſhape, I think it ſeems probable, that the form of all others in which it is the moſt efficacious, is that of ſolution in water by means of carbonic acid. In this ſtate, it is both highly ſenſible to the taſte in a very minute quantity, eaſily ſeparated from its ſolvent as ſoon as it enters the ſtomach, and, when ſeparated, being a very ſoluble ſemi-oxydated calx, it is probably as liable to be acted on by the animal fluids, as in any other ſtate in which this metal can exiſt. The great impreſſion on the organs of taſte, which this form of chalybeate makes, may be ſeen by an actual computation of the quantity of metal here, and in ſome of the other preparations of iron. For inſtance, the Tunbridge water, which is a very pure chalybeate containing very little foreign matter, owes its medicinal properties to ſo ſmall a quantity as one grain of oxyd of iron in the gallon, held in ſolution by a very ſmall exceſs of carbonic acid. The chalybeate impregnation is however perfectly diſtinguiſhable both by chemical teſts and by the taſte.

Now, one grain of this oxyd contains no more than 77 per cent. of metallic iron, (*a*) the reſt being oxygen and carbonic acid. Cryſtallized ſulphat of iron contains, according to Kirwan, about 22 per cent. of metallic iron, (*b*) and therefore, .77 of a grain of metallic iron (the quantity contained in the grain of carbonated oxyd) indicates three grains and a half of ſulphat of iron; ſo that if the chalybeate taſte were as ſtrong in the ſalt as in the carbonated iron, three grains and a half of ſulphat of iron, diſſolved in a gallon of water, ſhould taſte as ſtrongly chalybeate as Tunbridge water. But by making ſuch a ſolution of ſulphat of iron, it will indeed be indicated by chemical teſts, and even be very ſenſible to an accurate taſte, but not at all to the degree of Tunbridge water. This however is a very large proportion of iron, com-

(*a*) This is the proportion given by Lavoiſier of metal and oxygen, in the imperfect oxyd of iron that remains after the combuſtion of iron in oxygen gas, and in this ſtate it is juſt ſenſible to the magnet. Now, as the ochre which the carbonated chalybeates precipitate by boiling, is, when dry, weakly magnetic, and as the intenſity of this property in ſome degree indicates the proportion of reguline metal, we may allow it to contain about as much regulus as in the former caſe.

(*b*) Kirwan's Mineralogy, Vol. II. page 21.

pared with that of Bath water, of which the higheſt eſtimation, does not make $\frac{1}{30}$ of a grain of oxyd in the gallon; which is about equivalent to ſomewhat more than a tenth of a grain of ſulphat of iron in the ſame bulk of water, a quantity which the taſte cannot at all diſcern even by the aſſiſtance of warmth. (*b*)

Nothing very remarkable occurs in the ſtate in which we find the other active ingredients in mineral ſprings. Several of theſe waters, even of ſome celebrity, are nothing more, nor are ſuppoſed to be any thing more, than a very dilute ſolution of well-known neutral ſalts in water, of a ſufficient ſtrength, however, to give it a very ſenſible purgative

(*c*) To aſcertain this, one grain of ſulphat of iron was put into a ſmall phial, and eighty drops of diſtilled water were added, which made a clear ſolution. One drop of this, taken as ſoon as the ſalt of iron was diſſolved, and before it could be decompoſed (which it will do in ſome degree ſpontaneouſly by ſtanding) was added to a pint of water of the temperature of 120°, and well mixed, making thereby the proportion of $\frac{1}{10}$ of a grain to a gallon. This gave however no chalybeate taſte. It required four drops to make the taſte in the leaſt apparent, but with eight drops it was very ſenſibly ſo. Even this ſhews the great power of the chalybeate impreſſion made by ſulphat of iron, ſince it is very diſtinguiſhable when in no higher a proportion than $\frac{1}{20}$ of a grain to a pint of warm water.

quality, eſpecially when taken largely; and to this purpoſe the water itſelf contributes not a little. The operation of mere water upon the bowels when firſt taken, by perſons of particular habits, and unaccuſtomed to ſuch a bulk of this liquid, is ſhewn in a ſtriking manner by the aperient effect which every mineral water that we know, *ſometimes* exerts; but which effect ſoon goes off when there is no other ingredient in the mixture to have a conſtant and certain operation on the bowels. Even an aſtringent water, ſuch as that of Hartfell, which is only a weak ſolution of vitriolated iron and alum, will often purge pretty briſkly on being firſt taken, though its regular and proper operation has quite the contrary tendency. From a review of the effects of the alkaline waters, eſpecially thoſe that are hot, ſuch as the Carlſbad and Vichy baths, it would ſeem that the ſoda, aſſiſted by warmth and dilution, has a great power in exciting all the ſecretions at the ſame time, and aſſiſting the action of the neutral ſalts. At leaſt it ſeems to be worthy of farther attention, to determine the benefits that may ariſe from giving an exceſs of alkali to any faline folution which may be prefcribed, in order to excite the different fecretions.

The compofition of the moft celebrated mineral waters having been known by accurate analyfis, feveral ingenious men have endeavoured to confirm their experiments by fynthefis; and to produce, by artificial means, a compound, in all refpects fimilar to the natural preparation. To this too was added the additional motive of being able to fupply the want of the natural waters, in places, and at times when thefe could not be procured. The illuftrious Bergman, in his excellent treatife on mineral waters, has given very good ideas on the method of preparing them artificially; but fome of the proceffes which he propofes, are imperfect, and liable to objections. Where the water to be imitated is only a folution of fome neutral falts, fuch, for inftance, as the Epfom, Sedlitz, or Sea water, all that it is neceffary to know, is the proportion in which they are contained in the natural ſpring; but the proceſſes of nature are not always imitated with ſo much eaſe. A greater difficulty lay in the way, which was, that of impregnating water with gaſeous ſubſtances to as complete a ſaturation, as is found in ſome of the moſt powerful mineral ſprings. This every chemiſt knows to be a very difficult object to attain, and impracticable with any of the more common apparatus now in uſe for ſuch purpoſes; but, under particular management, it has been attained, and ſome of the ſpecimens of artificially carbonated water that are to be ſeen, appear fully to equal in this reſpect the natural waters of Pyrmont or Seltzer. The ſaline and chalybeate principles may alſo be eaſily added, and the imitation will be complete for all medical purpoſes.

Theſe artificial compoſitions have defects as well as advantages. With regard to the former, we may obſerve, that it is always difficult to hit the ſame point of ſaturation with gas, and with the ſubſtances which the gas is to diſſolve; and this is particularly the caſe with every degree of ſaturation below the higheſt. Thus then, theſe medicines will not be ſo conſtantly the ſame as the natural ſprings; for, uniformity of compoſition is a very conſpicuous feature in almoſt every one of theſe. However, as it is generally the *defect* of the natural waters to be too weak in theſe active ſubſtances, and as no material inconvenience appears often to ariſe from an exceſs of theſe gaſes, it is probable that with tolerable caution, theſe ſubſtitutes might be generally adopted, if requiſite.

There are ſome kinds of chemical mixture, however, which art has not been able to imitate: the ſuſpenſion of ſiliceous earth in water, a curious and wonderful phenomenon in the hiſtory of many of the thermal ſprings, is a ſtriking example of this. If ſiliceous earth, apparently ſo inert and inactive on the body from its great difficulty of ſolution, ſhould ever be found to poſſeſs any medicinal properties, this will form a marked difference between the natural and artificial medicated waters. Perhaps the ſuper-ſulphurated waters of Aix, combined as they are with ſoda and with a high degree of heat, would exerciſe all the powers of the beſt chemiſt to imitate with ſucceſs. Several other combinations might be pointed out, in which, if *perfect* accuracy of reſemblance were required, we ſhould ſtill find the imperfection of art. Again, there is another caſe in which the natural water has a great advantage over the artificial; and this is, in ſome of the very compound thermal ſprings that are uſed for bathing as well as for a drink. It muſt be more difficult at all times to prepare a hot than a cold artificial water; and for the purpoſes of the Bath, much advantage is gained by having a large body of water, as at Bath, Aix, and the like, where the patient can move his limbs about freely when immerſed, and is ſurrounded with an atmoſphere of ſteam, mixed with the volatile gaſeous contents of the water, and where the heat is kept up much more permanently and uniformly.

On the other hand, ſome peculiar advantages may be gained by the artificial preparation of medicated waters. Several of the moſt valuable natural ſprings contain ſubſtances which are either uſeleſs or poſitively detrimental. Pyrmont water, for inſtance, contains thirteen grains in the pint of calcareous ſalts, which render it very hard; and hence it may certainly prove inconvenient to ſome conſtitutions. Other neutral waters contain ſo little of their moſt active ingredient, as to require often an inconvenient bulk of liquid to produce the deſired effect; as for example, where Scarborough or Epſom water are uſed as purgatives. All theſe defects may be remedied in the artificial preparation, by leaving out the uſeleſs and noxious matter, and increaſing that in which the proper medicinal virtue reſides. Art likewiſe can prepare out of the ſame materials, new compounds, which would be conſidered as valuable natural treaſures, were ſuch found. Of this kind, I ſhould reckon a moderately dilute ſolution of a neutral ſalt (vitriolated magneſia for inſtance) fully ſaturated with carbonic acid. This makes a very valuable addition to its powers as a medicine, from the known operation of this gaſeous acid in quieting irritation of the ſtomach, and rendering the ſurface of the body more cool and perſpirable; and beſides, it powerfully corrects the nauſeous taſte, which is in many inſtances a material objection to the neutral ſalts, eſpecially to a daily uſe of them as a gentle evacuant and alterative.

One more advantage I would mention,

which the artificial preparation of thefe medicines would promife, and that is, that of introducing much more fimplicity in their compofition than nature employs, and by this means we may be materially affifted in forming precife ideas of the operation of every part of thefe important clafs of remedies, which the reader will readily fee is a great object to be defired by the philofophical inquirer into the powers of medicine. Every one who examines into this fubject, muft be ftruck with the great inaccuracy and confufion of ideas that prevail in the defcription of the operation of mineral waters, and the great fimilarity of effect afcribed to very different fpecies of this large and heterogeneous clafs of bodies. It has been my object in the preceding pages, to attempt in fome degree to introduce more precifion in inveftigating the powers of thefe bodies; but the fubject can never be fully canvaffed, till we are in poffeffion of a greater number of facts founded on experiment; and, to promote this defirable end, the affiftance of art in imitating the proceffes of nature, may be called in with every profpect of advantage. In this view, therefore, the ftudy of the method of preparing mineral waters may be recommended to the medical inquirer as an interefting object of inveftigation.

For the practitioner who entertains a decided preference for the medicated waters which nature prefents, we may fuggeft the convenience of occafionally mixing different kinds of the fimple waters, in order to obtain the effects of fome of the more compound, which may not be at all times procured. Thus, a Spa or Pyrmont water, mixed with that of the Sea or Epfom, will make a good imitation of the Cheltenham or Scarborough fpring, according to the proportion ufed; as the one furnifhes in abundance the carbonic acid and the iron, and the other, the neutral purgative falt; and each of thefe contain, fo much of their active ingredients as to bear dilution, and yet to retain confiderable efficacy. The fynoptical table, which is inferted at the end of this work, will, it is hoped, afford fome affiftance in this object.

There is nothing more gratifying to the phyfician, who confiders the healing art in its true light, that of an experimental fcience, than to be able to add to the general ftock of profeffional knowledge, information which is to be afforded by the affiftance of a collateral fcience. Of thefe, none is more intimately connected with medicine, by a community in many of the objects, than chemiftry; and the aids which this fcience furnifhes, are conftantly increafing, on account of the rapid accumulation of experimental knowledge. An inquiry into the nature and right application of mineral waters, is certainly not one of the leaft important objects of phyfic; fince thefe are remedies that have been at all times peculiarly favourites with the public, and have deferved, from their real efficacy, much of the efteem in which they have been held. The fubftances concerned in the compofition of thefe waters, are fuch as come particularly under the accurate and diftinguifhing eye of modern chemiftry, and admirably illuftrate fome of its moft beautiful difcoveries. They have engaged the attention of the ableft chemifts for many years in various countries, and the importance attached to thefe inquiries, has abundantly repaid the labour and difficulty of the refearch.

Impreſſed with the idea, that the ſcience of chemiſtry has done more to illuſtrate this, than almoſt any other claſs of natural ſubſtances that are uſed medicinally, it has been my wiſh in the foregoing pages to lay before the pubiic a general view of our preſent ſtate of knowledge on this ſubject; in order to aſcertain, with ſome preciſion, the practical advantage to be derived from theſe facts. Viewing, with ſome regret, the apparent ſlight which has been thrown upon theſe inquiries by ſome, whoſe profeſſional knowledge attaches much weight to their opinions, I have endeavoured to clear away ſome cauſes of error, ariſing from too partial and confined a view of the ſubject; in order that the leading features of medical chemiſty, attached to theſe inquiries, may be rendered more conſpicuous; and my object in undertaking this work will be anſwered, if theſe pages will at all contribute to the advancement of the healing art.

In order to prefent the reader, under one point of view, with the moft confpicuous features in the compofition of the mineral waters which we have hitherto defcribed, the following fynoptical table is fubjoined. The order in which the individual waters are put, is the fame as that in the foregoing chapter, excepting only that the Bath water, which it was thought more convenient to defcribe among the Englifh thermal fprings, is here arranged under the chalybeates, a clafs to which it certainly belongs. I have made an attempt of a claffification of thefe waters, founded on the moft prominent part of their chemical compofition, and that which may be fuppofed to have the moft influence on their medicinal powers; but every fuch arrangement muft be imperfect, owing to the almoft imperceptible gradations with which individuals of one clafs approach to the others.

The reader will pleafe to obferve, that under the head of *Neutral Purging Salts*, are included the fulphats of foda and magnefia, and the muriats of lime, foda and magnefia. The power which the earthy muriats may poffefs of acting on the inteftinal canal, is not quite afcertained, but from their great folubility, and from analogy with falts, having fimilar component parts, we may, I think, conclude that this forms a principal part of their operation.

The reader will likewife obferve, that where the fpaces are left blank, it fignifies that we are ignorant whether any of the fubftance at the head of the column is contained in the water; that the word *none* implies a certainty of the abfence of that fubftance; and that the term *uncertain*, means that the fubftance is contained, but the quantity is not known.

THE END.

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A Synoptical Table, *ſhewing the Compoſition of the Mineral Waters deſcribed in this Work.*

[To face the laſt page]

Class.	Name.	Higheſt temperature. Fahrenheit.	Contained in an Engliſh wine pint of 28.875 cubic inches. Azotic gas. cubic inches.	Carbonic acid gas. cubic inches.	Sulphur. hydrog. cubic in.	Carbonated ſoda. grains.	Neutral purging ſalts. grains.	Selenite & earthy carbonats grains.	Oxyd of Iron grains.
Simpler cold	Malvern			uncertain	none	none	uncertain	uncertain	none
	Holywell				none	none	uncertain	uncertain	none
Simpler thermal . . .	Briſtol	74°	uncertain	3.75	none	none	2.81	3.16	none
	Matlock	66°		uncertain	none	none	uncertain	uncertain	none
	Buxton	82°	0.474	uncertain	none	none	0.25	1.625	none
Simple ſaline	Sedlitz			1.	none	none	185.6	8.68	none
	Epſom				none	none	40. ?	8 ?	none
	Sea				none	none	237.5	6.	none
Highly carbonated alkaline	Seltzer			17.	none	4.	17.5	8.	none
Simple carbonated chalybeate	Tunbridge		0.675	1.325	none	none	0.344	0.156	0.125
Hot, carbonated chalybeate	Bath	116°	1. ?	1. ?	none	none	10. ?	10. ?	uncertain
Highly carbonated chalybeate	Spa			12.79	none	1.47	4.632	1.47	0.56
	Pyrmont			26.	none	none	7.13	23.075	0.56
Saline, carbonated chalybeate	Cheltenham		uncertain	5.687	uncertain	none	62.125	6.85	0.625
	Scarborough			uncertain	none	none	20.	10.	uncertain
Hot, ſaline, highly carbonated chalybeate	Vichy	120° ?		uncertain	none	uncertain		uncertain	uncertain
	Carlſbad	165°		uncertain	none	11.76	47.04	4.15	uncertain
Vitriolated chalybeate . . .	Hartfell				none	none	none	none	4.815*
Ditto	Brighton		none	2.5	none	none	2.28	4.09	1.1
Cold ſulphureous . . .	Harrogate		0.875	1.	2.375	none	91.25	3.	none
	Moffat		0.5	0.625	1.25	none	4.5	none	none
Hot, alkaline, ſulpureous .	Aix	143°		uncertain	uncertain	12.	5.	4.74	none
	Borſet	132°		uncertain	uncertain	uncertain	uncertain		none
	Barege	120°			uncertain	2.5	0.5	uncertain	none

* That is, 2.94 contained in the ſulphat of iron (this ſalt when cryſtallized containing 28 per cent. of oxyd of iron, according to Kirwan) and 1.875 additional of oxyd of iron.