

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 / [William Saunders].

Contributors

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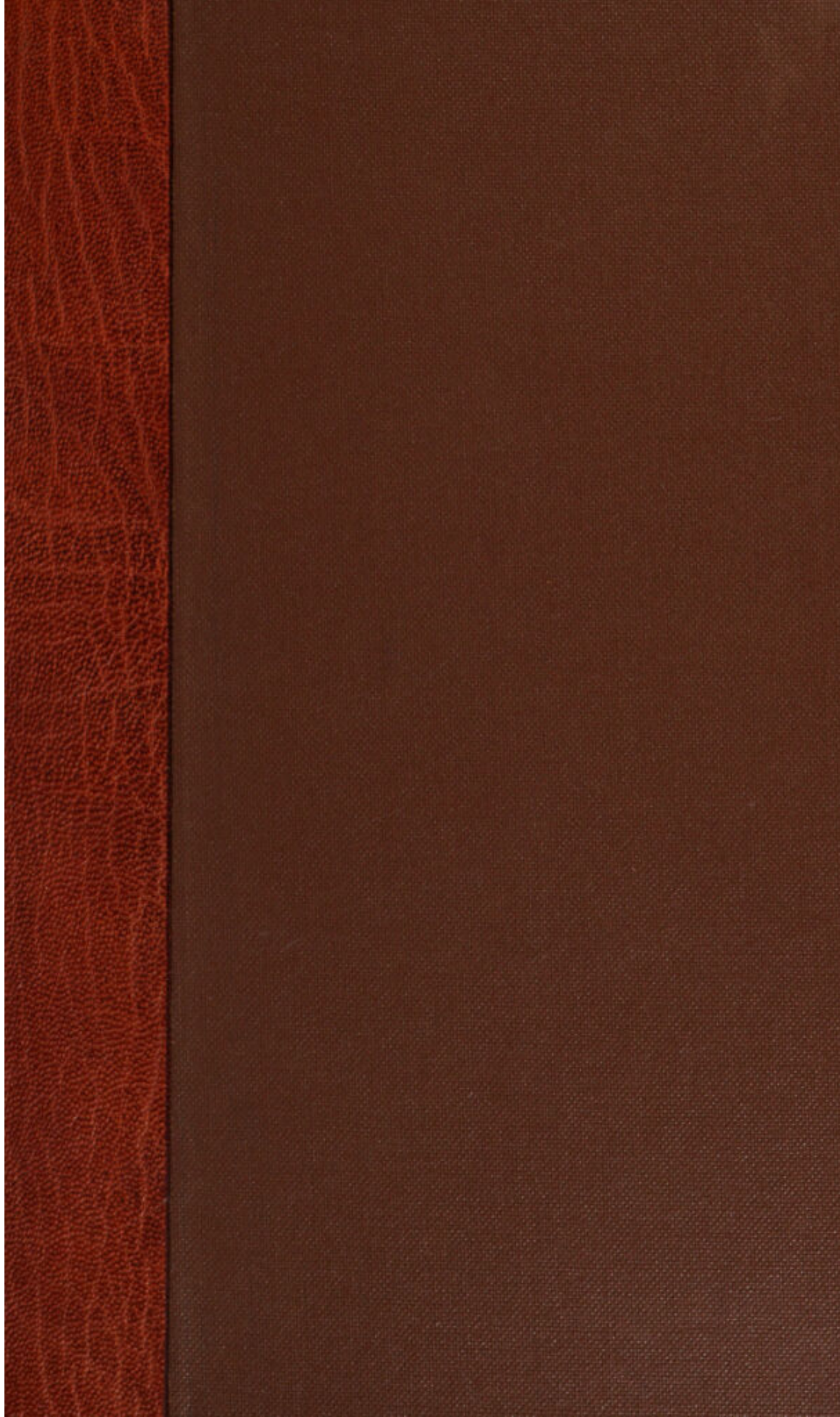
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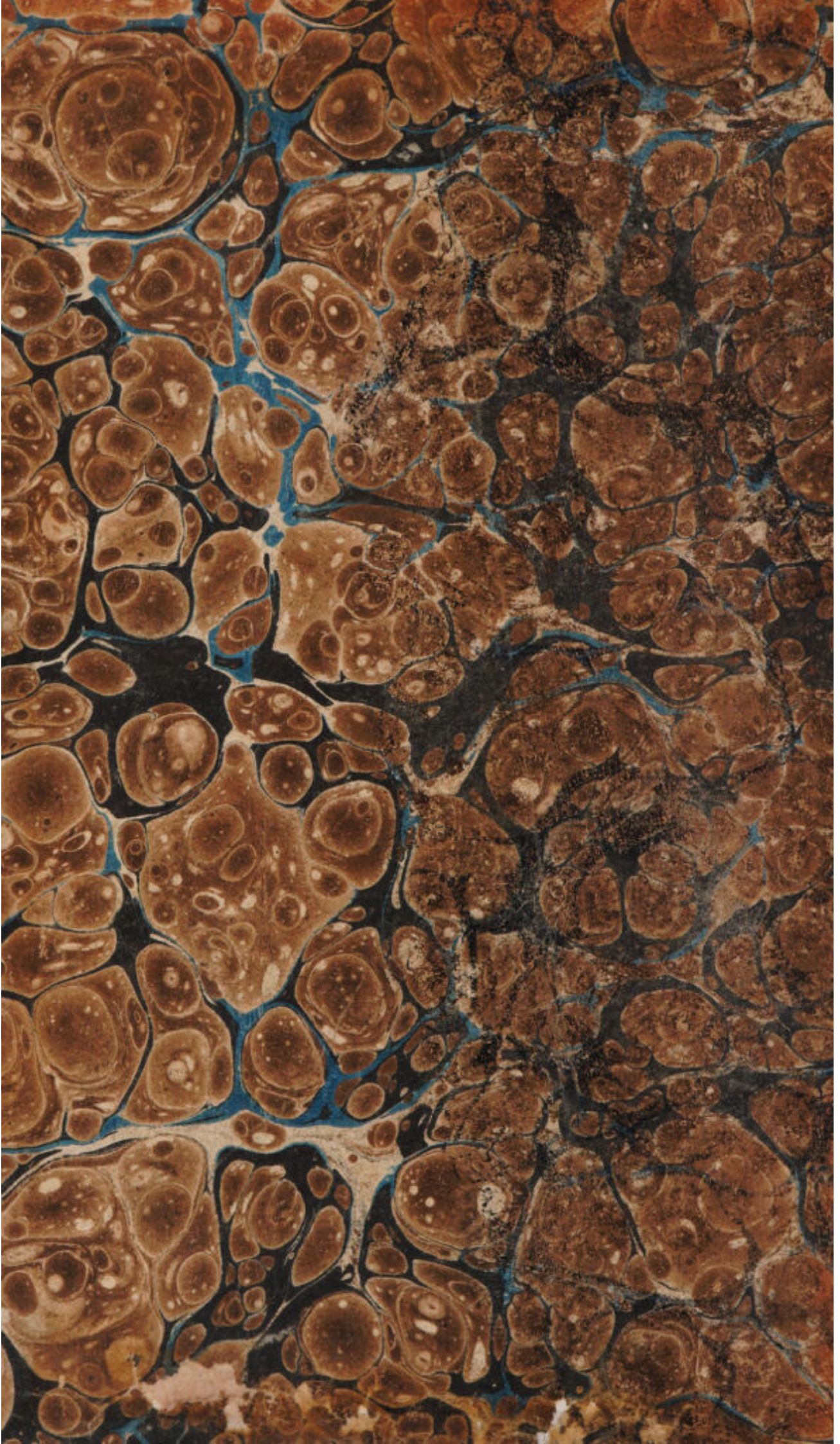
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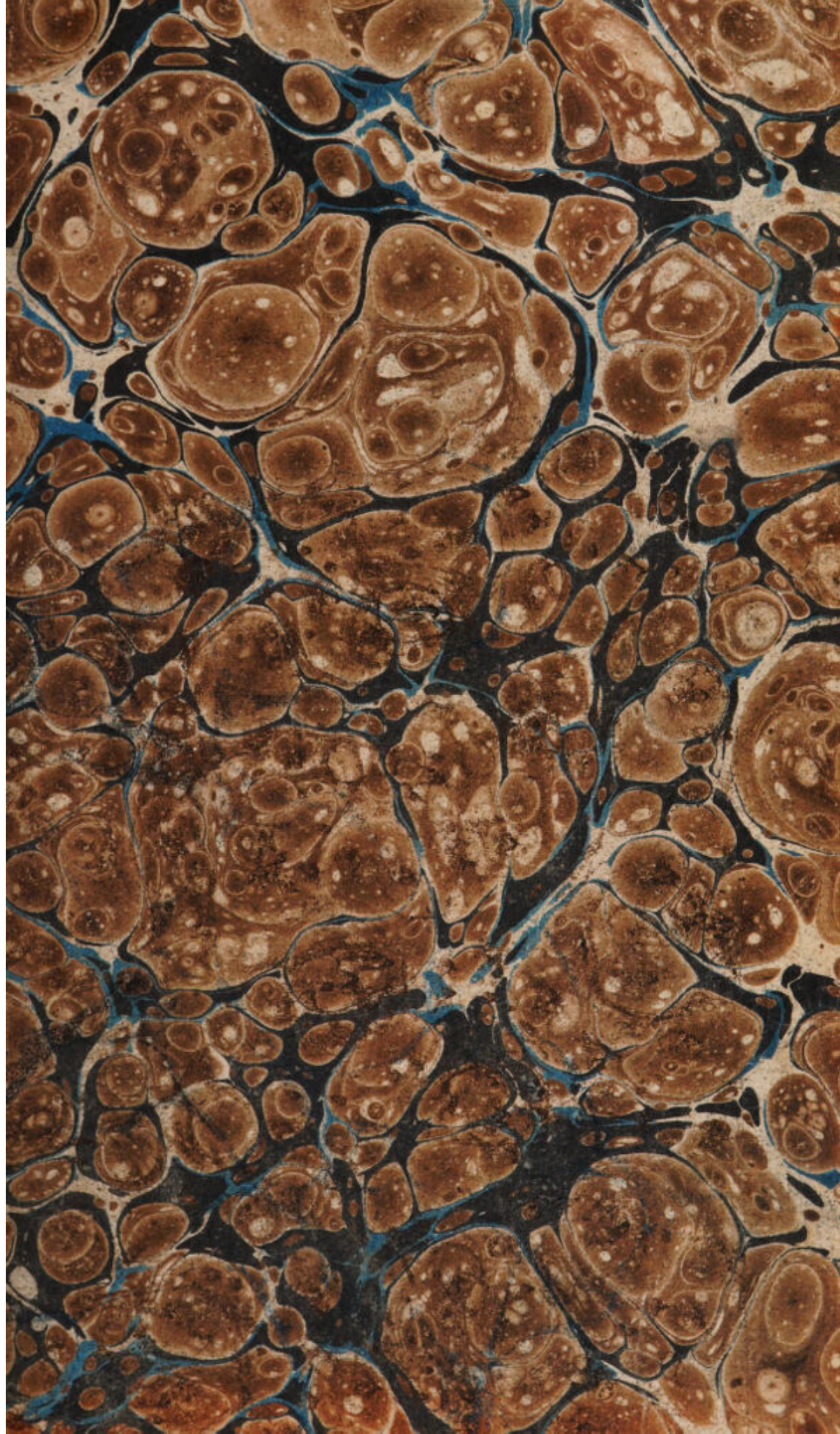
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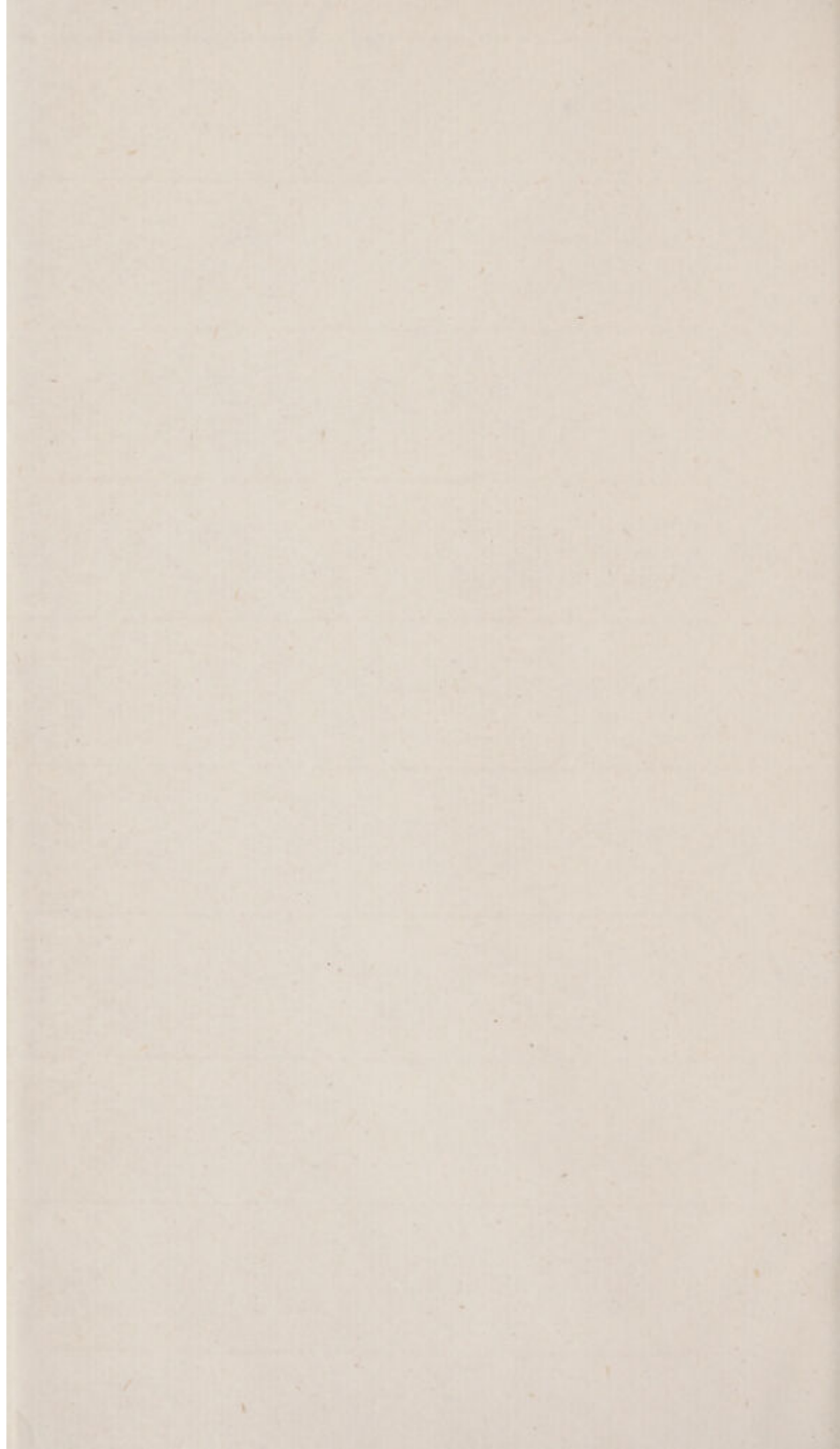






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A TREATISE
ON THE
CHEMICAL HISTORY
AND
MEDICAL POWERS
OF SOME OF THE MOST CELEBRATED
MINERAL WATERS;
WITH
PRACTICAL REMARKS
ON THE
AQUEOUS REGIMEN.
To which are added,
OBSERVATIONS
ON THE USE OF
COLD AND WARM BATHING.


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

SECOND EDITION, ENLARGED.

London:

PRINTED AND SOLD BY PHILLIPS AND FARDON,
GEORGE YARD, LOMBARD STREET.

1805.



A TREATISE
ON THE
CHEMICAL HISTORY
OF THE
MINERAL WATERS
OF THE
AQUEDUCT REGIMEN
OF THE
COLD AND WARM SPRINGS

BY WILLIAM SANDERS M.D. F.R.S.

Author of "The Mineral Waters of the Aqueduct Regimen"

LONDON: EDWARDS, 1801.

1801

Printed and Sold by G. EDWARDS, at the
Corner of St. Martin's Lane, London.



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.

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P R E F A C E

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

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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 scientific 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 increased 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 falubrious 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

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ways 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 likewise been mostly adhered to, as well as its principles, as they are such as are now the most familiar to those who are conversant in this science. With regard to the individual mineral springs which are particularly treated of, they are very few compared to the vast 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 those that enjoy a high degree of celebrity, that are interesting from some peculiarity of composition, or that serve to distinguish certain classes of these natural bodies, and illustrate their medical virtues. The reader will see, that the particulars concerning the chemical analysis of these springs are extracted from the various detached publications on the individual waters; and some pains have been taken to reconcile or account for differences of result, which sometimes happen where more than one authority has been consulted.

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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 examina-

tion. Zeal for the honour of a favourite fountain has, I think, induced them to refer to an unknown cause effects which may be fairly deduced from the operation of substances already familiar to chemical analysis. Surely an unbiassed person, who is aware of the comparative accuracy to which chemists are at present able to carry their enquiries, can hardly suppose that, whatever slight error might occur in the estimation of minute quantities, the actual existence of any powerful agent on the human body in any mineral water should escape the nicety of research. Every other fact concerning these bodies shews that it is only strong sensible properties which here indicate corresponding medical powers; the analysis of mineral waters as far as regards the mere ascertaining the presence of active contents, is by no means difficult to a person at all conversant in the experimental part of chemistry; a very few articles will comprise 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 considerable service, by collecting under one point of view, the leading features of those important improvements, which chemistry has been making for many years upon these subjects, particularly with regard to their application to medicine. This object is not fulfilled in those excellent, but purely chemical works, from the pens of Bergman, Kirwan, and others, with which this science is enriched; and the chemico-medical publications of Shaw, Hoffman, and Lucas, though always valuable, are now become imperfect, from the great acquisition of new matter, and often found erroneous in essential points. It is only in a number of detached essays on individual waters, that we find all the information which we possess; and out of these I have endeavoured to select the facts which are the most interesting, and reduce them to general arrangement. It has been my wish to bestow upon each part of the subject, 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.

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M I N E R A L W A T E R S, &c.

C H A P T E R I.

O N T H E C H E M I C A L C O N S T I T U T I O N O F
W A T E R, A N D I T S P O W E R S U N D E R
V A R I O U S N A T U R A L C O M B I N A T I O N S.

I N 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

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and that, under particular circumstances, they all deposit a portion of earth. These events constantly occurring with every natural water as it springs from the soil, several ingenious men have imagined, that earth and air were necessary constituent parts of perfect water, and have attempted to allot to each of them, their peculiar share in producing the various appearances of this fluid, and its effect on the human body. So Hoffman observes, (a) that “water is composed of watery moisture, or *water*, properly so called, of a fluid expansive ether, and of earthy and saline particles.” Assuming this composition as true, he goes on to assign the particular properties of each ingredient: “The ethereal part is the cause of the superiour lightness, briskness, intestine motion, and exemption from putrefaction; the watery part, which is by far the greatest in quantity, is composed of very subtile and mobile particles, which insinuate into, and penetrate every substance capable of solution; whilst the earthy and saline matter is fixed, and will not rise in distillation.” Hence too, the quality of different waters must, 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 quotation (selected from various passages in this 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 ex-

aggerated 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 acquiesced in, and has long put an end to the controversy. (a)

Water had hardly been re-established on the list of elementary substances, before the important question of its decomposition, according to the opinion of modern chemistry,

(a) The particulars of this interesting experiment are the following: a glass alembic was provided, of the kind called a *pelican*, which constantly returns the distilled liquor to that which is boiling, without requiring the vessel to be deranged, or stopping the operation. This alembic, furnished with a glass stopper closely ground in, was found to weigh one pound, ten ounces, seven gros and a half: then three pounds, fourteen ounces, five gros and a half of distilled water were introduced, the vessel closed, and the junctures carefully luted. The pelican was then placed in a sand 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 deposition was formed which gradually increased, till the distillation was discontinued. After every thing was cold, the luting was carefully taken off, and the vessel, with its contents, was weighed, and no increase or diminution of the original weight was perceived; but when the alembic was emptied and carefully dried, it had lost $17\frac{4}{10}$ grains. The earth deposited from the water, weighed $4\frac{2}{10}$ grains. The water itself was then evaporated to dryness, and left a further residuum of $15\frac{1}{2}$ grains, so that the whole quantity of earth obtained was $20\frac{4}{10}$ grains. The excess of 3 grains of earth over the $17\frac{4}{10}$ grains, the loss of the alembic, was supposed to be owing to a further abrasion of part of the vessel in which the water was evaporated to dryness.

began to be agitated. It would be foreign to our present purpose to give any history of this interesting question, and the gradual advances which this opinion has made to an almost universal establishment among chemists of every country. Water is, according to this opinion, a compound fluid, made up of two substances, neither of which can be exhibited separately, except in the gaseous form; and when aeriform, they are known, the one as *Hydrogen Gas*, or *Inflammable Air*; the other as *Oxygen Gas*, or *Vital Air*. These gases, 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, constitute the fluid, Water. It is to be observed however, that this circumstance of the composition of water, has very little concern with the chemical knowledge of mineral waters. None of the methods of examining these waters appear in any notable degree to reduce simple water to its original elements, but only to separate from it the foreign contents of every description, to which it combines while flowing under the surface of the earth: no process of

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the process of animal putrefaction, is supposed to be principally brought about by the decomposition of water, assisted by a moderate temperature, and therefore the same materials under the same circumstances of heat, may possibly undergo somewhat of a similar decomposition even during animal life. As this subject, however, is entirely confined to the regions of conjecture, and not connected with our present inquiries, we shall take no further notice of the ultimate decomposition of water.

Of all the classes of natural bodies, there are none into which water enters so largely as a constituent part, as those of the vegetable and animal kingdoms. These are peculiarly distinguished, in a chemical view, from the mineral kingdom, by possessing a structure remarkably liable to decomposition, and in which the quiescent affinities are never so adjusted, that the constituent parts of their bodies can, for a moment during life, remain at rest without forming new compounds. Most minerals will continue for ages unaltered, when protected from external chemical agents; but an animal or vegetable is at no

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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, alcalescence, 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 circu-

lation, 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 uses of this copious excretion seem to be not only to remove a superabundance of water from the system, but especially by carrying it off in a gaseous form, to constitute the great cooling process, and thus keep in proper check the production of heat by the lungs. In the copious excretion of urine, the proportion of water, though less than in the former case, is still very great. It is calculated by Haller at about $\frac{1}{2}$ to $\frac{4}{5}$, and it appears to have regular variations according to the previous diet, the time which this secretion requires in forming, and the frequency of discharging it. Our chemical knowledge of the other ingredients is still very imperfect, but they seem to be more various and peculiar than those of any other natural secretion. No other, likewise, shews such a total diseased change in chemical composition, as that which occurs during the saccharine diabetes.

On the whole, it is probable, that the purely chemical properties which water exercises when forming a constituent 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 exposed, which will increase or diminish the true solvent power of this liquid; and possibly too, on the order in which the other contents have been presented to it. This last circumstance has been but little attended to by physiologists, and yet as we must suppose that the laws of chemical affinity are not entirely superseded by the living powers, it is certainly probable that the order of solution of the different contents of the common animal fluid, may in some degree affect the respective proportion of the substances dissolved.

It is not only in the animal, and still more in the vegetable fluids, that water appears the most abundant ingredient, but even the solids of both these natural productions are found, when disorganized, to have been composed most largely of aqueous fluid, but altered in its texture, and deprived of its property of fluidity, by the union of a very small portion of other matter, assisted by the gradual process 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 driest 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

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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 atmospheric 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 $\frac{1}{8}$ 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 num-

ber of mineral waters, and the discovery of its chemical properties has cleared up a great many difficulties that stood in the way of former chemists. Water, at a moderate temperature, will readily take up its own bulk of carbonic acid gas, and becomes thereby bright and sparkling to the eye, acidulous and gently pungent to the taste, and sends off numerous bubbles when shaken or moderately heated. Water thus acidulated, or even long before it acquires these sensible properties, is capable of dissolving several earths, especially lime and magnesia, and a few metals, of which iron is the only one that is met with in the medical springs. The adhesion of the carbonic acid to the water is very weak, so that it may be all driven off in a gaseous form by boiling for about a quarter of an hour; and whilst the acid gas is flying off, the earths or iron which it had dissolved, are gradually precipitated in a pulverulent form; the former as a white powder, the latter as a light brown ochre. Water, strongly acidulated with carbonic acid, sometimes exerts a kind of intoxicating power, when largely drank. It proves fatal to fishes and some in-

fects, 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.

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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

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pecially those of lead, silver, and mercury; and blackens the surface of reguline silver or mercury, when they have been immersed for several hours. It forms a yellow precipitate with the solutions of arsenic. These changes on metallic surfaces or solutions, are owing to the union of the sulphur with the metal, and they are used as the most accurate tests of the presence of this gas. A few drops of strong nitrous acid, poured into this hepatic water, at once represses the offensive smell, renders the mixture more turbid, and causes the sulphur to be gradually deposited. The oxygenated marine acid has the same effect, but if added to excess, it acidifies the sulphur, and thus, instead of sulphur being deposited, sulphuric acid is produced. The adhesion of the sulphur to the hydrogen and water is very weak; for, hepatic water becomes turbid, loses its smell on exposure to air, or partly if kept closely corked, and pure sulphur is deposited. This is the origin of the sulphureous pellicles that are found in the channels in which this water flows, or lining casks and other vessels in which it is usually conveyed. Water, when heated to 80° or 90° , can with

difficulty be made to dissolve any of this gas; and hence, to procure it for the purpose of ascertaining its quantity, it should be received over warm water. Several hot springs contain this gas in abundance, and it is often found in conjunction with carbonic acid. When taken internally, the sulphureous particles seem to pervade the whole system, and even will, in time, tarnish any silver that is worn in the pocket.

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

The existence of this substance, in combination with a few natural waters, has been fully ascertained by skilful and accurate chemists. It is always, however, found only in a small quantity, as water exerts but little solvent power over this gas. Its adhesion to water appears to be looser than that of any other gaseous body, for it is readily expelled on the first impression of the heat used to collect aeriform substances from mineral waters. In some springs that contain this gas, a large quantity of it comes up along with the water, rises through it unmixed, and may readily be collected by any inverted vessel held over

the fountain head. Azotic gas does not appear to give any sensible 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 presence when dissolved; but it is a substance that requires to be mentioned, as it gives a peculiarity of composition to a few mineral waters that possess a high reputation.

These are the gaseous substances that have been hitherto found in mineral waters; they all have, in common, the property of re-assuming the aeriform state, by the application of heat, and it is then, for the most part, that their respective quantities are estimated by processes which belong properly to pneumatic chemistry. Of these gases, there are two, the sulphurated hydrogen, and the carbonic acid, which are by far the most important in a medical and chemical view, as materially contributing to the peculiarity of composition, and to the medicinal properties of the mineral water of which they are component parts. The carbonic acid likewise acts as a chemical agent, on other compound ingredients in these waters, and thus will often come into further notice in somewhat 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 faturated with carbonic acid, is also equally foluble in water; but when only partially faturated, it remains entirely info-
 luble, and, in this ftate, it forms the folid *carbonat of lime*, or *chalk*. This is the ftate to which lime fpontaneously tends when expofed to the air in either folution; in the one, by abforbing carbonic acid from the atmofphere, in the other, by giving off into the furrounding air its excefs of this acid; and in either cafe the carbonat of lime is precipitated as chalk. The fame happens when carbonic acid is added in any way to lime water, as when lime water is added to a carbonated folution of lime. Water, containing any quantity of carbonic acid, will diffolve as much chalk as is equal to the weight of the acid, if the latter be in confide-
 rable proportion to the water, but will diffolve about twice as much, if the water be but weakly impregnated with this acid, as Kirwan obferves. This is one fource of *hardnefs* in waters, but is readily got rid of by boiling, which drives off the excefs of carbonic acid, and thus caufes the chalk to be precipitated; hence the earthy cruft, 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 carbonate 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, petrifications, 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 eva-

porated, 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 salt produced by the union of lime with the muriatic acid, is found in a great variety of springs, especially in the brine springs, where it is a troublesome ingredient. It is bitter to the taste, very soluble both in water and spirit of wine, and very deliquescent. It is almost always accompanied with salt, from which it is with difficulty separated in manufacturing this article. The great bitterness of some salt waters, such as those of the Dead Sea, is owing to the muriats of lime and of magnesia, and not to bitumen, as was erroneously supposed. Muriat of lime is not discoverable with certainty by any single test.

In all the salts with the basis of lime, this earth is precipitable from any combination by the oxalic acid, or acid of sugar. This acid unites with the lime, and forms a compound, which, being nearly insoluble 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 solutions by pure ammonia, which is an important circumstance in analysis, as it is thereby distinguishable from magnesia and aluminous earth, which are both separated from their acids by caustic volatile alkali. But the mild or carbonated ammonia, will decompose all the earthy salts by double affinity, the alkali uniting with the acid of the earthy salt, and the carbonic acid with its earth; and as the caustic ammonia is highly disposed to attract carbonic acid from the air, when used as a re-agent, it should be mixed in a phial with the solution to be examined, and closely corked.

MAGNESIAN SALTS.

Magnesia is an earth that is found almost as widely diffused in the mineral waters of different countries as lime is, but generally not in such quantities. We have no instance of magnesian depositions 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 ex-

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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 ease with which the magnesian precipitate is soluble in cold dilute sulphuric acid.

ALUMINOUS SALTS.

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

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

This salt is soluble in its own weight of boiling water, but requires a much larger proportion of cold water. It readily forms crystals, permanent in the air, and has an acid and very astringent taste. Alum possesses naturally an excess of acid, which is necessary to the constitution of this salt, and therefore it shews with different re-agents the same appearances as an uncombined acid. Alum is but rarely contained in mineral waters, and is generally found associated with sulphat 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 those of certain lakes, especially the natron lakes in Upper Egypt. It is here often mixed with common salt, and they both are largely dissolved in the water, and form a crust of several feet in thickness at the edge of the lake, owing to the copious evaporation of their water of solution, effected by a tropical sun. Besides these large reservoirs of this valuable alkali, there are some springs in different countries which contain it in small quantities, but enough to receive thereby very sensible properties, and it is often super-saturated with carbonic acid. The valuable waters of Seltzer are of this kind, and they therefore shew at the same time the tests of an acid and an alkali. The alkalies, either pure or carbonated, will turn syrup of violets green, and Brazil wood purple; in which properties they are imitated by the carbonats of lime and magnesia; but the distinguishing test of an alkali is, to turn the yellow of turmeric to an orange or brick red, which the carbonated earths will not do. Carbonated soda is readily procured from its solutions by evaporation and crystallization; or, the quantity of uncombined alkali in any water may be de-

terminated 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 cryftallizes with great eafe by evaporation and fubfequent cooling, and is a falt which is for the greater part readily feparable from water. As it is often found in conjunction with fulphat of magnesia, and cryftallizes at the fame time, thefe two falts are not eafily procured in a feparate ftate.

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

This falt, of all others the beft known, and moft extenfively employed, is alfo one that is the moft univerfally and largely diffufed over every part of the globe. Befides the immense ftorehoufe for this falt in the waters of the ocean, it is found in a more concentrated folution in various lakes and brine fprings, and in vaft folid maffes on the fhores of different lakes, or many fathoms beneath the furface of the earth in beds that are worked as mines. In moft of the common fprings however, or even in thofe that are ufed medicinally, the muriat of foda is not found in nearly fo large a proportion as in fea water, and therefore in thefe it is only a falt of inferior confequence. Com-

mon 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 so small as hardly to be estimable by any chemical process. There are two solutions of this metal which are met with in mineral waters, that in the carbonic and the sulphuric acids, and sometimes the same water holds both these salts in solution.

17.—*Carbonat of Iron.*

Water, well saturated with carbonic acid, will dissolve about $\frac{1}{10000}$ of its weight of iron, as Bergman observes; but, for this effect, it is necessary that the iron should be in the reguline state, or at least so little oxydated as to be still magnetical. Iron is seldom met with under this form, compared to the frequency with which it occurs as a perfect oxyd: otherwise, if the latter were equally soluble with the former, almost every natural water would be a chalybeate. The carbonated chalybeates are in general perfectly clear when fresh from the spring, but the affinity of the carbonic acid is so small, that they soon grow turbid when exposed to the air, and gradually deposit a fine ochre, or car-

bonated oxyd of iron, which partly precipitates to the bottom of the vessel in which the water is contained, and partly swims on the surface in the form of a fine iridescent pellicle. The water is by this means entirely freed from every particle of iron, and will no longer indicate this metal by the most delicate tests. This separation likewise occurs, if the fresh water be kept in a bottle only half full, or carelessly corked. The walls of every chalybeate well, and the channels through which the water flows, are also lined with the same oxyd, forming a very good indication of the nature of the spring. The ochre, when analyzed, is found to be composed of iron, oxygen, carbonic acid, and water. An artificial solution of iron in carbonic acid (first noticed by Mr. Lane, and which cleared up every doubt on this subject) may be very readily made, by agitating for a few minutes, iron wire or filings in a bottle filled with water saturated with this acid gas; and this solution is a perfect imitation of most of the simple natural chalybeates. Caustic alkalies separate the iron entirely, but the aerated alkalies re-dissolve 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

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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. Silix, 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 margins of the boiling springs near Hecla in Iceland, appears to be

a spontaneous depofition from this fingular fpecies of mineral water. In thefe waters, the filex is accompanied by a fmall excefs of foda, but not enough to be at all equal by itfelf to the folution of this earth. Siliceous earth has alfo been found in other waters, though in much lefs quantity; but its folution in water is a natural procefs, which is one that art cannot imitate with any fuccefs. The prefence of filex is only afcertained by evaporating the water to drynefs, and treating the refiduum with water, and different acids, till every thing is taken up that is foluble in thefe menftrua. What remains is filex, which is diftinguifhed by fufing on the blow pipe with carbonated foda into a perfect glafs.

22.—*Alumine, or Pure Clayey Earth.*

This earth is entirely infoluble in pure water by any artificial means, and appears to be equally fo, by any natural procefs. Owing, however, to the great finenefs of its particles, and the quantity of water with which it combines, it remains very long fufpended, gives a milkinefs and opacity to water, and a fmooth

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 flow 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 pro-

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inches, these points are made use of as the standard ones for thermometrical division; and its specific weight being always the same under like pressure and temperature, it is employed for the comparative standard of specific gravity.

Pure distilled water can only be procured from a water which contains no volatile matters that will rise in distillation, and continue still in union with the vapour when condensed. Many substances are volatile during distillation; but most of the gases, such as common air, carbonic acid, and the like, are incapable of uniting with water at a high temperature: other bodies, however, such as vegetable essential oil, and in general much of that which gives the peculiar odour to vegetable and animal matter, will remain in water after distillation. So, the steam of many animal and vegetable decoctions has a certain flavour which distinguishes it from pure water, and the aqueous exhalation from living bodies, which is a kind of distillation, has a similar impregnation.

To obtain distilled water perfectly pure, much stress was laid by former chemists on

repeating the process a great number of times; but it was found by Lavoisier, that rain water once distilled, rejecting the first and last products, was as pure a water as could be procured by any subsequent distillations.

Distilled water appears to possess a higher power than any other, as a solvent of all animal and vegetable matter, and these it holds in solution, as little as possible altered from the state in which they existed in the body that yielded them. Hence the great practical utility of that kind of chemical analysis which presents the proximate constituent parts of these bodies, and which is effected particularly by the assistance of pure water. On the other hand, a saline, earthy, or otherwise impure water, will alter the texture of some of the parts, impair their solubility, produce material changes on the colouring matter, and become a less accurate analyser, on account of the admixture of foreign contents.

Distilled water is seldom 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*.

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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

increase of temperature, it loses common air and carbonic acid, and with this last, much of the lime which it held in solution. The specific gravity thereby becomes less, the taste not so harsh, but less fresh and agreeable; and out of a hard spring is often made a stream of sufficient purity for most of the purposes where a soft water is required. Some streams, however, that arise from a clean siliceous rock, and flow in a sandy or stony bed, are from the outset remarkably pure. Such are the mountain lakes and rivulets in the rocky districts of Wales, the source of the beautiful waters of the Dee, and numberless 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 streams from the mountains, and give rise to some of the finest rivers in Europe. An excellent observer and naturalist, the illustrious Haller, thus speaks of the Swiss waters:—"Vulgaribus aquis Helvetia super omnes fere Europæ regiones excellit. Nusquam liquidas illas aquas, & crytalli simillimas, se mihi obtulisse memini postquam ex Helvetia excessi. Ex scopulis enim nostræ per

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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 passed by a large town, and received all its impurities, and been used by numerous dyers, tanners, hatters, and the like, that croud to its banks for the convenience of plenty of water, should thereby acquire such a foulness, as to be very perceptible to chemical examination for a considerable distance below the town; but it appears from the most accurate examination that where the stream is at all considerable, these kinds of impurity have but little influence in permanently altering the quality of the water, especially as they are for the most part only suspended and not truly dissolved; and therefore mere rest, and especially filtration, will restore the water to its original purity. Probably therefore, the most accurate chemist would find it difficult to distinguish water taken up at London, from that procured at Hampton-

Seine water fresh from the river, but less so than Seine water once distilled. There was no perceptible difference between the water taken up at Paris, and some miles higher up, after the former had been filtered. Mr. Parmentier obtained nearly the same results with those of the committee.

court, after each had been purified by simple 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 stag-

nant 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

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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 felenitic 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 process is, to cause water that is foul, to pass through the very minute pores of any substance not of itself capable of imparting any thing to the water; and by this means every thing which is simply suspended in the liquor, but so intimately diffused as not to be separable by mere repose, is detained in the filter, and the water passes through clear and limpid. This is a process which is performed largely within the earth, and hence we find the purest waters to arise through clean sand or siliceous rock. To imitate this natural process, nothing is better than the porous free-stone of which filtering stones are usually made. Sand, clear gravel, pounded glass, and similar substances, are equally fitted for this purpose. Filtration may be performed either by causing the water to descend by its own weight through a porous substance, or to ascend through it by capillary attraction. The latter method, where it can be adopted, appears preferable. It is to be observed, however, that common filtration will not render water less saline, or separate any thing that is truly dissolved, but only what is suspended. I have said

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 particu-

lars which are entertaining and often instructive; and the scientific reader will frequently find, that it is only by slow degrees that the efficacy of any mineral water in every species of disease to which it is applicable, has been established; as for instance, where its use as a bath long preceded its employment as an internal remedy.

A collateral branch of inquiry of considerable importance, is that of *site*, under which term may be included all that relates to soil, general state of the atmosphere, purity of air, and face of the country around the spot that is enriched by this natural treasure; and which are circumstances of no small consequence to the invalid, since the advantages of air, exercise, and agreeable prospects, in most cases admirably coincide with the general curative effect of the spring itself. These advantages have often given a deserved preference to one water over another of equal medical powers, but placed in a less favoured situation. The site of the spring itself, the strata of earth through which it penetrates, and the nature of the soil out of which it rises into day, are also circumstances more particularly connected with, and often

throwing much light on its chemical composition.

In examining the water itself, the *sensible properties* claim the first notice, as by these we are often able to form a pretty accurate idea of the nature of its contents, especially those to which the peculiar medicinal effects are to be attributed. *The appearance to the eye*, that is, whether sparkling or quiet, clear or turbid, or with a slight shade of colour; and especially the *taste*, whether saline, chalybeate, or bitter; and the *smell*, whether fetid, sulphureous, or scentless; all these are circumstances of great importance, and naturally precede the chemical inquiries. The *temperature*, as determined by the thermometer, is also particularly to be noticed, as it sometimes forms the distinguishing feature of a separate class of natural waters, and is independent of chemical composition. After the sensible properties have been ascertained, the nature and quantity of foreign contents are to be determined by accurate *chemical analysis*, for it is by this alone, that we can come to a certain knowledge of the composition of any mineral spring. Chemists are in the habit of using

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 analysis; but, where it is applicable, it promises 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 *sensible effects* which it produces on the human body on being received into the stomach, as these directly indicate the cases in which it may be applicable as a medicine, and lead to one of the most important of all the uses to which a natural spring can be employed. To determine these with precision, and especially to point out to which of the foreign contents they are to be attributed, often requires much judgment and observation; and in fact is one of the most interesting subjects connected with the history of a mineral water. The circumstance of adding to the daily ingesta so large a quantity of liquid, and also some peculiarities in particular waters, likewise demand some attention as to the *mode of using them*, the doses which it is proper or safe to begin with, the time of the day in which they should 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 those that have acquired any degree of local celebrity; only, in proportion as chemical knowledge increases, this mode of classification must undergo successive alterations. Such, however, is not my object in the following pages; for, independently of the great extent requisite to notice every mineral water, there are a vast number that are but little known and inquired into, and therefore the chemical analysis of these must be very imperfect; and there are still more, perhaps, whose medical virtues may be referred to one or two well-known substances that exist in higher perfection in other and more frequented springs.

I have therefore selected among a great number, those only that deserve particular attention, or have acquired great celebrity, or may be considered as fair specimens of a numerous class. The order which I have preferred to follow, is chiefly that of degree of foreign impregnation with any thing that shews a sensible and striking difference from common water; beginning with the most simple, and proceeding to those 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 de-

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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 fore, it moderates the profuseness of the discharge, corrects the foetor 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, persons afflicted with sore eyes, have been in the habit of resorting to Malvern Holy Well. Another order of external diseases for which this water is greatly celebrated, is that which has been included under the general name of cutaneous eruptions; and even those obstinate cases of dry desquamations, that frequently follow a sudden application of cold in irritable habits, are often cured by this remedy. Where the skin is hot and dry, it remarkably relieves the intolerable itching of herpetic disorders, and renders the surface of the body more cool and perspirable. It appears, however, from a nice observation of Dr. Wall, that this method of treatment is not so successful in the cutaneous eruptions of very lax leucophlegmatic habits, where the extremities are cold, and the circulation languid; but that it succeeds best where there is unusual irritation of the skin, and where it is apt to break in painful fissures, that ooze out a watery acrid lymph. On the first application of this water to an inflamed surface, it will often for a time increase 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 kidneys 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, dressing with it quite wet, and renewing this application as often as it dries. The perfect safety of this practice on a preternaturally irritated surface, has been ascertained by long experience, and is in itself an important circumstance in illustrating the effect of moisture on the surface of the body.

The internal use of Malvern water, is sometimes attended at first with a slight nausea, and not unfrequently for the first day or two, it occasions some degree of drowsiness, vertigo, or slight pain of the head, which comes on a few minutes after drinking it. This effect Dr. Wall ingeniously explains from the temporary plethora of the vessels of the head, occasioned by the great ease and rapidity with which this pure liquid enters the absorbent system. These symptoms go off spontaneously 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 constant; frequently it purges briskly for a few days, but it is not uncommon for the body to be rendered costive by its use, especially, as Dr. Wall observes, with those who are accustomed

to malt liquors. In all cases it decidedly increases the flow of urine, and the general health of the patient; his appetite and spirits almost invariably improve during a course of the water, if it agrees in the first instance. To this, the fine mountain air, and beauty of the situation, which tempt the invalid to active exercise, will doubtless much contribute; and the temperance and regularity of life which are generally observed in these places by patients of every rank, will assist in securing the advantage which has been gained by the use of the water.

The duration of a course of Malvern water must vary very considerably, on account of the different kinds of disease for which this spring is resorted to. Cases of obstinate scrophulous sores, especially with caries in any bone, are always long in healing, and require a residence here for a considerable time. The same may be said of very obstinate herpetic eruptions; but where the cutaneous affection is mild, or where a tendency to it comes on at stated times, which is sometimes the case, this habit may be checked by a short use of this water; and hence some per-

fons 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.

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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 glass. It is very agreeable to the palate, but without having any very decided taste, at least none that can be well distinguished by a common observer. Its specific gravity is only 1.00077 which approaches so near to that of distilled water, that this circumstance alone would shew that it contained but a very small admixture of foreign contents. This water, as its name imports, is a thermal spring, but one in which the heat is very moderate. The exact temperature is given differently by different observers, which may be partly owing to a slight actual variation in its heat, but principally to a little difference in thermometers. Taking the average of the most accurate observations, it may be reckoned at 74° , and this does not very sensibly vary during winter or summer. A little peculiarity attends this fountain, which requires to be mentioned. The spring tides are known to rise to a remarkable height in the Severn and Avon, and with great rapidity. The Hotwell, although considerably higher than the river, is however so far affected by a spring tide, as to become thereby in some degree turbid, and is then not thought quite so efficacious. This gives

rise to a refinement in practice, in avoiding the medical use of the Hotwell during these periods, till by about two hours pumping, the water returns to its original purity (*a*).

Bristol water, besides being employed medicinally at the spring head, which is in fact but a small part of its consumption, is used largely at the table at the Hotwells, and for all domestic purposes. Its softness, or freedom from earthy salts, is almost proverbially known; and from its excellent quality of keeping untainted for a great length of time in hot climates, it forms a most valuable water for long voyages, and is accordingly exported in great quantities to distant parts.

The contents of this water have been ascertained at various times by able chemists, and in the modern improved state of chemical analysis, nothing further seems to be required to complete our knowledge of this water; nor does it appear probable, that there exists in it any substance which has not been detected,

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

although some difference may arise in estimating the exact quantities of these contents, none of which are in themselves at all uncommon 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 $47\frac{1}{4}$; 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 particulars of an examination apparently conducted 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 discovers fulphuric acid: and nitrat of silver exhibits the muriatic acid.

Nothing of a sulphureous nature appears by the delicate test of acetite of lead.

A further analysis of Bristol water by flow evaporation to dryness, gave to Dr. Carrick, the following contents in the wine gallon:

Of muriated magnesia . .	7.25
— muriated soda	4.00
— fulphated soda	11.25
— felenite	11.75
— carbonated lime . . .	13.50
	<hr/>
	47.75

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

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

It appears, therefore, that a Winchester gallon (of 231 cubic inches) of Bristol Hotwell water contains only $47\frac{3}{4}$ grains of solid contents, of which rather less than half are neutral salts with the basis of soda, and the remainder are calcareous salts: but that it also

holds in solution about $\frac{1}{7}$ to $\frac{1}{5}$ 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 restored without a further loss of this volatile acid. It still, however, continues to be a pure and excellent water for the table, and is used as such at the Hotwells.

That the reader may form a better idea of the properties of this water as a medicine, I shall give the solid and gaseous contents of each dose, calculated from the results of the analysis already quoted. This plan will be pursued, where it is practicable, with all the other mineral waters that will be noticed in the course of this work.

Half a pint of fresh Bristol water, which is a full dose, contains

Of sulphat of soda, muriat of soda, and muriated magnesia, gr. 1.404, or somewhat less than a grain and a half.

Of sulphat of lime and chalk held in solution 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 measure. Therefore, supposing the above quantity taken four times in the day, the patient will have added to his daily ingesta about five grains and a half of purgative salts; six grains and a half of calcareous salts; 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 diarrhoea, 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 those medicines which are generally prescribed and sometimes successful. But the high reputation which this spring has acquired, is, above all, in the cure of pulmonary consumption, one of the most distressing in its symptoms, delusive in its appearance, uncertain in its progress, and difficult to be resisted, of all the disorders with which we are acquainted. Much difference of opinion has arisen on the supposed virtues of Bristol water in this disease, and from the number of unsuccessful cases among those that frequent this place, many have been disposed to deny any peculiar power to this, superior to any simple water.* It is not easy to determine how much may be owing to the favourable situation and mild temperate climate which Bristol enjoys; but it cannot be doubted that the Hotwell water, though by no

* The water of Bristol is celebrated for its purity, and for its virtues in consumptions, and several weaknesses. It has certainly no claim to be thought a pure water; and, as far as my experience goes, it has as little just pretence to any of the medicinal virtues which it has been thought to possess.—*Comment. on the History and Cure of Diseases, by W. Heberden, M. D. p. 79.*

means a cure for consumption, alleviates some of the most harrassing symptoms in this formidable disease. It is particularly efficacious in moderating the thirst, the dry burning heat of the hands and feet, the partial night sweats, and the symptoms that are peculiarly hectic; and thus in the earlier stages of phthisis, it may materially contribute to a complete re-establishment of health; and even in the latter periods it may considerably relieve, when the prospect of a cure has long been doubtful, if not hopeless. We are not yet fully acquainted with the medical virtues which we may expect from the union of a small quantity of carbonic acid with water; but from comparing the effects resulting from this gaseous acid when in a larger dose, and giving very sensible properties to the water with which it is combined, there appears to be some reason for attributing to this substance, a part at least of the virtues of Bristol water.

The season for the Hotwells is generally from the middle of May to October, but as the properties of the water are the same during the winter, the summer 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 advisable; 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

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pidity, overcasting in a few minutes the finest sky, and filling the whole atmosphere with hurrying showers. However, unfavourable as the climate appears, there are several circumstances which render Buxton more tolerable to the invalid than would be at first imagined. One of considerable importance is the dryness of the soil, which, being principally a clean hard limestone, does not retain much moisture; and from the inequality of the ground, the showers that fall so frequently are quickly carried off in rapid torrents into the streams that occupy the vallies. Hence it is, that the least interval of clear weather may be immediately taken advantage of by the invalid; and all the mischiefs that can ever be supposed to arise from the stagnation of air are also intirely prevented by this turbulent atmosphere.

Few places so little favoured by nature with any but the wild romantic beauty of bare mountains and deep vallies, are so much indebted to industry and cultivation as the village of Buxton and its neighbourhood. Under the auspices of the Duke of Devonshire, the present 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 deposit, or form any incrustation, on the pipes or stone channels through which it flows in its course to the several baths. It is entirely void of smell or taste; it sparkles a little when first drawn, but apparently not more than the water of many common springs. Its temperature in the gentlemen's bath, is invariably 82° , which therefore entitles us to consider Buxton water as a thermal spring, though but low in the scale of these natural waters.

A thin column of steam generally hovers over the surface of the bath during the cool of the morning and evening, and sometimes during the whole day, which last circumstance is considered as a sure indication of approaching rain. The principal peculiarity in the appearance of this spring, is a very large quantity of a permanently elastic vapour, which rises along with the water through the crevices in the floor of the bath, forming clusters of bubbles of various dimensions, that pass through the water without mixing with it, and break as soon as they reach the surface. These bubbles may easily be collected by any vessel filled with water, and inverted so 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 slight degree curdles soap, which effect is prevented, by adding one grain of alkali to one ounce of the fresh water. Nothing sulphureous appears either from the smell, or by those delicate tests, the solutions of lead and silver. By evaporation to dryness, Dr. Pearson found in the gallon of Buxton water only 15 grains of residuum, of which he estimates $1\frac{3}{4}$ grain to be muriat of soda, $2\frac{1}{2}$ grains to be sulphat of lime, and $10\frac{1}{2}$ grains to be carbonat of lime.

A quantity of air was long observed to be both contained in fresh Buxton water, and to rise up along with it through the crevices of the pavement of the bath. The perfect insignificance of the solid contents, led chemists to pay more attention to the gaseous products: the gas which rises through the water was supposed to be carbonic acid; but Dr. Pearson by his experiments fully ascertained that this was a mistake, and that it is in fact azotic gas mixed with a small portion of atmospherical air. Buxton water contains about $\frac{1}{64}$ of its bulk of air in true chemical combination. Sixteen pints of the water, exposed to a boiling heat for a considerable time, yielded about

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The general result therefore of the analysis of Buxton water is the following: it is a remarkably pure water, and possesses no peculiar sensible properties except that of a higher temperature than all the adjacent springs; and as this circumstance is invariable in every season, the source of the heat depends on some internal cause, in which it differs from the cold natural waters. The little solid matter which it contains is such as is found in every common spring, and is of the most inactive kind. It holds in solution, however, a small quantity of azotic gas, as this air is very imperfectly soluble in water. In this respect only, does the chemical analysis of Buxton exhibit any thing different from the pump water in common use (*d*).

smallest traces of that metal, it is presumed that Dr. Higgins was misled by some accidental circumstance. It was only the result of his analysis, and not the process, that Dr. Higgins thought proper to make public, and therefore it cannot require any further attention.

(*d*) Dr. Pearson's analysis being conducted at a time when the nature of the gaseous fluids was but very imperfectly known, considerable merit is due to this ingenious chemist for his researches into that which gives Buxton water its peculiarity of composition. At the same time it may be added, that there is still 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 reaction, 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 inflammation or external injury, where the first

increase of action is past. Thus, the chronic rheumatism in all its forms, succeeding to the acute, and where the inflammation has been chiefly seated in moving parts, is often wonderfully relieved by this bath; and the healthy actions is soon so far restored, as to enable the patient to use the more powerful remedy of sea bathing, or the common cold bath. On the other hand, the loss of action produced by true paralysis will seldom admit of much relief by a Buxton bath, but requires the more direct stimulus of heat (*b*).

The use of Buxton water, when considered as an internal medicine of great activity and considerable efficacy, is a subject that demands some attention, as much controversy has arisen as to the source of its medicinal powers. It is not easy to collect from the writers on this subject, what are the precise sensible effects produced on the body by a moderate dose; or wherein they differ from those of mere water. In fact, it is at all times difficult, even in those mineral springs whose foreign

(*b*) For further observations on this subject, the reader is referred to the chapter on the external use of water, afterwards considered 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 use of this simple remedy will often relieve the distressing symptoms of heart-burn, flatulency, and sickness; and, if persevered in, will increase the appetite, render the secretions more regular, and improve the general health and spirits that are so intimately connected with the functions of the digestive organs. A large number of the invalids that resort to Buxton are of this class. The water appears to produce various effects on the bowels. Not unfrequently a spontaneous diarrhoea is the consequence of its use for some days, and this is always salutary; but it is more common, especially in habits where the action of the bowels is naturally sluggish, for costiveness to come on during a course of the water, which must be remedied by aperient medicines. Another class of disorders much relieved by the internal use of Buxton water, is the painful complaints of the kidneys and bladder, connected with the formation of calculus. The pain of these affections is much

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

relieved by the water, and its use as a bath will often assist its employment as an internal medicine. The comparative purity of the water may here be a principal cause of its efficacy. Buxton has been much recommended in various cases of gout, especially where the high inflammation of particular limbs has gone off, and where it has left either a number of dyspeptic symptoms, or a rigidity or impaired action in the seat of the disease. In this disorder however, the use of Buxton water seems to me to be very ambiguous, and seldom admissible. We are advised by Dr. Denman always to add some aromatic tincture to the water taken in these cases, without which it would not be safe or adviseable: but it appears to me generally hazardous to employ such means of qualifying the medicinal powers of a mineral water, as highly apt to bring on a habit of accustoming the stomach to the excessive stimulus of ardent spirit, under the insidious form of a stomachic medicine, and can hardly fail of doing much more injury than will be counteracted by the good produced by any mineral water so exhibited. Indeed I think it may be laid down as a general

rule, that the only additions which it is advisable 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 derange-

ment of the organs of digestion, it is not to this mineral spring that we should trust to check these dangerous symptoms. From what has been said, it will appear that it is chiefly in chronic cases, unattended with much vascular action, that Buxton might be visited with advantage by invalids; and the numbers that annually receive here very important relief, afford a very honourable testimony to the efficacy of its waters.

The doses prescribed by the earlier practitioners were, according to the custom of former times, much more abundant than are employed at present, and would make the modern directions quite superfluous. Now, however, it is considered as a full course to take two glasses of about a third of a pint each before breakfast; interposing between the two a little gentle exercise, and to repeat the same quantity again between breakfast and dinner. It is seldom taken medicinally in the evening.

A calculation of the actual quantity of foreign contents in these doses will exhibit very minute portions of very inactive substances. A single dose of a third of a pint contains about $\frac{1}{13}$ of a grain of common salt, and about half a grain of sulphat 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 situated in a deep narrow valley, on the banks of the Avon, in the county of Somerset, a few miles higher up that river than Bristol, and at the extremity of its navigable course for small vessels from the Bristol Channel. The country around is composed of hills of moderate height, generally steep in their sides, 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 sides by lofty hills, which block up every outlet except those that admit the Avon, which takes a fine serpentine course through a rich vale, and bounds the city from the North-East to the South-West quarter. The view therefore from the neighbouring hills is rather confined; but besides the natural advantages of the place, it possesses that noble assemblage of splendid buildings, decorated with a profusion of elegant architectural ornaments, which have justly 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 pre-eminence 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 account 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

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waters being of a heat below the animal temperature, and only deserving that appellation from being invariably warmer than the general average of the heat of common springs. These waters, which have at first given celebrity to this spot on the banks of the Avon, and have been the means of erecting and supporting a splendid city, are now eminently accommodated to the use of invalids, by the erection of elegant baths, and by various other buildings, calculated for convenience or amusement.

There appears to be three principal sources of these waters, called the King's Bath, the Cross Bath, and the Hot Bath. These springs all arise within a short distance from each other, at the lower part of the town, and not far from the Avon, into which the hot water terminates, after having passed through the several baths. The supply of water is so copious, that all the large reservoirs used for bathing are filled every evening with water fresh from their respective fountains. There appears to be a slight difference in the properties of the water of each of these three baths, which we shall take occasion to notice, where it gives rise to a selection in their medical use.

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such as the King's Bath just filled, a slight degree of pungency strikes the nose, similar to that of an effervescing mixture, but according to Dr. Falconer, never accompanied with any thing fetid or sulphureous. The taste of the water deserves particular attention, from some peculiarities that attend it. When hot from the pump, it fills the mouth with a strong chalybeate impression, without any particular pungency, and accompanied with scarcely any kind of saline taste; on this account it is by no means disagreeable, and may be taken in a larger draught without disgust than most other waters in which the taste of iron predominates: what is remarkable, however, is, that as soon as the water cools, even before there is any sensible precipitation, the chalybeate taste is entirely lost, and nothing but the slightest saline sensation to the tongue remains; or rather, there is then no distinguishable difference between this and common hard spring water (*d*).

(*d*) Dr. Falconer asserts, that Bath water, when cold, becomes not only more saline to the taste, but acquires a peculiar and indescribable flavour which lasts some time longer. I cannot help thinking this an instance of a kind of refinement in obser-

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burns with a blue flame, and sulphureous odour; and leaves a residue which is in a small degree magnetical. If digested with water, it is said to render it slightly chalybeate. There is also a brown or olive coloured scum, which floats on the surface of the water in small quantities, and which some years ago gave rise to much discussion, as it was supposed to be a sulphureous compound of a peculiar nature, and was called *Bath Sulphur*. Dr. Lucas has the merit of refuting this opinion, and detecting some petty frauds which were practised to keep up the idea of its sulphureous nature. It is doubtless only a vegetable substance of the nature of a conferva (*f*). Another matter which is brought up along with the Bath water from the different springs, is a quantity of gas, which is constantly to be observed rising through the body of water in the baths, in large clusters of bubbles, and may be readily collected by an inverted bottle held at the surface of the water. This circumstance had been noticed long before the nature of the gas was ascertained; and at first, 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 $\frac{1}{10}$ 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 entirely, 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 $3\frac{1}{2}$

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 $\frac{1}{38}$, 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 scruple, or 430 grains of solid residuum, which is only about 71 grains in the gallon. The proportion of soluble to insoluble matter also differs. Out of 80 grains of solid residuum, warm water, repeatedly added, could dissolve only 31 grains, leaving, therefore, 49 for the insoluble part. This, if brought to the proportion of the 71 grains of total residuum in the gallon, will give about $27\frac{1}{4}$ grains of the neutral salts, and $43\frac{1}{4}$ of the selenite and insoluble calcareous earth.

Lastly, Dr. Gibbs, whose analysis is not complete, obtained a solid residuum in the proportion of about 93 grains to the gallon, after the water had been intirely evaporated, and the remaining mass thoroughly dried. Of this there were dissolved in the proportion of $77\frac{1}{4}$ grains by the united action of water and nitrous acid, but about $15\frac{1}{4}$ grains were left behind, which, when mixed up with soda and exposed to the blow pipe, effervesced and fused into a perfect glass, and was therefore siliceous earth (*k*). This discovery of filex, where it was not suspected, appears to be of importance in explaining some apparent errors

(*k*) Nicholson'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 (1): "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

(1) 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 briskness or effervescence to any water, nor do we find in the Bath water any marks of an uncombined acid by the delicate test of litmus (*m*). This water has therefore no claim to the title of a brisk carbonated mineral spring, for the quantity of carbonic acid is less than in many common pump-waters, neither is there any thing unusual in the combinations of this acid, except that of holding dissolved a minute portion of iron.

With regard to the quantity of this metal, nothing certain however has been ascertained, except that it is extremely small, probably nearly the least that is possible to be detected by chemical tests. The method used by the

(*m*) In order that waters should redden litmus they must contain at least about $\frac{1}{18}$ of their bulk of carbonic acid, uncombined with an earth or alkali, as Kirwan observes in his excellent Treatise on Mineral Waters, page 36; but those waters that hold in solution a much less quantity of this acid, will still dissolve a minute portion of iron, and become sensibly 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 some minutes shaken with iron filings; and as Dr. Falconer observes, the chalybeate of Bath water is increased by this process.

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 $\frac{1}{80}$ 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 dissolved; whereas Dr. Priestley's experiments did not shew an eighth of this quantity. But since Dr. Gibbs finds in this water $15\frac{1}{4}$ grains of siliceous earth in the gallon, all which remains in the residuum that is insoluble in water, as well as the carbonat of lime, we may well suppose that the two have been confounded with each other; and that in fact the Bath water contains only about seven or eight grains of the calcareous earth, which would require for their solution about as many cubic inches of carbonic acid, which is still however much more than Dr. Priestley's calculation.

From the various chemical investigations that have been mentioned, we may form this general conclusion concerning the composition of Bath water; that it contains a good deal of calcareous salts, which render it hard and unfit for domestic purposes; that it holds in solution but little, if any, neutral alkaline salts, and therefore is scarcely saline; that it is in a very slight degree impregnated with carbonic acid; in a still slighter with iron, and as it should appear, only when hot from the spring; and that it holds suspended a small portion of

filiceous 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 filiceous 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

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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 analysts 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, demonstrate, 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

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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.

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The general indications of the propriety of using this medicinal water are in those cases where a gentle, gradual, and permanent stimulus is required, and where there is little to be feared from the sudden and transient heat, and increase of pulse that so often attend its exhibition. Bath water may certainly be considered as a chalybeate, in which the iron is very small in quantity, but in a highly active form; and the degree of temperature is in itself a stimulus, often of considerable power. These circumstances, again, point out the necessity of certain cautions, which from a view of the mere quantity of foreign contents might be thought superfluous. Although, in estimating the powers of this medicine, allowance must be made for local prejudice in its favour, there can be no doubt but that its employment is hazardous, and might often do considerable mischief in various cases of active inflammation, especially in irritable habits where there exists a strong tendency to hectic fever; and even in the less inflammatory state of diseased and suppurating viscera, and in general, wherever a quick pulse and dry tongue indicate a degree of general fever.

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efficacy, but by no means as forming the principal part of the plan of cure.

Another and less active disease of the biliary organs, the jaundice, which arises from a simple obstruction of the gall ducts, is still oftener removed by both the internal and external use of these waters.

Bath is better known than most other watering places, as a resort for patients afflicted with these disorders, which, at first, and in their most inflammatory state, affect the whole constitution, and afterwards leave a weakness, loss of motion, pain, or other diseased condition of particular limbs. Of this kind are gout, rheumatism, and several other disorders, which give rise to many varieties of paralysis. It is not my intention to enter into a history of these formidable complaints, which often require the utmost skill in their treatment; but merely to offer a few remarks concerning the use of this remedy in such cases. We should always keep in mind that this water, whether from its warmth, or from other causes, though capable of increasing a febrile state of body, where such already exists, 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 hospital, are affected with rheumatism in all its stages, and it appears from the most respectable testimony, that a large proportion of them receive a permanent cure (*t*).

In gout, the greatest benefit is derived from this water in those cases where it produces anomalous affections of the head, stomach, 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 troublesome and dangerous symptoms. Hence it is that Bath water is commonly said to produce the gout, by which is only meant, that where persons have a gouty affection shifting from place to place, and thereby much disordering the system, the internal and external use of the Bath water will soon bring on a general increase of action, indicated by a flushing in the face, fulness in the circulating vessels, and relief of the dyspeptic symptoms; and the whole disorder will terminate in a regular fit of the gout in the

(*t*) The Reader will find much information on this subject in Dr. Falconer's "Account of the Use, Application, and Success of the Bath Waters in Rheumatic Cases." 1795.

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neous complaints, and the relief produced in hypochondriasis, by the warm bath, and much of the benefit derived from the water in dyspeptic affections, spasm of the stomach, or intestinal canal, and similar disorders, may, I think, fairly be attributed to this cause alone, and therefore, to complete the history of the medical powers of this as well as every other water, I must beg to refer the reader to those parts of this work that treat of the warm bath, and the aqueous regimen (*u*).

The quantity of water taken daily during a full course, and by adults, is recommended by Dr. Falconer not to exceed a pint and a half or two pints; and in chlorosis with irritable habits, not more than one pint is employed. The morning is constantly the time for taking the waters, and the daily allowance is generally divided into three portions, of which two may be taken before breakfast at different times, and one afterwards. As the water of the Cross Bath is considered as less stimulant, and is certainly

(*u*) In the concluding chapter the reader will also find some further notice taken of the *modus operandi* of the Bath Water, especially 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 func-

tions of the human body; and therefore whatever powers Bath water may have above those of simple warm water, are eminently due to the peculiar mode of combination of its foreign contents (*x*).

The time at which the bath is made use of, is generally the morning, which is partly for convenience, and partly because this has usually been considered as the best time for this application. This is by no means, however, invariably the case, and in using the cold bath it is often necessary to deviate from this general rule. From two to three times a week the warm bathing is usually employed, and

(*x*) Dr. Gibbs suggests the probability that the siliceous earth assists materially in the general effect of the Bath waters. After what has been said of the great powers of very minute quantities, it will not be thought a sufficient objection against this opinion, that no more than a grain of flint, according to Dr. Gibb's own calculation, is contained in half a pint of the water; nor will its general insolubility in any of the animal fluids be an objection, since it is already presented to the stomach in a state of solution; nor its want of the sensible properties of taste and smell in any of its known combinations, since we know of some indisputably powerful medicines which have little of either; and therefore this opinion, though it does not impress the mind with any great degree of probability, certainly remains to be confirmed or refuted by further investigation.

the patients continue in from ten minutes to half an hour. If it produces head-ach or any degree of vertigo, it must be used very carefully in persons of a full plethoric habit ; and the time of remaining in the bath is in a great measure to be regulated by the sensations of the patient, who should always leave it when any degree of lassitude or faintness comes on. The choice of the different baths is here a circumstance of more importance, perhaps, than when the water is employed for internal use, since there is a very decided difference in their respective temperatures. That of the Cross Bath is about 94 ; whereas the Hot Bath is at least 8 degrees higher (*y*), and therefore the former is, in fact, only a tepid bath, being of a less heat than that of the human body, though it feels warm to the skin, even on the first immersion. The topical warm bath, applied by pumping on any diseased part, from the impetus of the falling water, is always a greater stimulus than mere immersion, and as the system is not thereby generally affected, it may be used in every case more

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

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

The waters of Bath are certainly among those that require a considerable time to be persevered in before a full and fair trial can be made. Their operation is very gradual, as indeed might be expected from a medicine which shows so few sensible properties or immediate effects. Frequently too they are apt to lie heavy upon the stomach when they have been taken for some weeks, and when this is the case they must be intermitted for a time, and may afterwards be resumed. Indeed it must be owned, that a large proportion of the patients who resort to these springs are afflicted with disorders that are in themselves only to be palliated, or at least are always very difficult of cure. Chronic rheumatism, habitual gout, dyspepsia from a long course of high and intemperate living, and the like, are disorders not to be removed by a short course of any mineral water, and many of those who have once received benefit at these fountains find it necessary to make an annual visit to them, to repair the waste in health during the

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“ 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 experience. 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 dispute
“ between those who by their experience
“ 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 decisions,
“ 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 ascertaining the virtues
 “ of these mineral springs, but that almost all
 “ our useful knowledge of them, as medicines,
 “ must be gained from experience. Their
 “ virtues may be considered either as they are
 “ used externally, or internally.

“ Externally used, either by immersing
 “ the whole body, or by deriving a stream to
 “ some particular part, they appear to be
 “ serviceable against contractions and other
 “ spasmodic affections of the muscles. In
 “ slight cutaneous disorders, warm bathing
 “ will sometimes clear the skin for a little
 “ while, but can hardly be considered as a
 “ cure. It has been a doubt with me,
 “ whether any weakness left by the rheuma-
 “ tism, gout, or palsy, have been sooner re-
 “ moved by bathing at Bath, than they
 “ would have been without it. In some pa-
 “ tients these weaknesses have been mani-
 “ festly increased after a course of bathing at
 “ Bath; and, according to my experience,
 “ cold bathing in these cases is preferable.
 “ It is by no means clear to me, that the
 “ external use of Bath water is more bene-

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“ 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-

“ circumstances 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
 “ scirrhus and ulcerous affections of the
 “ lungs, or of the abdominal viscera. They
 “ increase the hectic 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, hysterical, 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

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OF SIMPLE SALINE WATERS.

IN pursuing our plan of considering mineral waters, as far as can be done, in the order of the degree of sensible properties which they possess, and the simplicity of their composition, as far as regards their active foreign contents, we shall notice a few individuals of a numerous class of waters which may properly be termed the *simple saline*, or those that only differ from common water in being impregnated more or less strongly, with some neutral salt with either an alkaline or earthy basis, that renders it purgative, when taken in such a dose as the stomach can bear without being much incommoded by the mere bulk of liquid. In the second chapter of this work, I enumerated four neutral salts that appear to have a decidedly purgative effect, the muriats of soda and magnesia, and the sulphats of soda and magnesia. Of these, the two latter are the best known as medicines, since 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 Sedlicensis 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 fufpending the carbonat of lime that is diffolved.

The folid contents procurable from this faline water by evaporation to drynefs, according to Bergman's analyfis, 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
	<hr/>
	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 thofe given by this excellent chemift, which are all proportioned to the Swedifh Kanne, and in the Swedifh weights and meafures. The Kanne is here affumed to be equal to 190 English cubic inches, and contains about 6.58 English wine pints. The Swedifh pound is divided in the fame manner as the English Troy pound, and the correfponding divifions of the former are equal to 1.1382 of the latter; that is, the Swedifh pound is from $\frac{1}{3}$ to $\frac{1}{8}$ larger than the English Troy pound; the ounce, than the Troy

From this analysis it appears, that Seydchutzwasser is strongly impregnated with vitriolated magnesia, or Epsom salt, and it is to this, along with probably the small quantity of muriatic 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 sulphate 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

degree, &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 fenna, 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

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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 fre-

quency, 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 Purgine 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 nitrates of lead and silver are rendered white and opaque, and the nitrate 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 rapidity 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

less than a scruple of the Epsom salt, and according to the highest, about double that quantity. On that account, the water must be taken very largely, so that to produce the full purgative effect, the patient must take from two to three pints, the one succeeding the other, in a short length of time. It operates in a mild efficacious manner in this dose, but in a smaller, it rather determines to the kidneys.

With respect to the diseases to which it is applicable, they are precisely those for which Hoffman recommends the Sedlitz water. It should be remembered, however, that the latter is much stronger of the vitriolated magnesia, a circumstance of some consequence in a water where the bulk of the requisite dose is always more than can be well borne by delicate stomachs.

There are many other of the simple saline springs that might be enumerated, all of which agree with that of Epsom, in containing for their most active ingredient, and the only one that can be at all considered as a medicine, a notable proportion of some purging salt. 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 less quantity of saline contents than the others. None however of the simple saline springs in this kingdom are much resorted to, their place being supplied either by the saline chalybeate of Cheltenham, or the waters of the ocean, which last must be added to the list of simple saline purging waters, and requires some particular notice.*

* The Kilburn Well is situated at the south western extremity of the Parish of Hampstead, about two miles from Tyburn Turnpike, in the road leading from thence to Edgware; the result of a very accurate analysis of it is given by Mr. Blifs, of Hampstead (to whom I afterwards refer on the subject of Hampstead waters). The result of his analysis is as follows:

Oxyd of iron not appreciable

	Grains.
Carbonate of lime - - - - -	8 $\frac{40}{100}$
———— of Magnesia - - - - -	10 $\frac{75}{100}$
Extractive matter - - - - -	3
Muriate of Magnesia - - - - -	33
———— of Lime - - - - -	14 $\frac{75}{100}$
———— of Soda - - - - -	18
Sulphate of Soda - - - - -	117 $\frac{50}{100}$
———— of Magnesia - - - - -	265
———— of Lime - - - - -	42
Insoluble matter - - - - -	1 $\frac{60}{100}$
	<hr/> 513 $\frac{00}{100}$ <hr/>

Gaseous Contents.	Cubic Inches
Of Carbonic Acid Gas - - - - -	18 0
Of Common Air of ordinary purity	5, 5
	<hr/> 23, 5 <hr/>

SEA WATER.

AMONG those natural waters that are simply saline, that contain no unusual quantity of gaseous bodies, and the composition of which is not doubtful, the waters of the ocean, for the immense supply and degree of saline impregnation, hold a very conspicuous place.

Sea water is by far the strongest in saline matter of all the natural waters which are used medicinally, and indeed of all the waters that we are acquainted with, certain brine springs and salt lakes excepted, which last are only employed for the purpose of extracting their contents.

The water of the sea, as it washes the shores of our island, is a very heterogeneous compound, containing a considerable quantity of saline substances, and holding suspended an infinite number of minute animal and vegetable particles, composed of all the variety of marine productions that people this element.

Sea water, taken up near a rocky or clean sandy coast, or at a considerable distance 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 than 40° , or higher in the hottest summer than 65° , whereas the heat of rivers, especially when shallow and their current flow, 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 saltier 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 considered as nearly the same in all places; in freedom from accidental extraneous matter, especially animal and vegetable substances, the deeper water is in general the purer. The composition of sea water is very accurately given by Bergman; that which this excellent chemist analysed, was taken up at 60 fathoms beneath the surface, about the latitude of the Canaries (*a*). This water had no smell, and its taste, though intensely salt, was not so nauseous as water which is taken from the surface. Its specific 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 presence of a carbonated earth, which in this case was magnesia. The oxalic acid immediately indicated lime; a fixed alkali precipitated a white earth which was magnesia, and muriated barytes shewed the sulphuric acid. Prussian alkali gave no indications of any metal.

(*a*) It was sent by the celebrated Dr. Sparrman, who accompanied the Forsters and Captain Cook in their voyage to the Southern Ocean. See *Bergman's Essays*, 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.
	<hr/>
	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 magnesia, as has been already mentioned, by adding the sulphuric acid in some form or other, generally as sulphat of iron. It is the muriated magnesia which gives the bitter taste to sea water, and probably assists much in its operation upon the human body.

The foregoing results will give a proportion of 1 of saline contents to about $23\frac{1}{4}$ of water, but on our shores, it is not greater than 1 of salt to about 30 of water, and therefore the quantities must be reduced to this ratio. Sea water on the British coast may therefore be calculated to contain in the wine pint,

	grains.
Of muriated soda -	186.5
Of muriated magnesia	51.
Of selenite - - -	6.
	<hr/>
	243.5

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

Among the sensible effects that succeed a moderate dose of sea-water, may be particularly mentioned that of thirst. It seldom excites nausea 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

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ulcerating, and always tedious in their cure; at other times a deep-seated inflammation, followed by caries of bone, profuse discharge, and tedious exfoliation; or else a troublesome and painful ophthalmia; so often characteristic of this disorder. In all such cases, the internal use of sea water is almost intirely confined to those periods of the disease when there is no general fever and hectic tendency, when no symptoms of danger are present, and when the object is rather to prevent a relapse, than oppose any present disease. The external use of sea water, either as a general cold bath, or as a topical application to indolent swellings, or granulating ulcers where the healing process has commenced, coincides perfectly well in these cases with the general intention. The peculiar power of sea water and sea salt, as a discutient, employed either internally or externally in scrophulous habits, was brought considerably into notice by Dr. Ruffel (a), and subsequent experience has

(a) See "Ruffel on the Use of Sea Water in the Diseases of the Glands. London, 1760."—This author also recommends another marine preparation, the Sea-wrack, (*alga vesiculosa*), a plant very common on all our shores, which bears a number of vesicles that are filled with a salt liquor. This vegetable, when

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

Indeed the enormous quantities of fea water which the country people will often take when they can make a fhort vifit to the coaft, amply prove the fafety of this natural medicine.

It is often neceffary to perfevere for a long time in the ufe of the fea water, and it is a great recommendation to it, that fuch a perfeverance is fo feldom productive of any bad confequences to general health. Dr. Ruffel mentions cafes where a pint of this water has been taken daily for 200 mornings, without any interruption, which produced a continued courfe of moderate purging, and yet the appetite continued all this time perfectly good, and the health improved.

It is only by great patience and perfeverance, that this medicine has been able to affift fo materially in performing cures in fome of the moft obftinate diforders 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 Coblantz, 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.

less so than might be supposed from its mere appearance, and has a gently saline and decidedly alkaline taste. If it be exposed to the air for about a day, or even be kept in vessels carelessly corked, it intirely loses its pungency, and the alkaline or lixivious flavour becomes proportionably stronger.

The habitudes of this water with different re-agents are strikingly illustrative of its chemical composition.

Tincture of litmus grows red upon the addition of a small quantity of Seltzer water, but in the open air, or especially 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; syrup of violets turns green; and tincture of rhubarb red, by this water; but these last tests are much more perceptible when the quantity of water is lessened by evaporation. These simultaneous marks of both an acid and an alkali, and the circumstance of the former being lost by gentle heat, clearly indicate that the alkali is super-saturated with a volatile acid, which must be the carbonic, and it is on

this account too that the taste is both acidulous and alkaline.

Any of the strong acids, or even old Rhenish wine, (as Hoffman says) dropped into fresh Seltzer water, will immediately disengage copious bubbles of gas, which is almost pure carbonic acid. Nothing metallic is discoverable by the nice tests of galls, or Prussian alkali.

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

The oxalic acid shews the presence of lime; the nitrat of silver that of muriatic salt.

No sulphuric acid is discoverable by the nicest tests.

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 magnesia are deposited, and a saline mass 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
	<hr/>
	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 reagents. 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 strong impregnation with carbonic acid, and to the small proportion of soda 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 diseases.

Few mineral waters have acquired a higher reputation than that of Seltzer, and we may add, that few deserve greater consideration from the real medical virtues which it possesses, and from the variety of disorders to which it is applicable. Hoffman has spoken of it with the highest commendation, and if we must allow something for the natural partiality which a German writer must feel for his own mineral springs, we must however admit, that the greater number of his observations on this subject, have been amply confirmed by later practitioners. The cases for which Seltzer water may be used with an undoubted prospect of advantage, seem to be the following: (a)

(a) See in the *London Medical Observations and Enquiries*, v. 4. a very sensible paper on the analysis and virtues of Seltzer water, by the late Dr. Brocklesby, read July, 1768.—The chemical observations of that period are now superseded by the more accurate and modern inquiries; but this paper contains some very satisfactory and interesting cases.

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 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 kidneys, 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, fabulous, 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,

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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*.

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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 basin 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 pruffed 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
				<hr/>
				5.
				cubic inches.
Of carbonic acid gas	-	-	-	10.6
Of azotic gas	-	-	-	4.
Of common air	-	-	-	1.4
				<hr/>
				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 $\frac{1}{12}$ 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 effervesce 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

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where the person who uses them is in a situation to take much and regular exercise.

The general operation of these chalybeates is therefore to increase the power of the secretory 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 waters 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 suf-

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 un-

able to reach. Such for instance, are those of derangement in the whole functions of the alimentary canal that are produced by scirrhus of any important organ, or any slow suppurating abscess. It is by being employed injudiciously in such cases, that these waters have often disappointed the sanguine expectations that have been held out; and thereby they have frequently lost much of the regard to which they appear to be really intitled.

The prescribed method of using the Tunbridge water is judicious. The whole of the quantity daily used, is taken at two or three intervals, beginning at about eight o'clock in the morning, and finishing about noon. The dose at each time varies from about one to three quarters of a pint, according to the age, sex, and general constitution of the patient, and especially the duration of the course, for it is found that these waters lose much of their effect by long habit; and in this respect they differ much from the saline purgative waters, for the latter will continue to produce a moderate evacuation from the bowels daily for a great length of time with undiminished efficacy.

A single dose of half a pint of these waters

fering 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

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

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will contain, according to the analysis which we have given, $\frac{1}{10}$ of a grain of oxyd of iron; about $\frac{1}{5}$ 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, $\frac{2}{3}$ 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

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 excess of carbonic acid, by which they acquire very considerable sensible properties, and probably an equal increase in medical virtues. In other respects, however, the Spa water is very pure and free from saline contents of any activity, and therefore this and the Pyrmont water may be considered as the best examples which we possess of the *highly carbonated chalybeate waters*. We shall take some notice of each.

The marquisate of Franchimont, in the principality of Liege, (a) contains a great variety of these chalybeate springs, scattered over a pretty extensive district, but the most frequented of these are at the villages of Malmendy, and especially Spa, which last is now become a considerable place, owing to the great

(a) Lucas, vol. I.

resort of invalids and strangers of every description. The medicated springs of this district have been known for several centuries, and have long constituted much of its natural riches. The whole of this district, as Dr. Lucas observes, is composed of rude and often uncultivated mountains, many of them, however, covered with wood, and often wet and boggy. It is watered by the noble river Meuse; and affords a most agreeable contrast 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 smelting houses that are scattered over the country.

Of the number of springs, not less than sixteen, which are enumerated by Lucas, we shall only select the Pouhon spring within the town of Spa, as this is by far the most copious, the most frequented, and especially that which chiefly supplies the large exportation which is made of this water for foreign consumption.

The Pouhon is a large flow deep spring, which arises from a flaty rock in the centre of the village of Spa. In cold dry weather it

appears colourless, and perfectly transparent. When first taken out of the well it scarcely sparkles, but presently covers the inside of the glass with small air bubbles, which it also emits very copiously when shaken or poured from one glass to another. In moist weather the water of the surface of the well appears rather turbid, and on the approach of rain, a whistling or humming noise is heard, which the country people call the music of the spring. This water has an agreeably acidulous taste, mixed with a strong impression of a chalybeate, and this latter remains in the mouth for a considerable time. The specific gravity, according to Bergam, is 1.0010.

When a glass of the Pouhon water is exposed to a warm air, it soon parts with a number of air bubbles, throws up an iridescent pellicle on its surface, becomes turbid throughout, and finally loses entirely its acidulous chalybeate taste. If it is first corked, and then set in a warm place, it presently causes the cork to fly out with an explosive noise.

The composition of the water is well illustrated by the several 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, fumach, 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 presence of carbonic acid, carbonated earths, and at the same time a small portion of an alkali; and they likewise shew the existence of iron, and a muriatic salt.

The actual contents of a wine pint of Spa water, as ascertained by Bergman, and reduced to English measure, are the following:

	grains
Of oxyd of iron - - -	.56
Of carbonated lime - -	1.47
Of carbonated magnesia -	4.46
Of carbonated soda - -	1.47
Of muriated soda - - -	.172
	<hr/>
	8.132

Total—about eight grains of solid matter.

The gaseous 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 six ounces and a half in measure, in every wine pint.

Spa water therefore appears to be a very strongly acidulous chalybeate water, containing more iron, and especially more carbonic acid than any that we have hitherto men-

tioned. 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) Ruttty'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 kidneys 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 kidneys or concretions in the bladder; and by alleviating

the extreme pain of these disorders, they materially contribute to the restoration of the healthy functions. (d)

All that has been said under the preceding article, concerning the use of chalybeates, in disorders in females, arising from derangement in the regular menstrual evacuation, applies peculiarly to the Spa waters, and especially in removing sterility, when arising from fluor albus, or relaxation of the uterine system; and in the other sex in preventing involuntary discharge of semen, and the debility arising from gonorrhæa.

In disorders of the alimentary canal, in bilious vomiting, diarrhæa and dysentery, the Spa water is often of considerable use as an auxiliary, and especially in restoring the healthy action of these parts, and removing their debility; but as it possesses in itself no certain power in evacuating the bowels, it can seldom be trusted to intirely without the use of some aperient. In the debility of stomach, arising from a debauch, a draught of this water is highly refreshing and salutary.

(d) Hoffman—"De fontis spadani & schwalbacensis convenientia."

Though these chalybeates may generally be taken without much preparation, it should not be forgotten, that their diffusive stimulant properties, render them often improper in inflammatory complaints, attended with much heat, flushing of the face, and determination to the head; and as this determination is itself occasioned by the water, it may often be adviseable in plethoric habits to employ blood-letting or other evacuations, previous to using this medicine. If these precautions apply to all chalybeates, they are particularly necessary in the very active form in which the Spa water is constituted; and these evacuations are intirely independent of those that may be necessary to remove any local congestion in the alimentary canal, and which must often be continued during the whole course of this mineral water.

The doses of this water must principally be regulated by the experience of the individual patient, though it may be observed, that as it produces no very powerful effect upon any of the usual evacuations, it may be taken as largely and freely as the stomach and bowels, or the general system, 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*) Ruttty's Synopsis of Mineral Waters.

The taste is highly agreeable, being strongly acidulated, and possessing a pungency very similar to that of brisk Champagne 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 sulphuric; 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, balauftine 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 entirely 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 medicamentorum 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 iron56
— carbonated lime	4.46
— carbonated magnesia	10.03
— selenite	8.58
— sulphated magnesia	5.57
— muriated soda	1.56
	<hr/>
	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 estimated 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 chalybeates, 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 proportion of iron, and it is besides a very hard water, containing much selenite, and earthy carbonats.

The sensible effects which this water occasions, highly correspond with the chemical analysis. When fresh from the spring, and drank copiously, especially on an empty stomach, it strikes the nose with a very pungent vapour, and produces a kind of temporary intoxication. At all times too, it invivens 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 use of the Westphalians, who are in general of a robust constitution, and live upon hard strong food. It is certain that whatever effects are produced on delicate stomachs by a hard water, may be here apprehended from the large proportion of earthy salts; and this is one circumstance in which an artificial mineral water has a decided advantage over a natural one. Pyrmont water mixes pretty smoothly with milk, and in this form it has been particularly recommended for gouty cases; and as it is so powerfully impregnated with active principles, it will bear a considerable dilution where this may be thought necessary, and still retain so much of the iron and carbonic acid, as to be equal in strength to most of the common acidulous chalybeates.

The dose of this water is about the same as that of Spa, under similar circumstances; but it may be observed that the country people who flock to this fountain of health on all occasions, 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 dose to their complaints, than that of drinking it as copiously as the stomach will bear. Where attention is paid to quantity, we may reckon about three pints as a daily allowance in common cases, and this will contain, according to the above analysis, about a grain and a half of oxyd of iron; sixty-nine grains of selenite and earthy carbonats; about twenty-one grains of Epsom and common salt; and seventy-eight cubic inches, or about two pints and a half in bulk, of carbonic acid, partly combined with the iron and earths, but mostly only united to the water, and very readily volatile in the heat of the stomach.

After considering these carbonated chalybeates, whose active properties appear to be intirely confined to the iron and carbonic acid in different proportions, we may with propriety proceed to those which, in addition to these two substances, hold in solution a considerable quantity of some purgative salt,

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 measures of gas, of which two-thirds were absorbed by lime water rendering it turbid, and therefore was carbonic acid, and the remainder was common air, or else azotic gas, united with a minute portion of sulphurated hydrogen.

During evaporation, this water at first throws up an earthy scum which effervesces with acids (*b*), and is therefore carbonated lime; and deposits its oxyd of iron. At the conclusion of the process, a large quantity of a crystallizable salt is procured, which is a mixture of vitriolated soda, vitriolated magnesia, and common salt, and several uncrytallized or deliquescent salts are also obtained.

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

Of a crytallized salt composed of

fulphated soda and fulphated	grs.
magnesia - - - - -	480
— muriated soda - - - - -	5
— muriated and carbonated magnesia	25
— felenite - - - - -	40
— oxyd of iron, nearly - - -	5
	<hr/>
	555

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

Together with	cubic ins.
Of carbonic acid - - - -	30.368
— an air, chiefly azot mixed	
with some hepatic - - - -	15.184
	<hr/>
	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. Ruttj 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 *these* quantities should be made with rigorous exactness.

possesses several of the most active of those ingredients which give medical properties to particular waters. It is in the first place decidedly saline, and contains much more salt than most of the waters which we have hitherto mentioned, that of the sea excepted. By far the greater part of the salts are of a purgative kind, and therefore an action on the bowels is a constant effect produced by this medicinal spring, notwithstanding the considerable quantity of selenite and earthy carbonats which may be supposed to have a contrary tendency. Cheltenham water is besides a chalybeate, and if the analysis before us be at all accurate, it is one of the strongest that we are acquainted with. The iron is suspended 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 brisk, though more so than common spring water. It has besides a slight impregnation of sulphur, but so little as to be scarcely appreciable, except by very delicate chemical tests.

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*) Ratty.

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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 dropfy 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 course of evacuation than with most other medicines of this kind, it seems however probable that this circumstance will alter, and somewhat impair the benefit which would arise from the iron alone; so that the Cheltenham water cannot be used in every case where a simple chalybeate water is indicated. There are some constitutions which are naturally languid or debilitated by disease, but which do not shew any marks of obstruction, or those symptoms that have been attributed to acrimony in the fluids; and these cannot bear with impunity any constantly increased operation on the bowels. This shews therefore the necessity of some caution and judgment in the use of this spring. It is likewise often a question of some moment, whether the patient should use the water so as daily to increase in a small degree the natural evacuation of the bowels, or whether he should drink it only at intervals, and in larger doses, so as to be briskly purged. These are circumstances, which, I think, are not always sufficiently attended to by the greater number of invalids, and would require the judgment of a professional man on the spot.

It is an advantage attending these saline waters, that they may be used at once, without any preparation; nor is any other medicine often required during their use, except, as has been already mentioned, the occasional addition of the crystallized salts, where the water itself does not prove sufficiently active to the bowels; and likewise the use of the warm bath in several of the cases, and more especially the diseases of the skin.

The season for drinking the Cheltenham water is during the whole of the summer months, and in such a course of medicine the circumstance of season is probably of some consequence. The water should, if possible, be always drank at the fountain head, and never kept long exposed to the air. It might, however, be cautiously warmed in close vessels, when its coldness would prove offensive to the stomach of the patient. The dose must vary considerably, 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, most advantage is obtained by taking a full purgative dose at once, so that the stools 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
 “ felenite 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, impart-
 “ ing to the palate the disagreeable flavour
 “ of the hepatic gas, instead of the bitter taste.
 “ The carbonic acid gas is not in great pro-
 “ portion, but can easily be detected by lime
 “ water. The hepatic gas is readily disco-
 “ vered by invisible words, written with a
 “ solution of mercury in nitrous acid, becom-
 “ ing legible when dipped in the water;
 “ they turn immediately yellow, and after-
 “ wards 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 mu-
 “ riate 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 soda seems to be
 “ contained in the water, in a tolerable pure
 “ state, without the usual bitter, and may
 “ impart to it some peculiar medical pro-
 “ perties.”

Upon evaporating a gallon of it which was sent me from Cheltenham, I found the gross contents of the residuary matter to be, about one ounce and 30 grains. Upon examining it, it was found to consist chiefly of muriate of soda, sulphate of magnesia, and sulphate of soda. The hepatic gas was soon dissipated by boiling, and from every chemical test that was employed, the same effects were produced, as in the old Spa; it may therefore be safely admitted that its medical powers are the same.

During a short residence which I made at Cheltenham in the summer of 1802, I was consulted by many invalids, and had an opportunity of conversing with others, who were under the use of the purgative saline waters of that place. I soon perceived that they were very indiscriminately used in a variety of opposite diseases; 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 scirrhus 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, symp-

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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, rather 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

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bowels, rather than to the kidneys, 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 advisable 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.

These thermal waters have been frequented for a great number of years, many of them contain baths which are indisputably of Roman construction, and are decorated with elegant buildings that have been constructed by several of the French princes. As an example of the general nature of these springs, we may select that of Vichy, which is one of the most conspicuous.

The town of Vichy is situated in a very fertile plain watered by the River Allier, full of vineyards and fruit trees (*a*). This plain, which is at a moderate distance from the lofty mountains of Auvergne, abounds with springs of very different kinds; for both hot, tepid, and cold waters, are here found almost contiguous to each other. The hot and tepid springs, like most others of this class, issue forth in great abundance and with impetuosity. There are six different sources at Vichy, which vary a little in temperature, and in the proportion of the foreign contents. The

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

taste of them all is more or less saline, and somewhat bitter, and they possess a degree of pungency to the smell. On the addition of any of the stronger acids, a copious effervescence is excited, indicating the presence of much carbonic acid. The addition of galls causes a slight change of colour to a rose-purple, but this only takes place when the water is fresh. By evaporation, these waters deposit an earth which effervesces strongly with acids, and is therefore carbonat of lime, and yield at last a residuum, of which a part is easily crystallizable, gives a vivid green with syrup of violets, effloresces in the air, and has all the properties of carbonated soda.

The sources of these waters appear to be quite out of the reach of any influence from the atmosphere, for no variation is perceived in them either in winter or summer. In their channel they leave a yellowish mud, which is doubtless principally oxyd of iron.

All the waters of Vichy, therefore, are warm, chalybeate, and alkaline, probably too, mixed with some earthy muriats, which increase their operation on the bowels; for the residuary salt is found to be less 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 kidneys, 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 soothe 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

rheumatism, sciatica, gout, and the like; and in many of these, the internal use of the water very properly accompanies the external. This is particularly the case with many of the disorders peculiar to the female sex, owing to irregularity in menstruation, and a defect in the functions of the uterine organs; and hence these springs have acquired great reputation for the removal of barrenness, chlorosis, and other female complaints. The celebrated Catherine de Medicis, the mother of several French princes, is said to have been much indebted for her fertility to the waters of Bourbon-Lancy.

As the waters of the thermal springs of Auvergne and the Bourbonnois lose all their chalybeate principle as well as their temperature by carriage, they are not of sufficient importance when become merely supercarbonated alkaline waters, to be an object of commerce like the Seltzer; and therefore, though highly interesting to the naturalist and the physician on the spot, it will not be necessary to give them here any further notice.

CARLSBAD WATERS.

THERE are few waters that have more engaged the attention of chemists and physicians than the very celebrated thermal chalybeate springs at Carlsbad in Bohemia, better known by the name of THE CAROLINE BATHS. As these possess a higher temperature than any of the hot springs in our own country, and have a peculiarity of composition of which we can exhibit no example here, it will not be uninteresting to give some description of them, for which we are furnished 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 especially chalybeate; and of these many are highly acidulous and cold, like the waters of Spa or Pyrmont; but others are very hot, and these have given celebrity to the spot 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 petrifications around moss, pieces of straw, or

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

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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 disap-

pears 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 kidneys and bladder, that are attended with a discharge of fabulous 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 ferious mischief, when misapplied, cannot be doubted, its efficacy in removing various diseases, and relieving many distressing symptoms, is equally established by long experience.

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

The water, when taken from the well, appears perfectly clear, but it gradually deposits a quantity of oxyd of iron, even when closely corked; it still however retains at all times a large portion of this metal in solution. It has a strong astringent and inky taste.

With re-agents it shews 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 respect this water differs in a striking manner from the common carbonated chalybeates.

Tincture of litmus is in a slight 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 small quantity of gas arises, 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 fulphat of iron - -	84
— fulphat of alumine	12
— oxyd of iron - -	15
	<hr/>
	111

Total, 1 dram and a half, and 21 grains of foreign contents, of which by far the greater part is fulphat 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 considerable depth below the level of the water. All the vitriolated chalybeate waters contain alum, which is produced from the decomposition of the aluminous sulphuret, at the same time, and in the same manner, in which the sulphat of iron is generated. It is owing to the alum, that the water shews, by the test of litmus, the marks of some uncombined acid.

The Hartfell water, if preserved in close bottles, will keep for a long time unimpaired in its properties, except by the deposition of the excess of oxyd of iron, and from this deposition, the chalybeate and astringent taste of the salts that remain, become even more sensible. As, however, there then appears to be nothing remarkable in the chemical composition of this water, it is probably one that may at all times be imitated with great ease by any artificial solution of these two ingredients.

This chalybeate spring appears to be one that possesses no inconsiderable share of medicinal virtue in the cure of several very important and dangerous diseases; and the daily experience of medical men, in the use 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 diarrhoea 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. Horsburgh 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. Horsburgh, 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 respecting this spring, 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 cursory and imperfect account of the most obvious properties of this water is given, first, on the authority of Dr. Relhan, whose observations are stated to have been made a considerable time since, and afterwards on that of Dr. Henderson, of Brighton. But these accounts, in the present state of chemistry, can scarcely

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

be of any other use, than that of enabling us to observe, that, in earlier periods, this spring had not remained unnoticed.

§ I. *Situation of the Spring.*

The spring issues from the declivity of a small eminence, situated about the distance of half a mile to the westward of Brighton, and a quarter of a mile from the sea. The ascent from the sea shore to the spring, is very gentle and inconsiderable; but the eminence from which it issues, is commanded on every other side, by a succession of small hills, which gradually rise round it.

The hill which extends immediately to the westward of Brighton, and over which the Hørsham road passes, consists chiefly of limestone. Extensive lime pits are opened on the borders of this hill, and the soil for some distance continues calcareous. But on approaching towards the chalybeate spring, the soil gradually becomes argillaceous, and the particular spot on which it is situated, appears to consist almost intirely of clay. Besides clay, however, it was found, in clearing away the rubbish, to form the reservoir 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 basin 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 basin, I observed, has its internal surface deeply corroded by the water, and its bottom is covered with a thick yellowish sediment, which shews itself abundantly wherever the water is allowed to stagnate, and particularly in the small crevices formed by the decayed brick-work which surrounds the well.

§ II. *External qualities of the water.*

(A)—On first inspecting the basin, early in the morning, and before the water had been stirred, its surface is commonly found covered, sometimes entirely, sometimes only partially, with a very thin, iridescent pellicle; and besides this, when the water has not been disturbed for some hours, there is also often a kind of yellowish scum, floating in irregular patches on its surface. The spring is at all seasons very plentiful, and does not appear to vary sensibly in its qualities. Yet after heavy rains the water is sometimes slightly 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 tests.*

Having now stated the spontaneous changes which this water undergoes, and its most obvious external properties, I proceed to relate the general results obtained by the application of tests, or chemical re-agents.

EXPERIMENT I.—Some of the water, just brought from the well, being heated in an open vessel, and kept boiling for a few minutes, no precipitation took place, and no other obvious change was produced in the water, except a slight diminution of its transparency.

EXPER. II.—The same experiment being repeated in a tubulated receiver, the neck of which was immersed in mercury, in order to prevent the access of air, the water, after undergoing ebullition for a few minutes, appeared as transparent as before.

EXPER. III.—A small 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 drop-

ped 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 precipitate took place immediately.

EXPER. XIII.—The sulphuric, nitric, and muriatic acids, produced no effervescence, 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 oxalate of ammonia and oxalate 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 occa-

sioned 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 used in prosecuting it.

1st, From experiment 1, 2, and 3, it appeared obvious, that no part of the solid ingredients of this water, was kept in solution by means of a gaseous acid; since boiling, even to a considerable extent, did not produce any precipitation.

2dly, From experiments 2, 3, 4, 5, it was inferred, that the access of air promoted in this water, the precipitation of some metallic substance.

3dly, From experiment 6, it was suspected that the water was slightly acid; but, from experiment 7, it appeared evident that this circumstance did not depend upon the presence of an aerial acid.

4thly, It was inferred from experiment 8, that neither pure nor carbonated alkali, nor pure earth were present in the water. From experiment 9, a small quantity of carbonated earth might have been suspected, but such an inference being incompatible with experiment 13, the slight change of colour alluded to, in the infusion of turmeric, was supposed to depend on some other cause.

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8thly, The experiments 17 and 18, indicated the presence of sulphuric acid, and it became probable that the alteration of litmus, observed in experiment 8, depended either upon this acid, in a separate state, or upon some of its compounds, which have the same 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 absence of hepatic smell, it appeared sufficiently obvious, that the water was free from hepatic gas, or hepatic compounds.

§ V. *Plan of Analysis.*

On collecting the information derived from these general results, it appeared that the only substances which I could positively expect to find in the water, by a more particular investigation, were iron, combined with the sulphuric, 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 accu-

rately 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 $\frac{1}{10}$ 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.

§ 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 purpose, but Mr. Glasfer, a very intelligent and well-informed chemist and druggist, of Brighton, obligingly offered his assistance for this tedious operation. A whole gallon of water was carefully evaporated over a water bath, and the residue, which appeared in the form of a greenish mass, was allowed to dry at the same temperature. This residue weighed exactly 55 grains, which makes for each pint $8\frac{1}{3}$ th of solid contents, dried at 212° . This residuary matter soon gave signs of deliquescence, and increased in weight by exposure to the atmosphere.

(B)—After this first trial, having often had occasion, in London, during the course of this analysis, to evaporate new quantities of water, which were sent to me from Brighton, I found it much easier and more expeditious to begin by concentrating the water briskly to a small compass, over an Argand's lamp, in a Florence flask, and then to finish the desiccation of the residue over a water bath, at any desired temperature. The heat which I have generally used for these

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 summer or winter, constantly yielded *eight grains and a half* of solid residue, dried at 160° , for each pint of the water, and the accidental deviations from this proportion, which have occasionally occurred, have never exceeded a quarter of a grain.

(C)—The process being carried on in the manner just related, the whole mass of solid matter presented itself in the form of a greenish incrustation, thick at the bottom, and gradually thinner towards the edges. But on closer examination, a quantity of yellow powder, (which afterwards proved to consist chiefly of iron), appeared collected in the centre, and there was seen also a kind of snow-like substance slightly spread over the whole surface. Viewed through a magnifying glass, the whole mass offered the appearance of a confused crystallization; and soon afterwards signs of deliquescence manifested themselves by the appearance of small drops of water on different parts of the surface. These various ap-

pearances deserved the more notice, as they pointed out the necessity, before proceeding any farther, of rendering the residue homogeneous, by careful mixture and trituration, in order to obtain corresponding results from different portions of the same residue.

§ VIII. *On the modes of filtration and desiccation adopted in this analysis.*

This part of chemical manipulation is of such material importance in an inquiry of this kind, and is so intimately connected with the results, that although I wish to avoid enlarging upon practical details, yet I can hardly proceed farther, without giving once for all, a few explanations which the subject seems to require.

As the difficulty of getting, in London, large supplies of the chalybeate, in its recent state, made it necessary to operate upon a small scale, it became the more necessary to guard against the various sources of inaccuracy to which chemical manipulations are liable. And as it is principally to the diffe-

rent modes of *filtration* and *desiccation*, that the striking discordances which frequently occur amongst experiments, in other respects similarly conducted, are to be ascribed, it is only on this part of the subject that I shall offer a few observations.

(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 similar in weight, are cut from the same sheet, and applied the one over the other, in order to filter the solution through both. The residue is then, after due desiccation, weighed, by putting the paper containing it in one side of the balance, and the plain piece of paper, similarly dried, in the other. The difference gives the weight desired. In some cases it may be expedient to separate the residue, in order to weigh it by itself; but in general the former method is less liable to error. A little tediousness in this mode of proceeding no doubt arises from filtering through a double paper; but it is sometimes 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.

§ X. *Silica.*

(A)—This insoluble substance, after being repeatedly washed with distilled water, and

heated to redness in a small platina crucible, weighed $\frac{1}{8}$ th of a grain. This being mixed with a minute portion of alkali, and tried with the blow pipe, readily melted into a transparent glass. The experiment being repeated with a different portion of the same residue, a similar result was obtained; only the quantity of silica yielded in the latter instance, was $\frac{1}{3}$ th instead of $\frac{1}{8}$ th of a grain, a small difference, which gives an average of $\frac{1}{10}$ ths of a grain of ignited silica, for 10 grains of the solid residue; or a quantity corresponding to 17 parts of silica for 1000 of the solid ingredients of the water, dried at 160° . *

(B)—Some suspicion having arisen that the siliceous matter might have been yielded by the glass vessels, and in the processes of solution and filtration, in order to ascertain

* I shall observe, once for all, that in giving the results of my experiments, most of which have been repeated several times, I have generally, for the sake of brevity, stated only one result. Whenever I have been able to trace any particular source of error, in any individual experiment, I have repeated it, and have only stated the result of that which has clearly appeared to be the most accurate. But when experiments, conducted exactly in the same way, have presented but very slight variations in the results, I have, in this case, 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.

§ 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 consequence of its bringing the metal to that state of uniform oxygenation which is most favourable to its union with the prussic acid. Having then added a solution of prussiat of potash, measuring one cubic inch and a half, (a quantity known by previous trials to be sufficient for the precipitation of the whole iron), the fluid instantly passed to a blue colour, and a blue precipitate, darker than the solution, gradually subsided, leaving the supernatant fluid transparent and nearly colourless. After a few hours, the clear fluid was separated by means of a syphon, and the remaining muddy fluid, containing the Prussian blue, was thrown into a filter. This prussiat of iron, after being carefully dried, at the temperature of 160° , weighed exactly 8 grains. I repeated this experiment three times, without any sensible variation in the result.

Before I could draw any positive conclusion from the last experiment, with regard to the real quantity of sulphat of iron, it remained to be determined by comparative trials, what quantity of prussiat of iron my solution of prussiated potash, 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 considered as a standard of comparison sulphat of iron in its *crystallized state*, which is not that in which it actually exists in the residue under examination. In order to ascertain what allowance ought to be made for this circumstance, or in other words, how much a given quantity of green sulphat of iron, in its crystallized state, lost in weight by being desiccated, 20 grains of the crystallized salt, reduced to a powder, were exposed to a heat of 160° , and weighed at different periods of the desiccation. 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 seemed to bring the salt to its maximum of desiccation, under that temperature, the 20 grains were reduced to 14; and the salt, in this state, was changed to a whitish powder.

EXPER. IV.—The same experiment being repeated, with this difference, that the 20 grains of crystallized sulphat were previously dissolved in water, and then evaporated to

dryness at the same temperature of 160° , the 20 grains were reduced to 12, which is 2 grains less than in the preceding experiment.

Taking the last of these experiments (which seems the most applicable to the present case) as a standard of reduction, it will be found that 20 grains of the residue contain in fact only 4.24 grains of *dried* sulphat of iron, a quantity corresponding to the 7.079 grains of *crystallized* sulphat, which were deduced from the former estimation. It is obvious therefore, that the mode of calculation just proposed, would be more strictly correct; but the state of crystallization being a much more uniform standard of the quantity of moisture, than any artificial process of desiccation, I should, on that account, prefer the former mode of computation.

EXPER. V. — The solution (Exper. 1) from which the iron had been precipitated by prussiat of potash, although quite clear at first, and having only a greenish cast scarcely perceptible, was found, after standing for a few days, to have deposited another distinct, though not ponderable quantity of Prussian

blue. Suspecting from this circumstance, that some minute portion of iron had escaped the action of the prussiated potash, I heated the solution with a view to complete the precipitation. But instead of the very small additional quantity of precipitate which I expected, the fluid having previously passed to a muddy green, and then to a blue colour, soon deposited another copious blue precipitate, which, after the usual filtration and desiccation, weighed no less than 2.8 grains.

EXPER. VI.—A suspicion naturally arose, that this new prussiat, proceeded, at least principally, from the test itself. In order to ascertain this point, one cubic inch and a half of the above mentioned solution of prussiat of potash (a quantity equal to that used in ex. 1) was boiled, first by itself, 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 solution of prussiat of potash, a dense white precipitate appeared, which was instantly redissolved without any application of heat; but if a considerable proportion of acid was added, a permanent white precipitate subsided.

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 filix. 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 precipitate 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 $\frac{7.072}{100}$ appeared from Mr. Allen's more direct estimate, to be $\frac{7.20}{100}$, 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, consisted of 67.6 of metal, and 32.4 of oxygen.

By combining these results with those of the two former experiments, it will be found that the 10 grains of residue (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 crystallized sulphat (which, in exper. 8, yielded 1.8 grs. of oxyd), would be 1.22 grs. or 24.4 in 100; a quantity corresponding to 0.36 of the oxyd.* As however the proportion of oxyd in the salt, must depend upon its degree of oxydation, these results, even allowing them to be perfectly accurate, can only be applied to experiments made exactly under the same circumstances as those just related. But I should not omit to mention, that my brown oxyd of iron, had a more distinct reddish 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, such as it is obtained from pure green sulphat; and 0.48 in the red oxyd, such as it exists in the red sulphat of iron. In my experiment, the oxyd appeared to contain 0.324, which is a kind of intermediate proportion between those just mentioned.

although the process of precipitation and calcination, was, as much as possible, carried on in a similar manner. It must be observed, also, that my solution of 5 grains of iron, having not been brought to the state of crystallized sulphat, some doubts may arise as to the degree of oxydation which the metal underwent in that solution.

Before I conclude my observations on this part of the subject, I should not omit to remark, that wherever in the course of this inquiry a quantity of iron has been precipitated from the water, whether merely in consequence of its being kept for some time (as in exper. 2. D), or by means of concentration, it has never presented itself in the state of ochre, or simple oxyd of iron; but on the contrary, has always, upon careful examination, appeared to be combined with a portion of sulphuric acid, forming what has been called a sub-sulphat of iron.

§ XII. *Red sulphat of iron.*

EXPER. I.—Twenty grains of residue were put in a phial, with about 150 grains of alco-

hol, 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 deliquescent residue, obtained in the former experiment, contained a quantity of red fulphat of iron. In order to form an estimate proportion of this salt in a given quantity of the residue, the yellow watery solution above mentioned, proceeding (exper. 1) from 20 grains of residue, was treated with prussiat of potash, which occasioned a precipitation of Prussian 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 presence of red fulphat in the residuary matter, is manifestly shewn by these experiments, yet they do not by any means prove, that the salt actually existed in the recent chalybeate. On the contrary it appears probable, that it is the product* of the several operations to which

* Mr. Kirwan, in his "Essay on the Analysis of Mineral Waters," in which he has so much contributed to the advancement of that part of chemical science, expresses a belief that the fulphat of iron, which has occasionally been discovered in mineral waters, did not exist in those waters, previous to the analytic processes to which they were subjected.

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 suggested in a former part of this paper, the possibility of some muriat of iron being contained in the water. This conjecture, the experiments above related, do not precisely contradict, but they render it extremely improbable.

In the first place it must be remembered, that if any muriated iron did exist in the water, it could only be in a very minute quantity, since it must have made part of the small portion of red sulphat of iron which was estimated from the preceding experiments, both these salts being equally soluble in alcohol.

Had the spirituous solution contained no other salts but the red sulphat or muriat of iron, the presence or absence of the latter would have been easily demonstrated by nitrat of silver, or any other test of muriatic acid. But in this case, as it will be proved hereafter, the muriats were discovered, which prevented my obtaining an absolute proof of the water being perfectly free from the presence 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 fuccinat 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 tem-

perature of 160° . Five grains of the selenite thus obtained and dried, being redissolved in water, and afterwards precipitated by oxalat of ammonia, and dried at 160° , weighed 4.25 grains; which is equivalent to 117 parts of selenite, for 100 parts of oxalat of ammonia. Consequently the following formula, $4.25:5=4.1:x$, will give 4.82 grains, as the quantity of selenite contained in 10 grains of residue, dried at 160° .*

§ XV. *Alum and Epsom salt.*

The presence of these two earthy sulphats in the water, being by no means improbable, I tried to discover them in the following manner.

* This estimate of course supposes that selenite is the only calcareous salt present in the water. Muriat of lime, which is often found in mineral waters, could not be expected in this, since its existence, except in extremely minute quantities, is incompatible with sulphat of iron. In confirmation of this, I tried the muriatic salts obtained from the solution in alcohol (§ XIII. exp. 1), with oxalat of ammonia, which occasioned only a very slight cloud, without any ponderable precipitat.

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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 precipitate 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 subfulphat 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 fulphat of iron and selenite, and 3 grains of muriat of soda: and from the last result in particular, I concluded, that neither alum, nor fulphat of magnesia, were contained in the water.

* It may be observed that the quantity of fulphat 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 subfulphat, in the residue insoluble both in alcohol and water, which consisted entirely of selenite and subfulphat 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. I) 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 fuccinat 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 fuccinat 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 fuccinat 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.

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6thly, That if 100 parts of pure alumine prepared from alum, and brought to the consistence of a paste, * be dissolved in sulphuric acid, and afterwards precipitated by succinat of ammonia, and calcined in a red heat, the residue will be exactly equal in weight, to that procured by calcining in the same manner, without any previous solution and precipitation, a similar quantity of pure alumine taken from the same mass.

EXPER. VI.—Being now possessed of a direct mode of precipitating alumine, I made a solution of 10 grains of residue, and after precipitating the iron from it by prussiat of potash, and the lime by oxalat of ammonia, I added succinat of ammonia. But not the

* I procured this paste by precipitating a solution of alum by pure ammonia, and afterwards washing the precipitate repeatedly in great quantities of distilled water, and heating it gently once or twice with ammonia. The water at last came off perfectly free from sulphuric acid; and a portion of the paste thus prepared, being dissolved in muriatic acid, and a strong solution of muriated barytes added, a slight cloud only was produced, without any distinct precipitate. And as nitrat of barytes produced no cloud whatever, I suspected that the slight effect of muriated barytes might possibly be one of those anomalies, such as Mr. Kirwan has observed with regard to muriat of magnesia, quite independent of the presence of any foreign substance.

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 generally 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 estimate the quantity of this salt, I had again recourse to alcohol. 20 grains of residue were put into a phial, with about 120 grains of alcohol of the specific gravity of 810. The undissolved part was allowed to subside, after shaking the solution repeatedly, and letting it stand for several hours. The clear fluid being then decanted off, and a solution of carbonat of ammonia *fully saturated* with carbonic acid, being added, the mixture became thick and turbid, and passed to a dirty brown colour. This muddy fluid being filtered, and phosphat of soda added to the clear solution, a cloudiness immediately appeared, and in a few minutes a white powder subsided, which, when dried at a temperature not exceeding 100°, weighed 2.8 grains.

The precipitate obtained by this method*, being a triple salt, composed of phosphoric

* This very easy and valuable method of precipitating magnesia, was first suggested by Dr. Wollaston. It is obviously founded upon the property which fully neutralised carbonat of ammonia possesses, first to dissolve the carbonat of magnesia which is formed in consequence of a double elective attraction, and afterwards to yield the earth to the phosphoric acid, with which, and the ammonia, it forms a triple salt. With

acid, magnesia and volatile alkali, (the same combination which Mr. Fourcroy has discovered in the bladder of a horse, and Dr. Wollaston has shewn to compose 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 magnesia was required to form, by the process above mentioned, a known quantity of this triple salt.

EXPER. VIII.—For this purpose, I evaporated to dryness a solution of muriat of magnesia, in a heat of 160° . 5 grains of the residue thus obtained were dissolved in water, and both

regard to the preparation of the carbonat of ammonia, Dr. Wollaston's method consists simply in pulverising a quantity of the common carbonat, and exposing it for a few hours to the action of the atmosphere, thinly spread on a piece of paper. I found that 100 grains of common carbonat of ammonia recently sublimed, being treated in this manner, were reduced to 57 grains: and a solution of salt thus prepared had no smell whatever. But no certain inference can be drawn from this experiment, respecting the proportions of carbonic acid and volatile alkali in the common carbonat, since (as Mr. Davy has shewn in his excellent treatise on the nitrous oxyd), those proportions vary considerably according to the degree of heat with which this salt is sublimed.

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.

posing for about a quarter of an hour, common calcined magnesia to a red heat, so as to be certain that all the moisture and the carbonic acid had been expelled, were dissolved in muriatic acid, and precipitated as in exper. 7. The triple salt being collected on a filter, and thoroughly dried in a heat not exceeding 100° , weighed 26.3 grains. Consequently 2.8 grains of this salt, or 1.79 grains of muriat of magnesia, contained only 0.53 grains of pure magnesia; a proportion which is equivalent to 100 grains of triple salt dried at 100° , for 19 of magnesia prepared in the manner just described. I dried the 26.3 grains of triple salt at a temperature not exceeding 100° , fearing that it might be decomposed by a greater heat; but I was rather surprised to find, that being afterwards exposed to a heat of 160° , it lost only 2 grains.

§ XVII. *Sulphuric acid.*

In order to ascertain the quantity of sulphuric acid in the chalybeate, a solution of nitrat of barytes was added to a pint of the

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of foda, 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 foda: 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 foda 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 subfulphat; 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 conclusion.*

On recapitulating the various results of this analysis, in order to present them in one view, it appears, that 100 parts of the solid residue 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 crystallized green sulphat.
Sulphat of lime -	48.2	
Muriat of soda -	18.	} Dried at 160°
Muriat of Magnesia	8.9	
Siliceous earth -	1.7	
Loss - - - -	2.0	
	<hr/>	
	100	}

And a pint of the water (which is equal to 8.5 grains of the solid residue) 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 crys- tallized green sulphat.
Sulphat of lime -	4.09	
Muriat of soda -	1.53	
Muriat of magnesia	75	} Dried at 160°
Siliceous earth -	14	
Loss - - - -	19	
	<hr/>	
	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 underground through strata of shale; and having 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 standing for some hours.

No appearance of any thing metallic is indicated by the usual tests.

By boiling a quantity of the fresh water in a proper vessel, 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 composed of carbonic acid, sulphurated hydrogen, and azotic gas. The two former might be expected to be contained, the one from the smell, and the other from the slight alteration in the colour of litmus; but the latter can only be ascertained by experiment. The azotic gas is more loosely attached to the water than the two others; (c) and besides, a large quantity of it is constantly rising up through the water at the spring head, precisely in the same manner as at Buxton and Bath.

(c) This was ascertained by receiving the gas expelled from the sulphureous water, in successive phials previously filled with warm water, and examining each separately. The first is chiefly azotic gas, but the carbonic acid and sulphurated hydrogen are not entirely expelled till the water has been boiled for some minutes. These facts are interesting in a chemical view, probably more than in a medical.

Harrogate water likewise contains several fixed saline substances which are left after evaporation; and which give it a strong bitter and saline taste, and produce sensible 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 soda —	615. 5
— muriated lime —	13.
— muriated magnesia	91.
— carbonated lime —	18. 5
— carbonated magnesia	5. 5
— sulphurated magnesia	10. 5
	—
	754. 0

And for the gaseous contents, cubic inches

Of carbonic acid gas —	8
— azotic gas — —	7
— sulphurated hydrogen	19
	—
	34
	—

Total, one ounce and a half and thirty-four grains of solid contents, and thirty-four cubic inches, or about eighteen ounces in bulk of

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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 less likely to return, than when only the resinous and drastic cathartics are made use 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 these cases, the sulphur may contribute to its medicinal powers. The same observations will apply to its use in scrophula, and in various visceral obstructions. But it is peculiarly from the cure of a number of cutaneous disorders, that the sulphureous waters of Harrogate have acquired their high celebrity, and accordingly a very large number of the patients who resort thither are of this class. In these complaints, the use of the water was formerly intirely confined to external application, and even then its efficacy was very fully established. Modern practice has introduced a considerable improvement in imploying this water largely as an internal medicine; and the union of the sulphur with the neutral salts in such a proportion as to determine regularly and moderately to the bowels, appears to be a plan of cure well adapted to these troublesome and often very obstinate diseases. 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. These complaints receive material advantage in the use of the warm bath, which accordingly makes part of the plan of cure; and during its use, very moderate doses of the water, warmed, and repeated at proper intervals, will materially assist in keeping up that full perspiration which is promoted by the bathing, and always kept up for some hours by confining the patient in bed after immersion, wrapped up in flannel. In this respect, however, the cold sulphureous waters are not so advantageous as those which are naturally hot; for the former, in being artificially warmed, must lose some of the sulphureous gas, on which part of their efficacy, even when applied externally, must depend. For this purpose therefore the hot sulphureous baths of Aix-la-Chapelle are certainly preferable, but we have no natural springs of this kind in our own country.

Among those disorders in which both the sulphureous and saline ingredients may be supposed to unite their valuable properties, we may mention the piles, and symptoms produced by several species of worms. The advantage of sulphur, 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 feeds, 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 Hart-fell 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.

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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

— fulphurated 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 fulphurated 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

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affecting the bowels. Scrophula is another disorder in which many receive very important relief here. It is chiefly however in the earlier stages, and slighter symptoms of this formidable malady, that the good effects arising from this water are the most conspicuous; but under this use, glandular tumours are often dispersed without suppuration, or any bad consequence. Frequently too, persons who have ill conditioned and irritable ulcers, apply the water as a constant dressing to the part, and with great benefit. Besides these diseases, the water of Moffat is now employed in a number of bilious complaints, in dyspepsia, and general want of action in the alimentary canal; and also in calculous cases.

With regard to the requisite dose, it may be observed in general, that this is a water which may be safely taken at almost all times, and by most constitutions. To produce much benefit, it should be used pretty freely in such doses and intervals as the patient can bear. The quantity usually prescribed, is from one to three bottles drank every morning; but there are many persons of a delicate stomach 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, furrounded 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 *Therme 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

less so with the cold, owing to the previous deposition of carbonated lime.

Litmus, in like manner, is rendered of a deep violet, and infusion of rhubarb of an orange red, both by the fresh and cooled water, and still more when it is considerably reduced by evaporation; and from this latter circumstance the presence of an uncombined alkali is indicated.

No metal is discoverable by the nicest tests.

The solid contents left after evaporation are, a small quantity of carbonated lime, of muriated soda, and carbonated soda, which last gives the lixivial taste, and acts a conspicuous part in the chemical composition of the whole.

But the most striking feature in this mineral water, and almost peculiar to it, is the unusual quantity of sulphur that it contains; the whole however so far united to a gaseous basis as to be entirely volatile by heat, so that none is left in the residuum after evaporation. In the common sulphureous waters, such as that of Harrogate, though this inflammable is indicated by every test and sensible property, it cannot be procured separate and in a palpable

form without the assistance of chemical agents: whereas here it is spontaneously separated; for it is found that wherever a large quantity of the Aken water passes hot from the spring through a confined place, the upper covering becomes by degrees incrusted with a very fine pulverulent sublimed sulphur. This is particularly the case on the dome of the vault that incloses the great source which supplies the emperor's bath. This is opened at times, and the sulphur brushed off, and sold under the name of *Aix sulphur*. The hydrogen therefore, which flies off in a gaseous form from this water, is supersaturated with sulphur, and deposits its excess of this substance in a very short time after it has become aeriform; but, however, the soda which the water contains, probably detains some of the sulphurated hydrogen for a time, since the peculiar odour of this compound is recoverable, even after the water has been once cold; but, as has been mentioned, it is entirely dissipated by the process of evaporation (*b*).

(*b*) The chemical reader is here referred to some excellent observations on this subject by Mr. Kirwan, in his *Treatise on Mineral Waters*. Hepatic air, he observes, consists 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.
		<hr/>
		21.75
		<hr/>

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, *fulphurated hydrogen*; but where the sulphur is in excess, it is termed *super-fulphurated hydrogen*. Sulphurated hydrogen, combined with any basis, forms a *hydro fulphuret*, 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 fulphurated 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 10 and 30).

Aix-la-Chapelle water seems to be a mixture of super-fulphurated 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 cheerfulness 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 kidneys, 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 kidneys 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 cases in which the hot bath is used, and more especially as a sudorific to excite a full perspiration, which is afterwards kept up by removing the patient to a warm bed for some hours. This is found to be a remarkably powerful auxiliary in curing some of the worst species of cutaneous disorders.

In using this water internally, the patient should begin with not more than half a pint for a dose, and repeat it more or less often according to the effects on the head, and the intention of drinking it. For producing a purgative operation, it is necessary to take from a quart to a gallon, a quantity which sometimes cannot be borne by the stomach; and in that case some of the saline medicines of this kind must be resorted to. By suffering the water to stand in an open glass for some time, its activity abates as the sulphur evaporates, and thus its action may be moderated, whilst the whole of the alkali is retained.

The town of Aix likewise possesses the advantage of being near to several chalybeate waters, which often are of great use in restoring to perfect health those 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.

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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 Pyrénées en 1788 & 1789, par F. Pazumot, 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 slight sulphureous odour. This continues some days, but without any apparent precipitate being formed.

The alkalies, fixed or volatile, occasion no alteration.

All the metallic salts are decomposed by the water. Nitrated silver immediately renders it turbid, and a brown precipitate gradually subsides. As soon as this metallic solution is added, the water loses the smell of liver of sulphur, and acquires that of sulphur singly. The nitrated mercury and acetated lead produce the same effect.

This water, as well as the other three springs, loses its sulphureous principle by cooling and by contact of air, or even in well closed bottles, if kept for some days.

A quantity of this water, slowly evaporated, soon loses the odour of the sulphur, and when dry, left a residuum, which was grey, acrid, and saline. Distilled water dissolved the greater part. This solution contained muriated soda, and an excess of soda, 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) Ruttty's Synopsis.

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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 those particular mineral waters which appeared to me to be the most deserving of notice, and to present a fair specimen of very extensive classes. In treating of these, care has been taken to subjoin to each, such an account of their medicinal efficacy as has been found to be established by long experience, and to be more peculiarly appropriate to the individual subject. The reader must, however, in many instances be struck with the general similitude in the virtues ascribed to each, even where the chemical composition appears to be the most distant; and as there is no reason to doubt of the accuracy of the fact respecting the actual existence of these valuable properties, which in most cases will be confirmed by the experience of every physician who has had opportunities of trying these remedies, it will not, I trust, 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

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cannot be disturbed with impunity. The retardment thus produced, will only be counteracted by an increase in the stimulus arising from mere distention. But if no more aqueous dilution were employed than what was solely necessary as a solvent for the solid part of the aliment, the additions thus thrown into the circulating mass by the chylopoietic organs, would probably be too stimulating in their nature, and perhaps too soon *animalized*; and hence a strong tendency to plethora and an inflammatory state of body would be produced, and various disorders of the system would follow. On the other hand, if the powers of the stomach are naturally weak, so that digestion is a very slow process, the spontaneous chemical changes that the food would take on out of the body, begin within the stomach before they can be prevented by the proper action of that organ and its secreted liquor; hence the acidity of stomach, heart-burn, and eructations, and all the train of symptoms included under the general term of dyspeptic. But these again will be prevented in a great measure by proper dilution; as the simple addition of water will moderate the stimulus 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 secretions and excretions, the quantity and state of these, as regulated by that of the watery ingesta, becomes of high importance. During the whole course 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 skin, and the kidneys; and this removal of noxious matter appears to be full as necessary to the constant health of the animal, as the daily supply of food by the mouth. A proper degree of dilution favours this salutary process; and what strongly proves its use, and the necessity of removing out of the system the circulating fluid when it has performed its office, is the well-authenticated circumstance of persons having lived long on water alone, in situations where they were prevented from receiving any supply of solid aliment from without.

Now as there is here no new succession of circulating fluid that is properly nutritious, that which is already contained within the vessels, must be perpetually acquiring properties which render it more and more injurious;

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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 consider the use of water as a medicine, in the various acute and chronic diseases, to which, under one form or other, it is constantly applied.

Writers on the materia medica have justly made a distinct order of diluents, as medicines differing in their operation from that of all other substances. I mean now to make some observations on this class of medicines, only I must reduce the catalogue of *diluentia* to a single article, namely, pure water, employed however at different temperatures, according to the indications pointed out by different symptoms which will be noticed as they occur.

The employment of water as a diluent in *acute diseases*, is one of the most important of its uses considered as a medicine, and it will not be uninteresting to inquire on what grounds are founded those beneficial consequences that attend its use in these cases.

It appears to me that many physicians who

have been in the habit of prescribing particular forms of diluents, either as ptisans or decoctions of some demulcent vegetable, neutral salts largely diluted with water, or vegetable and mineral acids in a grateful form, have not always laid due stress on the most important ingredient in all these prepared drinks, the watery diluent itself. This may be partly owing to the familiar use which we make of water in diet, rather than as a medicine; and yet, important as this article of the ingesta is at all times, it might be thought peculiarly so at the time of acute disease, when none of the circumstances that usually affect the state of the body are inactive in producing changes, good or bad, upon the disordered frame. The little activity too shewn by most of the impregnating matters of these drinks, when taken separately, compared with the essential benefit which they produce when in the form of the greatest dilution, would alone direct the attention of the medical inquirer, to that part of the diluent medicine, the powers of which it is my present object to illustrate.

The instinctive desires or aversions of per-

sons labouring under any species of disordered functions, have been justly considered as deserving the highest attention from the physician, and in most cases, when present, will furnish him with useful hints for his treatment of the patient. In acute diseases, the thirst after water is peculiarly remarked as a characteristic symptom, and one that is sufficiently constant to be a basis of nosological description; and it is to be observed, that here the wishes of the patient are directed towards water alone, and that too of the most icy coldness that can be procured. Thirst, therefore, is a direct instinctive indication of increased heat and want of dilution, and this is so uniform, that the degree of fever may often be pretty well estimated by the eagerness of the sufferer after cold drink. In like manner, I have often observed it to be an unpromising symptom in fever, when the sensation of thirst is only relieved for an instant by taking large draughts of cold liquid; as it shews that the surface of the body is still unable to receive the great benefits which are to be derived from simple dilution. The feeling of thirst may however be in some measure 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 researches of the best physiologists, that the blood is not merely a peculiar chemical mixt, but a living part of the animal economy, subject to disease, 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 case with any other organized part of the body while performing the functions of life. One essential alteration which the blood undergoes during inflammation, and which is almost characteristic of inflamed blood, is a diminished tendency to spontaneous coagulation. This, as the late ingenious Mr. Hewson has clearly pointed out, is the immediate cause of the size or buffy coat of inflamed blood, and is produced by the circumstance of the red globular part subsiding at the usual time after the blood is drawn, but not accompanied by the gluten, which last coagulates at a later period; and being now no longer mixed with the colouring globules, assumes a purer form, and its natural grey colour. This change of the coagulability of the blood is of itself probably a great advantage in enabling it to circulate more freely through the minuter vessels, 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

increased to a great degree by the circumstance of the blood being in a more active state than usual, and probably evolving an uncommon quantity of heat during the whole of its course: this again is checked by aqueous dilution, which, as it were, quenches the flame and abates the unusual stimulus arising from the state of the inflamed blood.

Another source of the advantage derived from introducing a greater quantity of pure water into the mass of febrile blood, is in diminishing the tendency to effusion of coagulable lymph from the serous arteries. It is well known that one of the most common terminations of inflammation of membranes is a copious effusion of gluten, or coagulable lymph, which, by assuming a solid form, occasions painful and dangerous adhesions; or else it is the production of true pus, the presence of which brings on a variety of unpleasant symptoms. These consequences of increased action in membranous parts, and of preternatural effusion, must be much lessened by diluting the contents of the circulating fluid, which will diminish the increased stimulus on the exhalent vessels, in the same manner as it

does that on the blood vessels; and thus the ferous 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 reaction 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 precision in terms where the things themselves admit of accurate distinction.

Simple dilution in active fever may, however, be carried to excess, though not, I apprehend, in the way which would appear the most obvious, that of increasing effusion to a morbid degree into the cavities of the body. But, an excess of watery liquid thrown in faster than the emunctories can carry it off, must induce a temporary plethora in the blood vessels. It is certainly not improbable that the absorbents of the stomach may be active, and transmit a fluid so easily taken up as water is, with great facility, whilst at the same time the exhalents or the secretory vessels, which are the extremities of the arterial system, are comparatively inactive or morbidly constricted, and the secretion of urine equally defective. We know that, in health, the circumstance which induces us to take an unusual quantity of liquid, is a previous increase of the action of the exhalents by means of exercise; and whilst this and the secretion from the kidneys 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 ascertained 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

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blished, 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 relat-

ing to an habitual use of water, which require some notice, as they are intimately connected with the subject of mineral waters.

Much has been said by eminent writers concerning a proper selection of the water which is to be used in various forms as our common drink; and an attention to this object, has been as strenuously insisted on in recommending a place of residence, as the more obvious circumstances of air and situation. There certainly appears to be some ground for this caution, for any considerable impurity in a liquid which makes so large a part of our diet, must be felt, in some way or other, in the general functions of the animal economy. Dr. Heberden, an accurate observer, and most judicious practitioner, has particularly insisted upon this point, and has recommended as a fair subject of experiment, a course of distilled water to be used medicinally in those cases which have been thought peculiarly exposed to receive injury from the hard springs in common use (a). It is to be regretted however, that we have not such authentic facts and observations conducted on a sufficiently

(a) Medical Transactions, vol. I.

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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 positively noxious, and this is chiefly with very irritable stomachs where it produces symptoms of dyspepsia. Invalids and young children are the most likely to suffer from this cause; for the great importance of a healthy and regular performance of the functions of the stomach and bowels in infants is well known, and a hard astringent water taken into their tender organs, may very probably induce a faulty digestion, costiveness, and disorder in the whole alimentary canal, which in infants is always dangerous, and sometimes fatal.

Another, and more decidedly beneficial use of water as a medicine, is in relieving those deranged functions of the stomach and bowels, and biliary organs, occasioned by the most frequent of all causes of disease, especially with men of a middle age, and in easy circumstances, a long and habitual indulgence in high food, strong drink, and all the luxuries of the table. In such cases there are three direct causes of disease, 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 those digesting organs that have been deranged by a long continuance in the habits which produce dyspepsia. Every practitioner is acquainted with those valuable and more active remedies, which it is necessary to use in such cases; but these it is not my intention to enlarge upon.

In the use of water as a medicine in chronic as well as acute diseases, regard is also to be had to the circumstance of temperature.—The simple diluent effect will be perhaps the most powerful at a temperature approaching to the animal heat, or nearly that of Bristol water; it is however, less grateful at this degree than that of 45° to 60° , the usual heat of our ordinary springs. The common idea of the debilitating effect of tepid water, seems to be but ill founded, except we go to a height of temperature much above that of the animal body. The tepid waters of Bristol or Bath are never observed to produce any weakening effect on the stomach, but, on the contrary, the appetite and general health are improved under the use of them; and it does not appear that in any of the thermal mineral springs that we are in the habit of using 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 lived, 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 considered the use of water as an article of diet, and as an internal diluent in acute and chronic diseases; there is another very important application of this liquid which deserves 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 skin can bear it.

The circumstance of the animal temperature being about a medium degree between these extremes, the great effect that immersion has upon that temperature, and the powers of the body that produce and regulate it, have caused an essential difference in the physiological and medical view of this subject, according to the degree of heat at which immersion is employed; and therefore, it will be necessary to consider separately the subject of bathing, in a heat much under that of the animal, and in one that nearly equals, or is above it. We shall

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 person is immersed in cold water, the following occurrences are well known to take place: first, there is a general sensation of cold, forming that sudden shock to the whole system, which is one of the most important effects of the cold bath. This is almost immediately succeeded by an equally universal sense of warmth, which increases rapidly to a certain point, so as to cause the surrounding water, though actually cold, to feel of a comfortable warmth; and this feeling is sooner produced, and continues longer, in proportion as the person is in full health, and naturally possessing a vigorous circulation. By degrees, however, if the body continues immersed, it becomes chilled; violent shivering comes on, the extremities grow numb and pale, sometimes sickness takes place, and at last, the animal powers are exhausted by cold and fatigue. In this process, the most remarkable effects are those which occur first, and are directly consequent to the shock of immersion; and these require particular attention in a medical view, as it is only to the production of these that the cold bathing should be suffered to proceed.

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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 unctuousity 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, pro-

duces a strong tendency to sleep, provided the exhaustion be gradual, and does not proceed at once so far as to produce shivering and quickness of pulse, and that derangement of the functions, which resembles the cold fit of an intermittent.

The peculiar sensibility of the skin to the impression of sudden cold, as produced by the cold bath, may often occasion effects somewhat different in degree from what might be expected from the mere circumstances of the coldness of the water, and the general vigour of the body.

This sensibility may probably be in some cases more, in others less, than the general balance with the arterial system; and thus the effects of cold immersion will not, with all persons, be followed by a reaction precisely proportioned to the coldness of the fluid which determines the actual force of impression, and the strength of the constitution to regulate the reaction. To a diminished sensibility of the skin, occasioned by long habit, we may probably attribute the ease with which the attendants on the cold and sea baths, remain for some hours in a medium, which, from its

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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

those of losing heat. The sensation of heat likewise 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 pulse, are often very striking; but it is necessary to be aware of the increased frequency produced in persons not in the least feverish, by the mere apprehension of plunging into very cold water. This natural, and in many persons insuperable alarm, may very materially retard the salutary reaction in delicate habits, especially where the degree of cold is carried to the utmost extent which the constitution is at all able to overcome. To such, much advantage will be derived from a tepid bath, where the shock is more moderate, as for example, that of Buxton; and even the idea and name of a tepid bath, has some effect in reconciling the mind as well as the body in some degree to the impression of sudden cold. When the shock of immersion is fully over, and the reaction established, the pulse becomes slow, regular, and in general, small; and so continues till the body begins to be chilled, if the im-

merſion be perſeuered in. This change of pulse from being hurried and irregular, to a flow and ſteady heat, is moſt ſtrikingly ſhewn in immerſion or affuſion of cold water during ardent fever, and is one of its moſt ſalutary effects.

Much has been alledged in favour of the advantage of ſalt over freſh water uſed as a bath. Where the ſkin is particularly irritable, and eſpecially where any cutaneous diſeaſe is preſent, there is no doubt but that the ſaline ingredients of ſea-water may have conſiderable effect: the ſame may be ſaid when a perſon is immerſed for a conſiderable length of time, as in long ſwimming in the ſea; but where the immerſion is but momentary, as is the caſe with by far the greater number of invalids who uſe this powerful remedy, and where the moiſture that adheres to the ſkin is wiped off carefully as ſoon as the patient comes out of the water, it is difficult to conceive how ſea-water ſhould here have any action different from freſh water at the ſame temperature, and in the ſame circumſtances of agitation and expoſure.

The diſeaſes and morbid ſymptoms 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 unspirable 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

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“ the heat be higher than natural, it brings
 “ on interruption of respiration, a fluttering,
 “ weak, and extremely quick pulse, and cer-
 “ tainly might be carried so far as to extin-
 “ guish animation intirely.” The most salu-
 tary consequence which follows the proper
 use of this powerful remedy, is the produc-
 tion of profuse and general perspiration; and
 this is a consequence, partly, perhaps, of the
 sudden reduction of the animal heat to its
 natural standard, but principally of the great
 reaction produced throughout the whole of
 the circulating system by means of the violence
 of the shock. It is this circumstance that ap-
 pears to give so much advantage to a *general*
 effusion of cold water in fevers, in preference
 to any partial application.

It has been said by some medical observers,
 that the process of perspiration is diminished 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 precise point of
 temperature which is the most favorable to the
 flow of this excretion; and therefore, when too
 high, it may be often necessary to bring down
 the animal heat to the perspirable point. Per-

spiration, 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 pre-

cede a complete delirium, and occasions a sound and easy sleep. If an intire immersion in cold water be employed, and the body be in a fit state to produce reaction, a full and general perspiration will follow; and this is much more complete than where no previous shock of cold had been given; and in the earlier stages of fever it will often intirely put an end to the complaint.*

These circumstances, therefore, are decidedly in favour of universal ablution, over that which is only partial; and as that reaction which brings on a perspirable state of the skin will be produced with the former, by using water even of a tepid warmth, it may be so regulated to the strength of the patient as to be applicable to almost every case of increased animal temperature. There are many particular symptoms which receive much relief from applying cold water to the parts affected. So, I have

* See Dr. Currie's farther illustration of this subject, in a second volume lately published, of his *Medical Reports*, on the effects of water, &c. &c. in which there is a very interesting letter from Dr. Gregory, on the salubrious effects of cold bathing, in the *Scarlatina*.—See likewise a very ingenious treatise 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 seen the pulse made slower and more regular, by this topical application.

The cold bath is better known, especially in this country, as a general tonic remedy in various *chronic diseases*, and under these circumstances some precautions are necessary, different from those required in acute fever.

In chronic diseases it is to be observed, that the cooling power of cold water is not the object in view; nor is it at all requisite or salutary, except as being the medium through which the reaction is excited. The general circumstances of disorder for which cold bathing appears to be here of service, are, a languor and weakness of circulation, accompanied with profuse sweating and fatigue on very moderate exertion, tremors on the limbs, and many of those symptoms usually called nervous; where the moving powers are weak, and the mind listless and indolent, but at the same time where no permanent morbid obstruction, 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 chlorosis, a disorder often extremely obstinate, and from the age at which it usually affects females, always exciting a good deal of anxiety. Although in most diseases not attended with a determination of blood to particular vital parts, where a general tonic plan is indicated, the cold bath forms an useful auxiliary, yet I have here almost invariably found it to be detrimental, and to increase the head-ach, chilliness, and languor, which at all times attend this disorder.

Cold bathing is likewise seldom admissible in those cases of disease in the stomach, with defect in the powers of assimilating food, which are brought on by high living, and constitute what may be termed the true dyspepsia. The healthy state of this organ is so intimately connected with the general power in the body of producing reaction on the skin, that, where the former is much debilitated, will almost constantly sympathize with any disturbance produced by an excessive and unusual impression on the latter. Besides, the process of digestion seems to require a pretty uniform state 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 cause, and which shew a remarkable sympathy with internal organs, especially the head and stomach; of this kind is the febrile erysipelas, preceded by nausea, rigor, and head-ach. In these the use of cold to the inflamed parts is always doubtful, and requires the utmost caution. Another kind of inflammation is that which comes on so far spontaneously, as not to be produced by actual external injury, but yet arises from predisposing causes that affect the whole system; of this kind are many of the phlegmonous inflammations that follow a general exposure of the body to cold, wet, and fatigue; or that succeed to gouty inflammation, and the resolution of fever: in such cases, the employment of topical cold may produce much benefit, but generally requires much judgment and precaution. There are, however, other topical inflammations which arise from a simple and direct morbid cause, and in which the general system is not at all affected, till the external disease, from violent and long-continued irritation, becomes itself the cause of derangement to the whole constitution. These are the cases that receive peculiar be-

nefit 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 several cases in which we find that irritation and heat of the skin, produced by local inflammation, will be much relieved by cold water; and in these too we find that no bad consequence arises to the general health by cold and wet upon the surface of the body. It is a common practice for those who frequent Malvern and similar mineral springs for the cure of herpetic eruptions, or ulcerations of any kind, to wet their linen with the water, and dress with it in that state, without receiving any injury. Another very distressing symptom, remarkably relieved by cold water topically applied, is that intolerable itching of the vagina, which women sometimes experience, intirely unconnected with any general cause, and which appears to be a kind of herpes confined to that part.

Cold water has also been used topically to parts that have become debilitated by being long

(*a*) I am happy to see the use of ice and cold water in burns, which has of late been much employed by several practitioners, particularly recommended by Sir James Earle, in an "Essay on the Means of lessening the Effects of Fire upon the Human Body," lately published by this eminent surgeon.

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,

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lant 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 water-

ing 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

increases the force and activity of circulation in the vessels to which it is applied, renders them full and turgid, and, according to the force of this stimulus, occasions pain, redness, inflammation, serous effusion, or intire disorganization. As the surface of the body is readily sensible to the impresson of heat as well as cold, a comparatively small force of stimulus in any heated medium, will produce considerable effects, directly, from the extent of surface that receives the impresson, and indirectly, by checking the constant flow of heat out of the body into the atmosphere. This last source of accumulation of heat is, however, soon obviated by an increase of the cooling process of perspiration, when the body is in health; but in acute fever, when the state of the extreme vessels is such as not to admit of this process, a very little unusual heat in the surrounding medium is very sensibly felt in the whole body. This was very apparent in the old method of treating the small-pox, and such febrile disorders, by what was called the hot regimen; which consisted in carefully excluding the cool external air, and heating that of the patient's chamber to an almost into-

lerable degree. The increase in frequency of the pulse, feverish heat, thirst, and tendency to delirium, experienced under this treatment, has now caused it to be almost universally disused in this country.

Water being a much better conductor of heat than air, we should expect the general stimulating effects of warm water to be greater than those 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 these effects are in a remarkable degree counteracted by the great relaxation and perspirability of the skin which warm water occasions; and hence it may be used both with impunity and even advantage, in many cases where the animal heat is already too high; for, by relaxing the skin, the great cooling process of perspiration will more readily follow, and the general effect will be that of diminishing heat. In this view, therefore, it appears, that the operation of the warm bath to the dry hot skin of a person labouring under acute fever and general accumulation of heat, may, in the end, be the same as that of the cold bath; that is, by inducing general perspiration, to

bring down the animal heat to the natural standard; and we actually find that this method is often employed with success.

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 op-

pression produced by mere febrile increase of circulation, practitioners have avoided the external use of cold, in order to promote the solution of the fever; and have trusted to the general antiphlogistic treatment, along with the topically relaxing application of warm vapour inhaled by the lungs.

Warm bathing appears to be peculiarly well calculated to relieve those complaints in the bowels that seem to depend on an irregular or diminished action of any part of the alimentary canal; and the state of the skin produced by immersion in warm water, seems highly favourable to the healthy action of the stomach and bowels. Hence we find that the natural thermal springs, when used as a bath, have all acquired a high and just reputation for relieving colics and obstructions in the bowels, when they depend either on a defect of the bilious secretion, or on a directly sedative and paralyzing cause, such as the poison of lead, and similar complaints; and the same effect is produced, though in a less degree, by warm fomentations to the abdomen.

Another very important use of the warm bath is in those 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 ferous 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 spine or the origin of the nerves. In such a loss 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 stimulus of heat, as applied by the hot bath, and elicited by friction, is here found materially to assist in the restoration of the diseased part to a state 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 assisted by any thing that will increase the stimulating properties of the water; as, for instance, by the addition of salt, which will have full opportunity of exercising its powers, both from the length of time in which the patient or the diseased part continues immersed, and the greater sensibility of the skin, when warm and moist. Here therefore we may expect particular benefit from the warm sea-baths which have been established in a few parts of this kingdom, or in the natural saline thermal springs of Carlsbad 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

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of these baths, the bather is first exposed naked to a dry heated room, which strongly

The baths are entered when the wood, which has supplied the furnace, is nearly burnt to ashes; and then the chimney is closed, so as to render the heat within the room almost suffocating to those that are not used to it. The bathers go into the room quite naked. In the private baths some water is generally poured upon the stones before entering them, but the common people expose themselves to the burning heat, lying on the stages where it is the most intense. This often at first produces a violent pain in the head, and great thirst, which leads some of them to drink large draughts of cold water, to the great injury of their constitution.

When the room is sufficiently heated, and the warmth becomes troublesome, cold water is poured upon the hot flints around the furnace: this is instantly converted into vapour, and fills the whole room, and the water is renewed whenever the vapour begins to clear away. This excites a most copious sweat upon the bathers, which they keep up by renewing the steam, and by friction of the whole body with the downy leaves of the lime tree rubbed over with soap. The frictions being finished, the bathers cool themselves with pouring buckets of cold or lukewarm water over their bodies, or often by plunging into some pond which is always near the baths, or else by rolling in the snow. They then dress, and return to their respective occupations. In the private baths, the same general management is pursued, only they are furnished with a smaller room adjoining to the bath, with beds in it, where the bather, after his various operations, retires till the sweating be over, which often terminates in a profound sleep." *See a paper, "on the Russian baths, and their utility in preserving health" &c. by M. Aulaine Ribero Sanchez, first physician to the Empress of all the Russias. Journal de Physique, 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

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varies according to the temperature of the individual, it is not possible to fix any exact limits to this term; only it may in general be remarked, that the tepid bath is that which gives the least possible sensation to the skin, and therefore its effects principally depend on the nature of the medium, and less on the circumstance of temperature, than in the hot or cold bath. In general, the heat of water which we should term tepid, is about 90° ; a heat in which the healthy body will bear immersion for a long time without experiencing any considerable general effect on the system. The state in which this degree of cold (compared with the animal heat) produces the greatest 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 immersion. In this instance, even tepid water poured upon the body of the patient, will prove a very salutary and safe remedy, and its operation will be similar, though in a much less degree to that of the cold bath. There are, besides, some disorders in which the warm bath is more adviseable in some 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 advisable 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 perusing the most popular treatises on particular mineral waters, especially on those of high and justly acquired reputation, written by practitioners long resident on the spot, we shall find in many of them a great fund of accurate chemical knowledge, and excellent medical observations; but we shall also, in the greater number of these works, meet with certain modes of treating the subject, which may fairly be brought under candid criticism. Some of these writers (especially those who have shewn themselves skilful and zealous chemists) have, I think, sometimes refined too much on the science, and have endeavoured to transfer the same accuracy of discrimination which experimental chemistry affords, to the explanation of minute effects produced on the living body by various substances during their stay in its complicated organs. Others again, have endeavoured to

throw a veil of mystery over the whole subject, and, professing to disregard all the information which chemistry affords, they have studiously avoided any attempt to explain the effects produced by certain mineral waters from a review of their contents, and have strongly favoured the idea of their being *specifics*, prepared by the hand of nature, against some of the most formidable and obstinate diseases with which the human race is afflicted. Among this class we find, however, many who from long and attentive observation have made themselves masters of all the practical information which presents itself in the variety of cases which resort to mineral springs; and certainly, if a physician could not be at the same time a sound practitioner, and attached to theoretical reasoning, there would be little hesitation in chusing the most useful walk, in preference to that which is perhaps the most engaging; but fortunately this is not the case, for on the contrary, we find the pursuit of a collateral science, especially one founded on experiment, materially to advance the knowledge of the healing art.

It is urged by some of the merely practical

writers on particular mineral waters, that the mode in which their active contents operate, is equally mysterious with that of some of our most powerful medicines, such as mercury and opium, and probably likely always to remain so; and therefore that accurate chemical examination is little else than philosophical trifling. But it should be remembered, that every medicated water is a compound, at least of the water itself, and of that which gives it its sensible properties, and these it is the peculiar object of chemistry to separate, and to estimate their respective proportions. Now, no practitioner will deny, that it is of consequence to know the proportional quantity of each ingredient in a compound form of medicine, that he may at least endeavour to ascribe to each its particular operation, although he does not pretend to explain how that operation is to be brought about.

If then we suppose a physician to employ in different cases, a great variety of compound medicines, in which however there was one ingredient common to all; and if among the various changes produced by these medicines, there were certain effects common to every

case, he would naturally be led to suppose, that these were produced by that ingredient which entered into each of his formulæ, and he would be thereby led to try it alone, and observe its operation, unconnected with that of every other active substance.

This appears to be the case with all the variety of mineral waters that are used medically. They have only one ingredient in common, the water itself; they all produce effects on the human constitution in some degree similar, which I would chiefly attribute to the watery vehicle; but, besides, there are several that act very powerfully on the body in different ways, and these effects are such as water alone cannot produce, but depend on the very active contents which entitle these springs to the appellation of *mineral*, and in which they differ from the generality of waters used for common purposes.

In the preceding chapters I have endeavoured to explain in general what are the effects produced by simple water used internally and externally, at high and low temperatures; and these therefore are such as, under similar circumstances in the animal body, may

be expected from all mineral waters, allowing however for any effect of an opposite tendency which the foreign ingredients may produce ; as, for instance, where a large quantity of an astringent and earthy salt may in some degree counteract the detergent power of pure water.

As an example of this similarity of operation, in very different waters, and which may certainly in a good measure be ascribed to the mere liquid, we may mention that transient determination to the head, often produced in delicate habits by the first exhibition of any of these waters. We find this circumstance noticed in the purest springs, and those that are the most free from foreign contents, as well as in every other water. So, in explaining the operation of the Malvern water, Dr. Wall says, " I cannot close this treatise
 " without mentioning one effect of the water,
 " that at first it frequently makes persons
 " drowsy, and sometimes give them a dull
 " pain in the head. Symptoms like these are
 " common upon the use of chalybeate waters,
 " but there is no metallic principle in this
 " spring. I think these effects must be owing

“ to the ready and easy admission of the water
 “ in the blood, whereby a plethora is brought
 “ on *pro tempore*.” To confirm this rational
 conjecture, the same writer adds, (what is also
 generally observed by others) that as soon as
 the urinary passages are open, these complaints
 go off immediately. In beginning a course
 of Bristol water, Dr. Nott observes, that
 the immediate sensible effects are generally,
 “ drowsiness, vertigo, and sometimes an ob-
 “ tuse pain of the head, which gentle eva-
 “ cuants relieve.” Among the consequences
 produced by the use of the chalybeate waters
 of Lauchstadt, Hoffman enumerates the fol-
 lowing, “ Non raro contigit, ut aqua nostra
 “ (*sc. Lauchstädiensis*) primum maximè ab
 “ infuetis pota, nauseam, vomitum, inflationes,
 “ dolores circa præcordia, *capitis graviditatem*,
 “ *somnolentiam* . . . suscitât; sed conti-
 “ nuato usu, & pervadente aquâ, omnia spontè
 “ evanescunt.” It is not uncommon for the
 Harrogate water, as Dr. Walker observes,
 “ to produce a sense of heat and universal
 “ fullness in those unaccustomed to drink it.
 “ The giddiness which some have experienced,
 “ is in almost every instance caused by an

— “over-dose of the water, when it fails in its
 “purgative operation.” The hot saline Caro-
 line baths in Germany, have a similar effect,
 for Hoffman observes that, on using them,
 “Alii torporem capitis persentiunt, inclina-
 “tionem ad somnum, vertiginem,
 “& hujus generis alia experiuntur, ob lenti-
 “orem aquæ per capitis tubulos & glandulas
 “colli commeatum.”

It is of consequence, therefore, in estimating the effects of the foreign ingredients of mineral waters, to be aware of those occasioned by the water itself, though it is often difficult to estimate the exact degree, where other substances combine with the simple fluid to produce a general operation. So, we almost invariably find that, during a course of any mineral water, where it does not positively disagree with the constitution, the appetite is improved, and the digestive powers strengthened. This, I have endeavoured to shew, may, in many instances, be the direct consequence of adding so much water to the daily ingesta; but it is often the joint effect produced by this liquid, by a chalybeate in an active form, by a gentle dose 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 subtle 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 system in general. A gaseous water appears to act more powerfully in proportion to the suddenness of the expulsion of the air, and therefore to the looseness of its adhesion to the water with which it is combined. Hence, the great relief found by taking mixtures in the act of effervescence, where the carbonic acid is applied suddenly, and in the gaseous state, to a large surface of the stomach. Hence too, the sudden effects similar to intoxication, caused in many persons by a large draught of highly carbonated water, such as that of Seltzer and Pyrmont.

The force of action which substances exert upon the living fibre, as well as on a simple chemical mixt, depends upon the degree of division of its parts; for this, the sensible properties and active powers of every particle are brought into action at the same time, and are capable of being extended over a large surface. This division of parts is brought about, either by mechanical means or by solution; by the latter it is effected more completely, but then the affinities of the solvent often oppose the combinations which would otherwise be formed by the substance 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 impresson 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 alkalis 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 most common and the most important of these substances in a medical view. Many of its effects are obviously such as concern the stomach only, such as that of checking a tendency to vomiting, for which an effervescent draught has been found remarkably efficacious. The giddiness and species of intoxication from Pyrmont and Seltzer water, is probably produced through the medium of the stomach; as these effects are particularly felt when this cavity is empty, and come on very suddenly, even before the vertigo and head-ach, which, as we have mentioned, also frequently follow a full dose of this water. A good deal too of the gas that is emitted copiously from the water when in the stomach, passes up through the mouth in troublesome eructations. It cannot be doubted however, but that part of these gases are absorbed into the circulating system, along with the water that conveys them into the stomach; and, by entering the circulation, may prove very important remedies, according to the nature of the substance absorbed. (a) The

(a) The effect of the carbonic acid in relieving calculous complaints, has been thought by some to indicate the absorption.

fulphurated 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.

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brought in any degree to resemble in form Bristol or even Seltzer water, it is not easy to conceive how the minute vessels would be thereby rendered more pervious, or that any mechanical impulse could be given to a gas to make it circulate more readily through capillary vessels than water will. In all probability, the contrary assertion would be better founded, for water will penetrate through inorganic pores so close as to detain air. The celebrated Astruc attempted to explain the operation of mercury in resolving obstructions and producing salivation, from the increased momentum which the blood would acquire when mixed with so ponderous a fluid as quicksilver; and this hypothesis was only objected to from the vast disproportion between the minute quantity of metal introduced, and the great effects which often followed. But surely no mechanical advantage to the freedom of circulation could be gained, by substituting an elastic for a non-elastic fluid; a gas, for a liquid.

A review of some of the most celebrated mineral waters, presents us with several facts that at first appear highly difficult of explana-

tion. 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. 1st.—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 tasted extremely brisk and subacid, and sent forth copious bubbles, but the taste of the iron was scarcely perceived till the impression from the acid had gone off. By the dilution, the chalybeate was made so weak in each phial, as only to become purple with galls after standing a quarter of an hour. The hot, as well as the cold liquor, still tasted acidulous, but, (as might be imagined, from the greater loss of carbonic acid) this flavour was less in the former than in the latter. The taste of the iron was however stronger, and more permanent in the hot solution, while it was scarcely perceptible in the cold.

Exper. 2d.—An artificial chalybeate was made by digesting iron filings in water, moderately impregnated with carbonic acid. This was much less brisk and carbonated to the taste than in the first experiment, but much stronger of the iron. Equal quantities of this water were put into separate glasses, and to one was added the same proportion of hot water, and to the other, cold water. These diluted liquors still gave a full purple with gall in about a minute, and the first change

of colour began in a few seconds. They both remained without sparkling in the glafs, and the cold folution had all the fenfible properties of the fimple chalybeates that are fo abundant in this country, fuch as that of Tunbridge. There was however a very decided difference in the tafte of the two folutions, the hot having a great intensity of chalybeate tafte, and more diffufed, as it were, over the whole fauces.

These experiments, made with as much accuracy as the comparifon of taftes will allow of, feem to fhew, that mere heat will much increafe the impreffion of a chalybeate tafte on the tongue; and, therefore, as I apprehend, will equally augment the ftimulating properties of the iron upon the ftomach, when exhibited in this form. They likewise fhew that a lofs of carbonic acid will not diminifh, but rather increafe the fimple chalybeate tafte; provided enough of this acid be left to hold the oxyd of iron in folution. This is not the cafe, however, with Bath water; for as it gives indications of containing very little carbonic acid, it readily parts with even that portion which fufpended the iron; and there-

fore I cannot consider this water, when cold, and especially transported to a distance, as any thing else than a common hard water. To confirm the superior effects of a heated liquor over one that is cold, upon the stomach and nervous power, we may add, that it is well known that the intoxicating property of vinous and spirituous liquors is much increased by heat.

If the idea of the superiour efficacy of warm, over cold chalybeates be just, it will likewise follow that the custom of warming the cold waters of Tunbridge and similar springs is judicious, not only to prevent the chill on the stomach, which is sometimes inconvenient to delicate persons, but also to increase thereby their stimulant properties. They are best heated by being put into a bottle, well corked, and immersed in hot water; but the strong waters of this kind will bear being lowered by the addition of boiling water, so as to bring them to a resemblance of Bath water.

Besides the carbonic acid, and the sulphurated hydrogen, which we may certainly consider as the most important of the gaseous 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 pre-operation 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 fulphat 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 fulphat 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 fulphat of iron, dissolved in a gallon of water, should taste as strongly chalybeate as Tunbridge water. But by making such a solution of fulphat 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 fulphat 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 fulphat 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 $\frac{1}{30}$ 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 fulphat of iron, since it is very distinguishable when in no higher a proportion than $\frac{1}{30}$ 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 saline solution which may be prescribed, in order to excite the different secretions.

The composition of the most celebrated mineral waters having been known by accurate analysis, several ingenious men have endeavoured to confirm their experiments by synthesis; and to produce, by artificial means, a compound, in all respects similar to the natural preparation. To this too was added the additional motive of being able to supply the want of the natural waters, in places, and at times when these could not be procured. The illustrious Bergman, in his excellent treatise on mineral waters, has given very good ideas on the method of preparing them artificially; but some of the processes which he proposes, are imperfect, and liable to objections. Where the water to be imitated is only a solution of some neutral salts, such, for instance, as the Epsom, Sedlitz, or Sea water, all that it is necessary 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

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blance 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

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which the artificial preparation of these medicines would promise, and that is, that of introducing much more simplicity in their composition than nature employs, and by this means we may be materially assisted in forming precise ideas of the operation of every part of these important class of remedies, which the reader will readily see is a great object to be desired by the philosophical inquirer into the powers of medicine. Every one who examines into this subject, must be struck with the great inaccuracy and confusion of ideas that prevail in the description of the operation of mineral waters, and the great similarity of effect ascribed to very different species of this large and heterogeneous class of bodies. It has been my object in the preceding pages, to attempt in some degree to introduce more precision in investigating the powers of these bodies; but the subject can never be fully canvassed, till we are in possession of a greater number of facts founded on experiment; and, to promote this desirable end, the assistance of art in imitating the processes of nature, may be called in with every prospect of advantage. In this view, there-

fore, the study of the method of preparing mineral waters may be recommended to the medical inquirer as an interesting object of investigation.

For the practitioner who entertains a decided preference for the medicated waters which nature presents, we may suggest the convenience of occasionally mixing different kinds of the simple waters, in order to obtain the effects of some 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 Epsom, will make a good imitation of the Cheltenham or Scarborough spring, according to the proportion used; as the one furnishes in abundance the carbonic acid and the iron, and the other, the neutral purgative salt; and each of these contain, so much of their active ingredients as to bear dilution, and yet to retain considerable efficacy. The synoptical table, which is inserted at the end of this work, will, it is hoped, afford some assistance in this object.

There is nothing more gratifying to the physician, who considers the healing art in its true light, that of an experimental science,

than to be able to add to the general stock of professional knowledge, information which is to be afforded by the assistance of a collateral science. Of these, none is more intimately connected with medicine, by a community in many of the objects, than chemistry; and the aids which this science furnishes, are constantly increasing, 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 least important objects of physic; since these are remedies that have been at all times peculiarly favourites with the public, and have deserved, from their real efficacy, much of the esteem in which they have been held. The substances concerned in the composition of these waters, are such as come particularly under the accurate and distinguishing eye of modern chemistry, and admirably illustrate some of its most beautiful discoveries. They have engaged the attention of the ablest chemists for many years in various countries, and the importance attached to these inquiries, has abundantly repaid the labour and difficulty of the research.

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 public 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 chemistry, 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 present the reader, under one point of view, with the most conspicuous features in the composition of the mineral waters which we have hitherto described, the following synoptical table is subjoined. The order in which the individual waters are put, is the same as that in the foregoing chapter, excepting only that the Bath water, which it was thought more convenient to describe among the English thermal springs, is here arranged under the chalybeates, a class to which it certainly belongs. I have made an attempt of a classification of these waters, founded on the most prominent part of their chemical composition, and that which may be supposed to have the most influence on their medicinal powers; but every such arrangement must be imperfect, owing to the almost imperceptible gradations with which individuals of one class approach to the others.

The reader will please to observe, that under the head of *Neutral Purging Salts*, are

included the sulphats of soda and magnesia, and the muriats of lime, soda and magnesia. The power which the earthy muriats may possess of acting on the intestinal canal, is not quite ascertained, but from their great solubility, and from analogy with salts, having similar component parts, we may, I think, conclude that this forms a principal part of their operation.

The reader will likewise observe, that where the spaces are left blank, it signifies that we are ignorant whether any of the substance at the head of the column is contained in the water; that the word *none* implies a certainty of the absence of that substance; and that the term *uncertain*, means that the substance is contained, but the quantity is not known.

THE END.

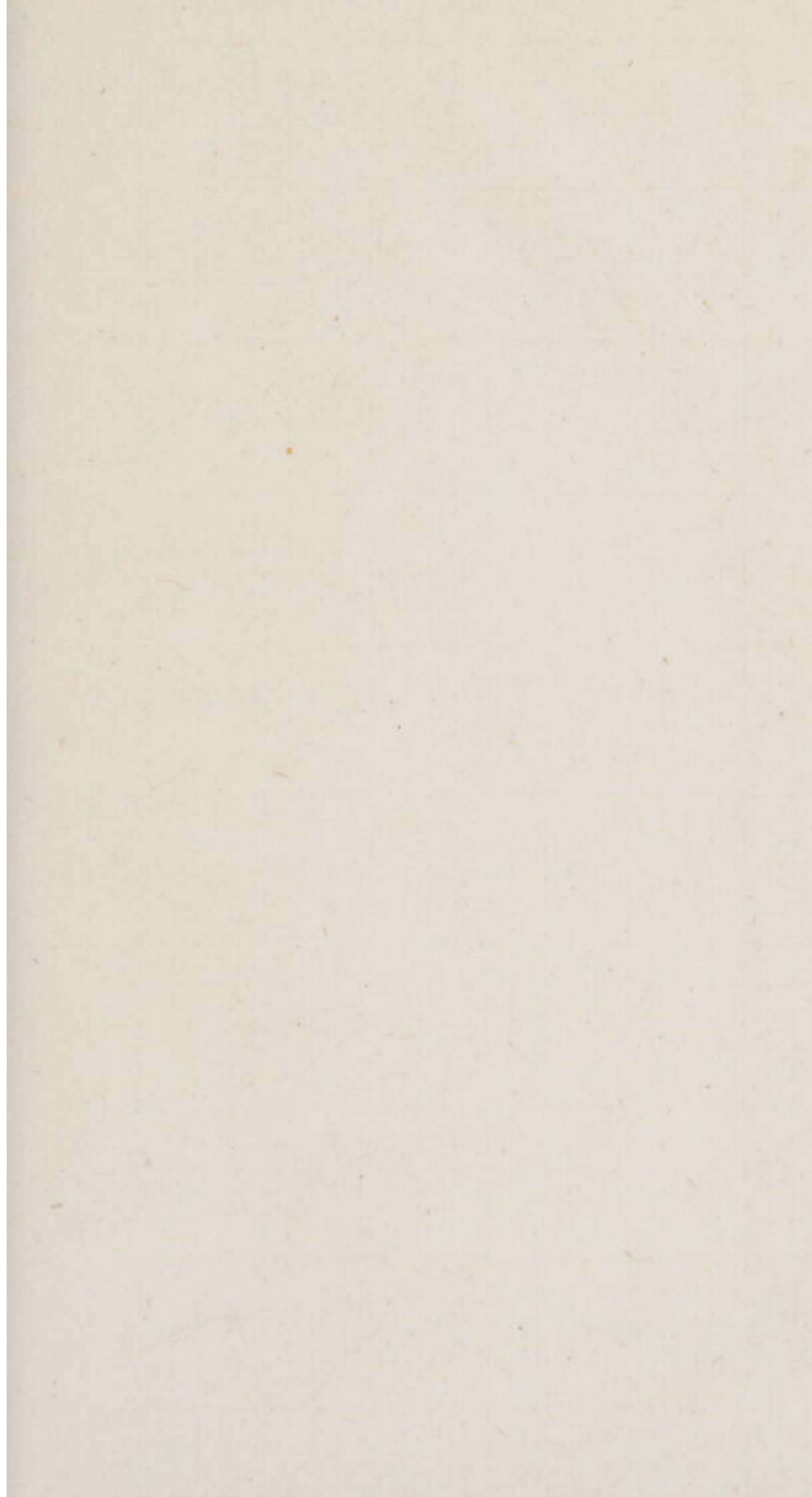
A SYNOPSIS TABLE, shewing the Composition of the Mineral Waters described in this Work.

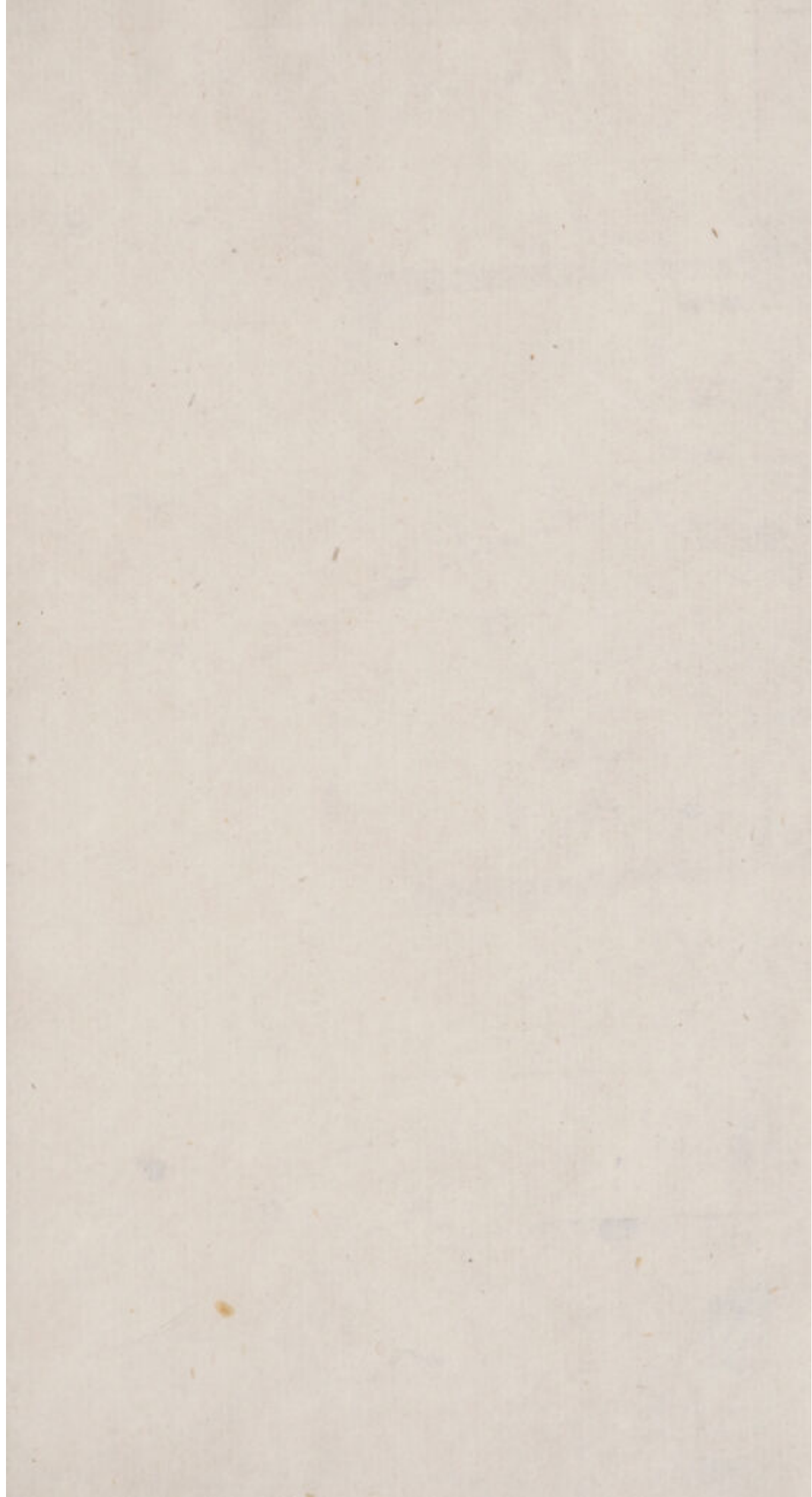
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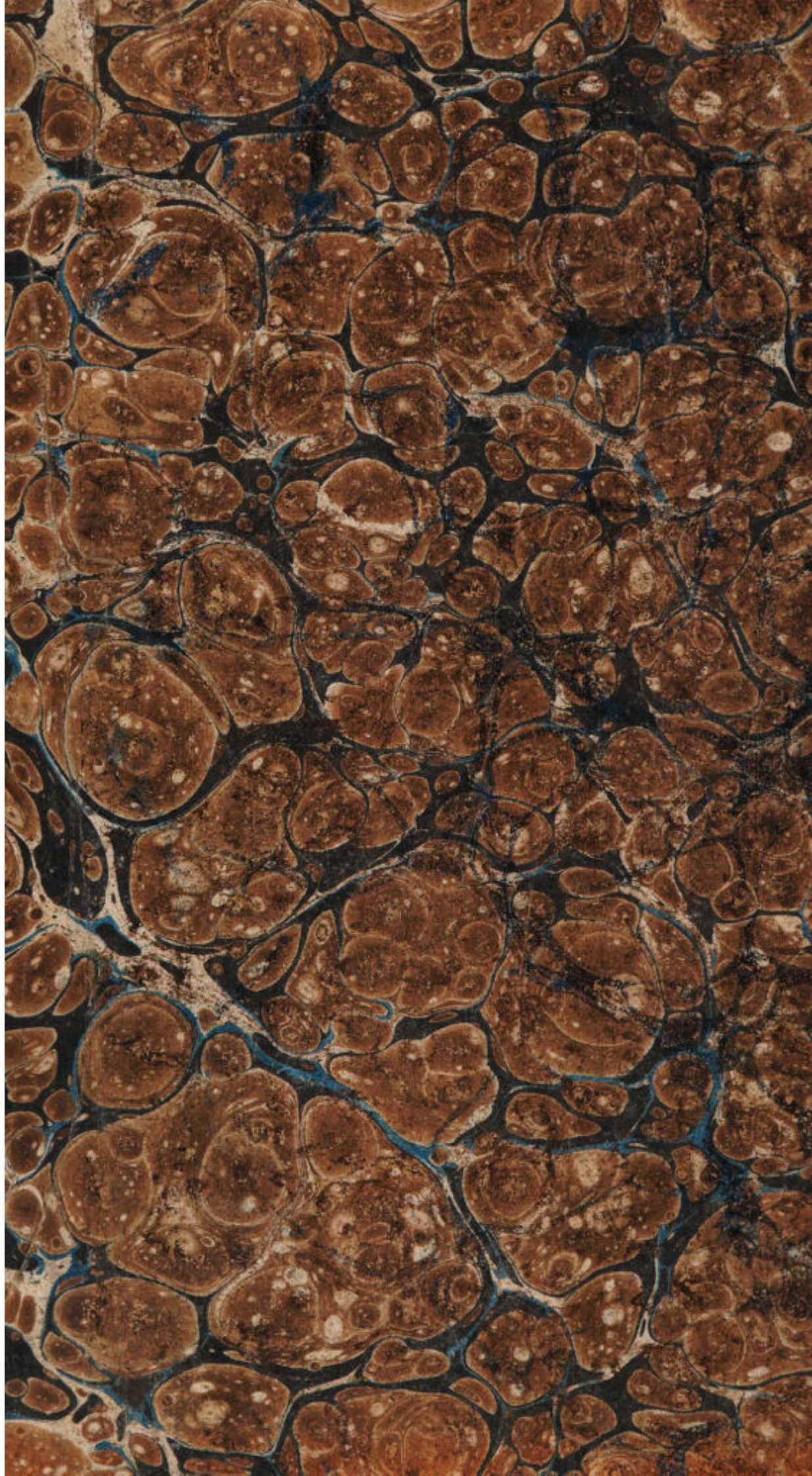
CLASS.	NAME.	H. left temperature. Fahrenheit.	Contained in an English wine pint of 28.875 cubic inches.						
			Nitrogen gas, cubic inches.	Carbonic acid gas, cubic inches.	Sulphurated hydrogen, cubic inches.	Carbonated soda, grains.	Neutral purging salts, grains.	Selenite & ear- thy carbonates, grains.	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
	Epsum				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	4.315*
Ditto	Brighton		none	2.5	none	none	2.23	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, sulphureous . .	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.

List of names of persons who have been	
Names	Residence
John Smith	123 Main St.
James Brown	456 Oak St.
William Jones	789 Elm St.
Robert Taylor	101 Pine St.
Thomas Wilson	202 Cedar St.
Charles Moore	303 Birch St.
George White	404 Spruce St.
Henry Black	505 Willow St.
Samuel Green	606 Ash St.
Benjamin Adams	707 Hickory St.
Joseph Baker	808 Sycamore St.
Samuel Johnson	909 Magnolia St.
John Miller	1010 Dogwood St.
James Davis	1111 Redwood St.
William Clark	1212 Cypress St.
Robert Lewis	1313 Juniper St.
Thomas Hall	1414 Fir St.
Charles King	1515 Palm St.
George Wright	1616 Cedar St.
Henry Scott	1717 Birch St.
Samuel Green	1818 Spruce St.
Benjamin Adams	1919 Willow St.
Joseph Baker	2020 Ash St.
Samuel Johnson	2121 Hickory St.
John Miller	2222 Sycamore St.
James Davis	2323 Magnolia St.
William Clark	2424 Dogwood St.
Robert Lewis	2525 Redwood St.
Thomas Hall	2626 Cypress St.
Charles King	2727 Juniper St.
George Wright	2828 Fir St.
Henry Scott	2929 Palm St.
Samuel Green	3030 Cedar St.
Benjamin Adams	3131 Birch St.
Joseph Baker	3232 Spruce St.
Samuel Johnson	3333 Willow St.
John Miller	3434 Ash St.
James Davis	3535 Hickory St.
William Clark	3636 Sycamore St.
Robert Lewis	3737 Magnolia St.
Thomas Hall	3838 Dogwood St.
Charles King	3939 Redwood St.
George Wright	4040 Cypress St.
Henry Scott	4141 Juniper St.
Samuel Green	4242 Fir St.
Benjamin Adams	4343 Palm St.
Joseph Baker	4444 Cedar St.
Samuel Johnson	4545 Birch St.
John Miller	4646 Spruce St.
James Davis	4747 Willow St.
William Clark	4848 Ash St.
Robert Lewis	4949 Hickory St.
Thomas Hall	5050 Sycamore St.
Charles King	5151 Magnolia St.
George Wright	5252 Dogwood St.
Henry Scott	5353 Redwood St.
Samuel Green	5454 Cypress St.
Benjamin Adams	5555 Juniper St.
Joseph Baker	5656 Fir St.
Samuel Johnson	5757 Palm St.
John Miller	5858 Cedar St.
James Davis	5959 Birch St.
William Clark	6060 Spruce St.
Robert Lewis	6161 Willow St.
Thomas Hall	6262 Ash St.
Charles King	6363 Hickory St.
George Wright	6464 Sycamore St.
Henry Scott	6565 Magnolia St.
Samuel Green	6666 Dogwood St.
Benjamin Adams	6767 Redwood St.
Joseph Baker	6868 Cypress St.
Samuel Johnson	6969 Juniper St.
John Miller	7070 Fir St.
James Davis	7171 Palm St.
William Clark	7272 Cedar St.
Robert Lewis	7373 Birch St.
Thomas Hall	7474 Spruce St.
Charles King	7575 Willow St.
George Wright	7676 Ash St.
Henry Scott	7777 Hickory St.
Samuel Green	7878 Sycamore St.
Benjamin Adams	7979 Magnolia St.
Joseph Baker	8080 Dogwood St.
Samuel Johnson	8181 Redwood St.
John Miller	8282 Cypress St.
James Davis	8383 Juniper St.
William Clark	8484 Fir St.
Robert Lewis	8585 Palm St.
Thomas Hall	8686 Cedar St.
Charles King	8787 Birch St.
George Wright	8888 Spruce St.
Henry Scott	8989 Willow St.
Samuel Green	9090 Ash St.
Benjamin Adams	9191 Hickory St.
Joseph Baker	9292 Sycamore St.
Samuel Johnson	9393 Magnolia St.
John Miller	9494 Dogwood St.
James Davis	9595 Redwood St.
William Clark	9696 Cypress St.
Robert Lewis	9797 Juniper St.
Thomas Hall	9898 Fir St.
Charles King	9999 Palm St.







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