A

TREATISE

ON THE

NATURAL AND CHYMICAL PROPERTIES

OF

WATER,

AND ON

VARIOUS BRITISH MINERAL WATERS.

BY

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LONDON:

PUBLISHED BY GEORGE WIGHTMAN, PATERNOSTER ROW; GEORGE DUPREE, BUCKLERSBURY, AND JAMES RICHARDSON, CORNHILL.

1830.

J. Haddon, Printer,
Castle Street, Finsbury.

TO HIS REVERED FATHER,

ISAAC BOOTH, ESQ.,

FOR THE

FOND CARE WHICH HE EXERCISED IN THE DIRECTION OF HIS FIRST PHILOSOPHICAL PURSUITS

AND

SCIENTIFIC INVESTIGATIONS,

THESE PAGES ARE RESPECTFULLY DEDICATED BY

HIS OBLIGED SERVANT,

AND DUTIFUL SON,

THE AUTHOR.

INTRODUCTION.

Public attention having lately been so fully aroused to the subject of water, from the impure state in which it was recently delivered to the inhabitants of the metropolis, forms one reason for the publication of the present work. Although the details of this subject are both interesting and important, there is no popular treatise to bring down the interesting observations of former chymists to the present state of chymical knowledge. To Dr. Saunders, in his valuable treatise on mineral waters, I am indebted for the greater part of the matter of the following pages, and I have preferred rather adopting the arrangement, and often the language of this intelligent writer, than any observations of my own.

Mineral waters have at all times attracted the attention of medical practitioners and the public, in consequence of their peculiar virtues. In the heathen mythology, every spring was placed under the auspices of its tutelary deity; and, on the first introduction of Christianity, they were transferred to particular saints, whose names many of them retain to the present day.

The immortal Hippocrates who first separated medicine from the study of religion and philosophy, and reduced the chaos of his predecessors to an useful and liberal art, noticed the subject of mineral waters. "Those waters," he observes, "which spring from rocks are generally hard, other waters are warm and afford iron, brass, silver, sulphur, alum, bitumen, and nitre.

Some are sweet, others saline, many aluminous, and each different in its effects from the other."

Hippocrates flourished about 460 years before the redemption of mankind; but it is certain that medicine was practised many centuries before his time. The earlier physicians paid great attention to ablutions. Mavor informs us that the warm springs of Palestine were known as early as the year of the world 1921, and Moses recommends bathing in many cutaneous diseases. Aristotle, who flourished A. C. 384, writes about certain acidulous waters in Sicily; and Pausanias, who lived fifty years afterwards, writes of the mineral waters of Caria, in Asia Minor, which were as sweet as milk. Strabo describes certain springs which were useful to drink as well as to bathe in. Atheneas, of Cicilia, gave an account of a fountain in Paphlagonia, in Asia Minor, which possessed an inebriating quality, and to which the inhabitants of the country frequently resorted. Vitruvius stated that warm and cold springs were employed internally, and praises bituminous water as of singular efficacy in many diseases. Seneca writes, "there are mineral waters which strengthen the eyes and nerves, others which heal ulcers, many which relieve the lungs and other viscera, and some which even suppress hæmorrhage." The younger Pliny, who was born before the middle of the first century, describes many mineral waters in Italy, Syria, Ethiopia, Greece, France, India, Arabia, Phrygia, and Germany, and enumerates their properties when used either internally or externally. He remarked the chalybeate taste left on the palate by the celebrated German Spa waters.

Although Celsus is silent on mineral waters, Scribonius Largus, his contemporary, praises chalybeate waters in diseases of the bladder. Galen also is silent on the present subject. Soon a cloud of ignorance involved mankind and the sciences in obscurity, until the discovery of printing caused literature to emerge from darkness, and shine with an unprecedented splendour. Baccius of Ancona was an early writer upon mineral waters. He ascribes all their efficacy to gold, silver, quicksilver, tin, or lead. The Hon. Mr. Boyle, afterwards the earl of Cork and Orrery, shed a lustre on the early part of the seventeenth century, and was the first to propose and explain the application of re-agents to denote the substances contained in waters. He published a work on mineral waters in 1685. The Academy of Sciences of Paris appointed M. Du Clos in 1667 to analyse the mineral waters of France, while Hierne examined those of Sweden the same year. Hoffman published a work on mineral waters in 1717. Many other papers were from time to time published in the Philosophical Transactions by the Hon. Mr. Cavendish, and the labours of Le Roi and Boulduc, who published an able treatise on mineral waters in 1729, and of Margraff, Priestley, Monnet, and Bergman, contributed to throw some light upon the composition of mineral waters. In this century also wrote Black, Klaproth, Destrump, Short, and Rutty. In the commencement of the nineteenth century Mr. Kirwan published his work, replete with very accurate views, which was succeeded by that of Dr. Saunders, whose work is yet considered the standard. Drs. Henry, Murray, and Thomson, have each contributed valuable observations in their respective treatises, and Drs. Garnet, Lambe, Scudamore, Mackensie, Mr. Richard Phillips, and others have written on certain particular writers.

Some apology may perhaps be necessary to the scientific reader who may honour these pages with his perusal. The composition of waters is a highly important as well as interesting subject, and by it much light may be thrown upon many geological phenomena. May not the presence of the chlorides, iodides, and bromides, indicate the existence of the ancient seas, in the same way as the nature of the saline contents of water, the strata from which they take their rise. The conflicting views of analysis, whether taken according to the saline contents, as the immediate educts of analysis, or formed from the peculiar views of Dr. Murray, require further elucidation. Besides which, the nature of the contents of various waters have not been ascertained with that accuracy which they require: and it is surprising that, with the excitement latterly produced by the water of the Thames, we are indebted to Dr. Lambe for the only attempt at its analysis. Some of the experiments of this chymist appear to me to indicate the presence of bromine in this water.

I had purposed to present to the public a more extended detail upon the present subject, with an analysis of each of the waters which now possess medicinal efficacy, but such an attempt would require more knowledge than my present means of information permit me to obtain.

To accomplish, however, this task, I have already possessed myself of many works of the most important and ancient authors upon the subject, and commenced an analysis of some of the waters. The results shall be from time to time communicated to the public in the Chymical Magazine, where I shall feel honoured with any communication upon the subject.

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95, *Shoe Lane, Fleet Street.*
August, 1, 1830.

CHAPTER I.

Water, in its several combinations.

Before taking a chymical view of the properties of water presented to us on the surface of the earth, either pure or in its various combinations, I deem it most proper to offer a few general observations on the nature of pure water, and the mode of its union with other substances. The physical properties of water are, its being under ordinary pressure, and at common temperatures, a fluid without colour, taste, or smell, assuming the solid form at 32° of Fahrenheit, and the gaseous at 212°, but returning unaltered to its fluid state on resuming any degree of heat between these two points.

Water possesses a large range of affinity for natural bodies, of which it is capable of dissolving a greater number than any other fluid ; it enters largely into the composition of other liquid bodies, performs many important functions in the vegetable and animal kingdoms, and enters largely into their composition as constituent parts.

Water is not only found throughout the earth in an uncombined state, with its particles in the different aggregates either of ice, water, or vapour, but in a permanent and chymical union with a vast number of substances, solid, fluid, and gaseous. The air of the atmosphere, and even that which is considered the driest, contains much water in solution. Many solid minerals and crystallised neutral salts contain water in their composition, some of the latter to more than half their weight.

A substance whose affinity for all bodies is so universal, and a fluid which occupies so important a rank in the operations of nature, may be supposed early to have attracted the notice of philosophers. Accordingly we find their attention long occupied in considering its nature, and whether it be a truly elementary substance. It long held this rank amongst the ancients, and to it was assigned the place of one of those four elements to which the composition of the globe was ascribed. It was, however, noticed by later observers that water always contained air in solution, and that under particular circumstances all water deposited a portion of earth. These circumstances occurring with every natural water, as it sprung to the soil, led several ingenious philosophers to consider that air and earth were necessary constituent parts of perfect water, and they attempted to allot to each its peculiar share in producing the various appearances of this fluid and its effects upon the body.

The supposed conversion of water into earth, effected by the process of distillation often repeated, and independent of the earthy residue of all natural waters, was another opinion formerly much in vogue, and which, being apparently supported by very strong facts, employed the skill and attention of the most able chymists. The illustrious Boyle found in his experiments that water, though purified by repeated distillation, if evaporated to dryness, always left a small residuum. The most accurate experiments on this point were those made by Margraff, of Berlin, an indefatigable experimentalist, who found that water which had been distilled seventy-two times, when evaporated to dryness, always left a considerable residuum.

As the earth which was obtained by these experiments was mostly siliceous, and produced in greater quantity by a violent boiling than at a gentle heat, it was suspected that its production was entirely owing to the abrasion of the glass vessels in which the process was carried on. The immortal Lavoisier repeated the experiment with a view to elucidate this question, and by weighing the vessel, both before and after the process, he found a loss of weight fully equal to that of the earth produced. This explanation was acquiesced in, and finished the controversy.

Hardly had water been satisfactorily re-established on the list of simple elementary substances before the important question of its composition began to be agitated. It would be foreign to our purpose to give any details of the history of this present interesting question, or any examples in its illustration. Water is a compound of two substances, neither of which are known but in a gaseous state, or in their various combinations, the one called oxygen, the other hydrogen. These gases unite chymically in the proportion of two volumes of hydrogen to one of oxygen, and are reduced into a fluid forming water.

It is to be observed that this circumstance of the composition of water has no concern with its nature or chymical action. None of the methods of examining water reduce it to its simple elements, but only separate from it the foreign contents of every description which combine with it when exposed to the action of the earth or air. The chymical action of water is not connected with the character of either of its constituents, the combination of simple elements always producing compounds of distinct and peculiar character.

There are many natural facts to the explanation of which the decomposition of water has materially assisted, and which are objects of great chymical interest. Water enters largely into the composition of many saline bodies, of which it is a constituent part, forming the water of crystallization, which salts, when deprived of this water, crumble into powder. The proportion of water varies in different salts, but it is always uniform in the same species of salt. Water is not, however, essential to the crystalline state, as many crystalline salts contain no water of crys tallisation.

Other substances (such as magnesia, alu mina, and sulphur) contain water, which it is almost impossible to separate except at a very high heat, particularly the last portions. Alumina possesses a very powerful attraction for water. This earth was supposed until lately to form an exception to the general laws of expansion by heat, from its contracting when exposed to an intense heat; but this peculiarity is now ascribed to the earth containing a considerable portion of water, which it only parts with at a high heat, and readily absorbing more when again cooled or exposed to the atmosphere.

Of all 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 chymical point of view from the mineral kingdom, in their different combinations and the large combining proportions of the elements of which they are composed. They possess a structure peculiarly 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, but are perpetually forming new combinations. Most minerals will continue for ages unaltered, when preserved from the action of external chymical agents; but an animal or a vegetable is at no two periods of its existence precisely the same. This varying composition is probably owing to the materials of which they are composed being capable of entering into new combinations when acted upon by external agents, as well as the perpetual internal motion and reaction of parts produced by their peculiar organization.

The organization of animal bodies, whether it be more or less complex, is owing to a system of cylindrical vessels generally ramifying into minute branches, and to a fluid which is perpetually circulating through these vessels. As all the solids are formed by deposition from the circulating fluids, and when rendered unfit for performing their peculiar functions, or from their becoming obnoxious to the body, are removed by this fluid, it is necessary that it should be capable of dissolving or suspending all the materials of which the solid parts are composed. One important property of water is its being the basis of all the fluids that are perpetually circulating through every tube of every organised and animated animal or vegetable body.

Water constitutes the greatest part of the blood. The insensible perspiration is almost wholly pure water, containing very minute proportions of common salt and animal matter, the latter in so small a proportion as only to be detected by the smell. Perspiration is a great natural distillatory process. Its obvious use seems to be to remove a superabundance of water from the system, and, by carrying this off in the form of steam, it constitutes the great cooling process by evaporation, and thus keeps in check the production of heat. In the copious secretion of urine 1000 parts contain 930 of water; 1000 parts of milk contain 928.

Not only does water appear the most abundant ingredient in the animal and vegetable fluids, but, when the solids of both these substances are disorganised, the residue is principally water, showing that either water or its elements, in the combining proportions of water, are their principal constituents. The experiments of vegetable physiologists tend to prove that the far greater part of the nutrition of vegetables is derived from the water which they absorb through the pores of the roots, and that, by submitting these substances to the process of destructive distillation, they are again resolved for the most part into water.

A distinguishing mark of organic matter appears to be that in it a vast proportion of water is capable of being so intimately blended with some of its principles as to lose its fluidity, and of giving a peculiar elasticity, flexibility, and cohesion, which are peculiarly 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 reaction of parts, and internal movements, are perpetually going on, without destroying that juxtaposition which is necessary to organic texture. A mineral or saline body, or any substance which is not the immediate constituent part of any animal or vegetable body, is scarcely ever susceptible of any intermediate state between the solid and the fluid, produced by a union with a liquid menstruum; but an animal or vegetable substance, such as the glutinous part of wheat flour, though dry and pulverulent, no sooner comes into contact with water, than it absorbs a part, becomes highly ductile, tenacious, and elastic, and will not unite with an additional quantity of the same fluid. Gelatine is an instance, where a small portion of an animal substance will deprive a large proportion of water of its fluidity.

If we consider water as the primary solvent of all the nutriment which the animal body receives from without, as the basis of all the secretions or excretions which perform peculiar functions either in animal or vegetable substances, as a large constituent part of the solids of every denomination—if we survey its agency as diffused through every circulating tube of a living body, or condensed into firm but slender fibres and solids—we shall not hesitate to allow it a high place among those important but simple materials out of which the curious and interesting structure of every animated being is formed.

It is one of that small catalogue of elements (a brief alphabet for so comprehensive a history) out of which a bounteous omnipotence has created the beauteous fabric of the living world, which, turn where we may, gives fresh cause of admiration, gratitude, and delight.

CHAPTER II.

Of the foreign contents of water.

An investigation into the nature of the various waters which presented themselves to the notice of the chymist, particularly those which were the objects of medicinal value, in order to distinguish the peculiarity in their composition to which they owed their several properties, was one of the earliest objects of chymical research. It was not, however, until lately that chymists were able to arrive at any degree of accuracy in their manipulations. The chymical analysis of waters is a complicated subject, and one that is justly considered to exercise, in a considerable degree, the industry, intelligence, and skill of the operator. The principal difficulty occurring in the manipulation of the early chymists was the great volatility of the most active contents of many of the most curious and celebrated waters, which escaped in the form of gas during the evaporation necessary to exhibit in a solid form the saline and earthy matters that were held in solution. Improvements in apparatus have, however, now enabled chymists to procure them in a separate state, to confine them in proper vessels, and to subject them to examination by means of proper re-agents.

Although it is my intention to give an account of all the foreign contents of waters, I deem it in the present work unnecessary to detail the basis of their chymical distinctions. The high degree of accuracy which the chymist requires, a necessarily familiar acquaintance with the operation of a great variety of chymical re-agents, and the different habitudes of a vast number of saline substances, which are either produced in the process of analysis or from the heterogeneous foreign contents of the waters, are obstacles which cannot be overcome but by an accomplished chymist, and which, therefore, renders it unnecessary for me to enter into any observations on this highly interesting branch of chymical science.

Water is found in nature in every degree of purity except the highest. Such is never procured except by artificial distillation, as all natural waters are constantly coming into contact with some substance which they either dissolve or hold in suspension, or are perpetually producing some modification upon matter, arising from the great range of the affinity of water, and its peculiar action as a chymical agent.

The foreign contents of waters are the following:—

1. Gases.

1. Atmospheric air.
2. Oxygen.
3. Nitrogen.
4. Carbonic acid.
5. Sulphuretted hydrogen.
6. Carburetted hydrogen.
7. Phosphuretted hydrogen.

2. Free Acids.

8. Sulphurous acid.
9. Boracic acid.

3. Free Alkalis and Earths.

10. Soda.
11. Lime.
12. Silex.
13. Alumina.

4. Neutral Salts.

14. Carbonate of potash.
15. Carbonate of soda.
16. Carbonate of ammonia.
17. Carbonate of iron.
18. Carbonate of lime.
19. Carbonate of magnesia.
20. Muriate of potash.
21. Muriate of soda.
22. Muriate of alumina.
23. Muriate of barytes.
24. Muriate of manganese.
25. Muriate of ammonia.
26. Muriate of magnesia.
27. Muriate of lime.
28. Sulphate of soda.
29. Sulphate of ammonia.
30. Sulphate of lime.
31. Sulphate of magnesia.
32. Sulphate of iron.
33. Sulphate of copper.
34. Hydrosulphuret of lime.
35. Hydrosulphuret of soda.
36. Nitrate of potash.
37. Nitrate of lime.
38. Nitrate of magnesia.
39. Borax.
40. Alum.
41. Iodide of potassium.
42. Bromine—probably in combination with potassium.
43. Arsenic?

5. Decomposed Animal and Vegetable Matter.

i. *Atmospheric air.*

Water at a moderate temperature very readily dissolves a small portion of atmospheric air, which it parts with under the exhausted receiver of an air pump, or at the freezing or the boiling point. All natural waters contain more or less of atmospheric air, but seldom more than one-twenty-eighth of their bulk. It is by means of the air which water contains that fishes carry on their respiration; for these animals soon die from suffocation in water that has been freshly boiled or distilled, or that is impregnated with an irrespirable gas. It is likewise to the air which water contains that it owes its sensible taste, as when this is expelled, by boiling, its taste is flat and insipid.

Water that has been deprived of its air soon regains it by simple exposure to the atmosphere. The only natural water which contains no air is probably snow or ice just melting; but, immediately on becoming fluid, it is of the temperature capable of absorbing the largest quantity of air. The snow torrents which fall from the hills in majestic cascades, constantly agitated into foam, and gradually depositing their earthy sediments, form a clear sparkling water of great salubrity and excellence. Such waters may be considered saturated with atmospheric air.

ii. *Oxygen gas.*

Oxygen gas in excess over the due proportion for atmospheric air is generally met with in all waters.

iii. *Nitrogen gas.*

Recently boiled water is found to absorb nitrogen gas.

Nitrogen gas is, however, a substance over which water possesses very little solvent power, and it is always met with in small proportions. Its affinity for water is less than that of any other gaseous body, and it is readily expelled on the first impressions of the heat used in collecting aëriform substances from mineral waters. In some springs containing this gas, a large quantity of it comes up along with the water, rises through it unmixed, and may readily be collected by an inverted vessel held over the fountain head.

iv. *Carbonic acid gas.*

All natural waters that spring from under the earth contain at least one-hundredth of their bulk of this gas, and every proportion of it is occasionally found from this quantity to an equal bulk of the water, and even more, the water becoming thereby very bright and sparkling to the eye. This is one of those gaseous bodies which impart to a variety of springs their medicinal efficacy, and the discovery of its chymical properties cleared up many difficulties which stood in the way of former chymists. Water at a moderate temperature will readily take up its own volume of carbonic acid gas, and becomes thereby bright and sparkling, acidulous and gently pungent to the taste, and sends off numerous bubbles, when moderately heated or shaken. Water thus acidulated is capable of dissolving several earths, especially lime and magnesia, and a few metals, of which iron is the only one, however, that is met with in mineral springs. The carbonic acid may be separated in form of a gas by boiling, when the earths or iron which it had dissolved are precipitated in a pulverulent form—the former as a white powder, the latter as a light brown ochre. By this means the largest portion of the saline contents of a spring or river water may be separated.

Water strongly impregnated with carbonic acid sometimes exerts a kind of intoxicating power when largely drunk, and proves fatal to fishes.

The process of the discovery of this gaseous acid and its remarkable properties was very gradual. The brisk lively taste and sparkling appearance of the strongly acidulated waters, such as the Spa or Pyrmont, were early noticed, as well as the readiness with which the gas escaped, and the consequent loss of sensible qualities. Of this property were several wells in London, supposed to be impregnated with the *spiritus mundi*, and sold by the monks as a kind of spiritual nectar, the most celebrated of which was the Holy-well near Shoreditch.

As several substances, especially oxide of iron, were found to be precipitated along with the expulsion of the gas, it was rightly inferred that it was this substance which held them in solution ; and this circumstance, added to the sensible acidity of these natural waters, gave rise to the opinion that the gas was a species of vitriolic acid, or a *volatile imperfect vitriol*, which term is often to be found in the numerous writers that made their experiments before the true nature of the carbonic acid gas was effected. The compounds of this acid, with the several alkaline, earthy, or metallic bases, form the class of carbonates, several of which will come under our notice as substances of particular interest to the chymist, especially in the composition of waters.

v. *Sulphuretted hydrogen gas.*

Hydrogen gas is by itself scarcely soluble in water, and is never procured alone from any mineral water.

Sulphuretted hydrogen gas, which consists of sulphur held in solution by hydrogen gas, is one of very considerable importance, imparts the medicinal value to many celebrated springs, and is found very plentifully in all those natural waters which emit that peculiar and offensive odour somewhat similar to rotten eggs, or the scourings of a foul gun-barrel. It is contained sparingly in many standing wells that are not much frequented, and where the characteristic smell is only to be recognized by agitating the water, as by dipping the bucket into it. This air is produced naturally by the spontaneous decomposition of pyrites, or sulphuret of iron.

Water at a medium temperature will absorb from two-thirds to three-fourths of its bulk of this gas, and, by long continued agitation, may be made to take up twice its bulk. Water thus impregnated has a very strong and offensive smell, a taste somewhat sweetish, and generally appears rather turbid.

The cohesion of the sulphur to the hydrogen is very weak; water impregnated with this gas soon becomes turbid, loses its smell on exposure to the air, or partly even 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 the lining of the 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.

vi. *Carburetted hydrogen gas.*

Carburetted hydrogen gas is recognized in most stagnant waters. Its origin is probably in the decomposition of some vegetable substances. It may readily be collected by stirring the bottom of the pond with a stick, and inverting over it a jar.

vii. *Phosphuretted hydrogen gas.*

Phosphuretted hydrogen gas exists in many stagnant waters, producing the phenomenon called Will o' the Whisp. Its origin is probably in the decomposition of animal substances. The peculiar odour of fishes, when putrefying, arises from the emission of this gas.

viii. *Sulphurous acid.*

Sulphurous acid exists uncombined in many native springs in the neighbourhood of volcanoes; it is found plentifully in Italy and the island of Ceylon. This substance combines in every proportion with water, and is found in many degrees of dilution. Dr. Vandellai, in a book entitled De Thermis Agri Pataviai, published in

1761, mentions a cave near to the town of Latera, about thirty miles from Viterbo, in Italy, where a clear acid water drops from the crevices of the rocks, and is collected by the country people in glazed earthen vessels. Such has a mild agreeable taste, and is diluted sulphurous acid. This cavern is so filled with noxious vapours that it cannot be entered without danger of suffocation, except in winter, or when it blows a north wind. A similar native water exists near the town of Salvena. Mention is also made of a spring in the province of Nota, in Sicily, the water of which is so sour that the neighbouring people use it instead of vinegar. In the waters in the neighbourhood of some coal pits sulphurous acid is detected.

ix. *Boracic acid.*

Boracic acid has been found uncombined in many springs in Italy.

x. *Soda.*

Soda has been found uncombined in many of the natural waters in the neighbourhood of volcanoes, particularly those of Iceland. It is also found uncombined in the boiling springs which are natural to that country. This alkali in combination with one of the acids exists in almost every species of natural water.

xi. *Lime.*

The presence of lime uncombined in any natural waters is perhaps conjectural, but it is of all the earths that which is most generally contained in natural waters of almost any description, as there are few springs which, during some part of their subterranean course, have not an opportunity of coming into contact with calcareous earth, and there is none which appears so readily soluble in a variety of menstrua. There are three salts of lime chiefly found in mineral waters, the carbonate, sulphate, and muriate of that earth.

xii. *Silex.*

When very minutely divided, this earth is readily suspended in small portions by running waters, and is gradually deposited on their remaining at rest. Very little, however, is taken up in this way; for the purest of all springs are those which take their rise in siliceous earths, where they are exposed to constant agitation, a circumstance very favourable to the abrasion of any earth. Silex is, however, found apparently in a state of true solution in some hot and tepid springs, particularly 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 silex, which it deposits in a semi-crystalline form when it comes in contact with the external atmosphere. The chalcedony which encrusts the margin of the boiling spring near Hecla, in Iceland, appears to be a natural deposition from this species of water. In these waters the silex is always accompanied with a small excess of soda, which two substances are capable of forming a chymical compound, soluble in water, but it must be observed that the water is not hot enough to be equal by itself to the solution of the earth. Silex has also been found in other waters, though in less quantity, but its solution in water is a natural process, which no art can imitate with success.

iii. *Alumina.*

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

xiv. *Carbonate of Potash.*

Potash, formerly called the vegetable alkali, exists very largely in most natural productions, but is rarely met with in any natural waters. The great source of the supply of potash for the purposes of commerce is the incineration of vegetable substances, in all of which it exists, but in some to a much larger proportion than in others. The carbonate of potash is the salt of this alkali first obtained, and from which all its combinations for the purposes of the arts are derived.

This substance is of great interest to the experimental chymist, from its being a compound of potassium and oxygen, the former being a metal which possesses so powerful an attraction for oxygen as to abstract it from all other bodies, a phenomenon which is attended with flame, when it is brought into contact with water, the metal burning with a very vivid light and floating on its surface.

According to Margraff, carbonate of pot ash exists in the water of Berlin.

xv. *Carbonate of soda.*

Carbonate of soda is found in many natural waters, sometimes very partially, at others in vast quantities. The most remarkable waters which contain this salt are those of certain lakes, especially the natron lakes in Upper Egypt, Abyssinia, and other parts of Africa. It is here generally found in connexion with common salt, both being largely dissolved in the water, and forming a crust of several feet in thickness on the edges of the lake, owing to the copious evaporation of the water which had dissolved them being effected by the heat of a tropical sun. Besides these great reservoirs of this salt, there are some springs in different countries which contain it in small quantities, but enough to give sensible and useful medicinal properties to the water. The waters of Seltzer are of this kind.

XVI. *Carbonate of ammonia.*

Carbonate of ammonia is met with in a few springs, although very rarely. In those cases where it is present it is suspected to originate from the decomposition of animal matter,—a probable supposition, as all the ammoniacal salts procured artificially have their origin from the animal kingdom. Carbonate of ammonia is seldom contained in any water so largely as to be immediately perceptible to the senses, or indeed to any chymical test. It probably exists in all distilled water, from the decomposition of the animal substances which the water contains; and hence, even with this delicate re-agent, the greatest care is necessary in the nicer chemical manipulations. Carbonate of ammonia dissolved in water is very readily volatilized by a moderate heat, and by concentrating the water in which it is contained. It arises along with the first aqueous vapour, and is entirely condensed in the first portion that is distilled.

Hence one reason why, in the process of distillation, for nicer purposes, the first portion is rejected.

xvii. *Carbonate of iron.*

As iron is a metal very 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 below the surface, and accordingly it is found very abundant in mineral waters, and may be 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 or styptic taste, which is very perceptible even where the proportion of iron is so small as hardly to be estimated by any chymical process. The salts of this metal, which are met with in mineral waters, are the carbonate and sulphate;

and sometimes the same water holds both these salts in solution.

Water well saturated with carbonic acid will dissolve about 1-10,000th part of its weight of iron; but for this effect it is necessary that the iron should be a protoxide.

Iron is rarely met with under this form, compared with the frequency with which it occurs in a higher state of oxidation; otherwise, were this as soluble as the former, almost every natural water would be a chalybeate. As it is this oxide of iron which gives to clay its colour, some idea may be formed of the extent to which it exists on the surface of the earth. The chalybeates which contain carbonate of iron 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 an ochre or carbonate of iron, which partly precipitates to the bottom of the vessel in which the water is confined, and partly swims on the surface in the form of a fine irridescent pellicle. The water is by this means entirely freed from the iron, and no trace of this metal can be detected by the most delicate tests. This separation likewise occurs if the fresh water be kept in a bottle half full or carelessly corked. The walls of every chalybeate well, the channels through which the water flows, and the stones over which it runs, are also lined with the oxide, forming a very good indication of the nature of the spring.

xviii. *Carbonate of lime.*

The circumstances of the solution of lime in carbonic acid deserve some attention. Lime uncombined is readily and completely soluble in about 700 times its weight of water, at the temperature of 60°, forming common lime water. The same earth, when fully saturated with carbonic acid, is also equally soluble in water; but, when only partially saturated, it remains entirely insoluble, and in this state it forms the solid carbonate of lime or chalk. This is the state to which lime spontaneously tends when exposed to the air in either solution, in the one by absorbing carbonic acid from the atmosphere, in the other by giving off into the surrounding air its excess of carbonic acid; in either case the lime precipitates as carbonate of lime or chalk.

The same happens when carbonic acid is added in any way to lime water, or when lime water is added to a solution of lime in carbonic acid. Water containing any quantity of carbonic acid will dissolve as much chalk as is equal to the weight of the acid if the latter be in considerable proportion to the water; but will dissolve about twice as much if the water be but weakly impregnated with carbonic acid.

This is one source of hardness in waters, but is readily got rid of by boiling, which drives off the excess of carbonic acid, and thus causes the chalk to be precipitated; hence arises the earthy crust or furr on kettles in which hard water has been boiled for a number of times. Some natural waters contain an unusual quantity of this calcareous earth, which is rapidly deposited as soon as they become exposed to the air, and thereby give an earthy lining to every tube through which they flow, and encrust with the same material every substance that accident or design may put in their way.

Of this kind are the various petrifying springs that form part of the natural curiosities of several mountainous districts, and have been applied to use in a very ingenious manner at the baths of St. Philip in Tuscany, and still more extensively at Gualecavelica in Peru.

xix. *Carbonate of magnesia.*

Magnesia is an earth that is found almost as widely diffused in the mineral waters of different countries as lime, but not generally in such quantities. It exists usually in the same combinations.

Water saturated with carbonic acid is capable of dissolving 1-300th of its weight of the pulverulent carbonate of 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. Magnesia is not so readily separable from water by boiling as lime, but continues to be deposited in small quantities during the whole process of evaporation. It is always accompanied with carbonate of lime in all natural waters; and the first ebullition of such water for a few minutes precipitates all the lime and the greater part of the magnesia.

xx. *Muriate of potash.*

The presence of this salt in waters is very rare. Berzelius states that he has found it in some of the waters in Sweden. Dr. Woollaston has also detected it in sea water. It is a salt possessing no peculiar chymical or medical qualities.

xxi. *Muriate of soda.*

This salt, the common culinary salt, of all others the best known and most extensively employed, is also that which is most largely diffused throughout the surface of the globe, and receives the generic name of this peculiar class of compound substances. Besides the immense storehouse for this salt in the waters of the ocean, it is found in a more concentrated solution in various springs and lakes, called brine springs, and in vast solid masses on the shores of different lakes, or many fathoms beneath the surface of the earth in beds that are worked as mines. In sea water common salt is a substance of great importance; in common springs, however, or those which are used medicinally, it is not found in such large proportions, and is there of inferior consequence. Common salt crystallises in cubes by mere evaporation of the water in which it is contained. Where not mixed with any earthy salt, it undergoes no change by exposure to the atmosphere; but it is often mixed with muriate of magnesia in natural solutions; and, muriate of magnesia being a highly deliquescent salt, the former then appears to possess this quality. It is never found alone, however, in any natural solution, but generally with sulphate of lime.

xxii. *Muriate of alumina.*

This salt is of very inferior consequence. Its presence has been detected in some natural waters.

xxiii. *Muriate of barytes.*

This salt has been detected in some waters in Italy. Its presence in mineral waters was discovered by Bergman.

xxiv. *Muriate of manganese.*

This salt has been found present in some waters in Italy and Sweden. It has lately been detected by Dr. Lambe in the waters of Leamington Priory.

xxv. *Muriate of ammonia.*

This salt was first detected by the Hon. Mr. Cavendish, in the waters at Rathbone Place, near Oxford Street, London. It is not unfrequently present in mineral waters. It is found in Italy and Siberia.

xxvi. *Muriate of magnesia.*

This is a salt formerly of much importance to the manufacturing chymist, as being the principal source he had for obtaining Epsom salts and magnesia, substances so extensively used for medical purposes. It is very difficultly crystallisable, soluble in water and alcohol, deliquescent, of a very nauseous, bitter, and saline taste, is found in various brine springs, and forms a considerable part of the saline contents of sea water. It is this salt which gives the bitterness to sea water; and, as it does not easily crystallise, it remains in the *mother liquid*, as it is called, or the liquid residuum, after the common salt has been separated in a solid form, during those processes in which sea water is boiled down to obtain the salt. In some parts of this 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 proportionally concentrated. This brine is afterwards evaporated and clarified, till it yields common salt in a degree of purity. The muriate of magnesia that remained was formerly decomposed by sulphate of iron, when sulphate of magnesia and muriate of iron were obtained. From this solution the Epsom salt was obtained in a crystallised state, separate from the iron and other impurities of the residuum of the brine, but the process is now superseded by the manufacture of Epsom salts and magnesia from the magnesian limestone.

xxvii. *Muriate of lime.*

This salt is found in a great variety of springs, particularly in the brine springs, where it is a very troublesome ingredient. It is bitter to the taste, very soluble both in water and alcohol, and highly deliquescent. It is almost always accompanied with common salt, from which it is difficultly separable in the manufacture of this article.

The great bitterness of some celebrated waters, such as those of the Dead Sea, is owing to the muriates of lime and of magnesia, and not to bitumen, as was erroneously supposed.

xxviii. *Sulphate of soda.*

Sulphate of soda is found very frequently in various lakes and springs, often associated with a great number of other saline substances, and in such quantity as to give a very considerable purgative effect. Sulphate of soda is very soluble in water, and contains half its weight of water of crystallisation, the greater part of which flies off on exposure to dry air, leaving the salt in a white pulverulent state, and proportionably stronger. To the taste it is bitter and salt, and cooling to the tongue. It crystallises with great ease by evaporation and subsequent cooling, and is a salt which is for the greater part readily separable from water. As it is often found in conjunction with sulphate of magnesia, and crystallises at the same time, these two salts require some care to separate them.

xxix. *Sulphate of ammonia.*

This salt is of very unfrequent occurrence, nor does it possess any peculiar medicinal or chymical characters.

xxx. *Sulphate of lime.*

This salt, called also gypsum and selenite, is one of the commonest of all the earthy salts that are met with in mineral springs, and generally accompanies every saline substance in natural waters, except where there is an excess of alkali. It is almost invariably found present with carbonate of lime, and hence calcareous depositions and petrifactions frequently contain a small admixture of this substance.

Sulphate of lime is a salt very sparingly soluble in water, requiring 500 times its weight of that fluid for solution, and gives it very little taste, but imparts that rough and harsh feel to the fingers and tongue which characterize insipid hard waters. This quality is very inconvenient for domestic purposes, the sulphate of lime decomposing or curdling soap from 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. Natural solutions of sulphate of lime are generally clear and well tasted. When such a water is evaporated, the earthy salt gradually falls to the bottom in the form of grey scales, in proportion as the water which held it in solution is dissipated; but mere boiling will not produce this precipitate, as it does with carbonate of lime; thus hard waters, which are employed for most culinary purposes, for making tea or brewing malt liquors, remain equally hard after the process as before.

xxxi. *Sulphate of magnesia.*

This salt, known also in commerce by the name of Epsom salts, is one of the most important, whether we consider it in solution in mineral waters, or as a substance largely used in medicine. It was first discovered native in a well at Epsom, whence it derives its common name; and it has been found in a great variety of saline springs, almost always combined with Glauber's salt and sulphate of lime, often with a chalybeate, and frequently in such quantities as to render the water that contains it purgative in a very moderate dose. It is to this salt, often combined with sulphate of soda, that all the natural purging waters owe their property. Sulphate 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, was formerly prepared from the refuse salt of sea water, but is now obtained from the magnesian lime stone.

xxxii. *Sulphate of iron.*

Sulphate of iron, known also under the name of green vitriol, is not very unfrequent in mineral waters, though much less common than carbonate of iron. This salt is the natural product of the spontaneous decomposition of sulphuret of iron (or martial pyrites), and is procured very largely from this ore for the purposes of manufacture. Sulphate of iron when crystallised has a fine emerald-green color, a strong chalybeate astringent taste, effloresces in the air, and is easily soluble in water. One circumstance regarding this salt requires notice, as it explains the nature of this species of chalybeates: iron, when in solution with different acids, combines with oxygen in two degrees; when in the state of the first oxide it has a great tendency to attract oxygen from every surrounding body that will yield it, and thus to reach the highest state. Pure sulphate of iron contains the metal only in the state of the first oxide; but when it is dissolved in water that contains common air, or has access to the atmosphere, an additional quantity of oxygen is absorbed by the oxide; it thereby becomes insoluble, and precipitates in the form of a brown ochre. Hence it is that these chalybeates deposit an ochry sediment as well as those with carbonate of iron, but from a different cause: in the present from a mere absorption of oxygen, in the other from a loss of carbonic acid. Very little iron is contained even in the strongest chalybeate waters, and yet there is no proportion, however small, which is not perceptible to the taste, even when there is not sufficient to be indicated by any of the usual re-agents.

xxxiii. *Sulphate of copper.*

Although the sulphate of copper, also known by the name of blue vitriol, does not come under view as an ingredient in mineral springs, being never used medicinally in this state, it is of some importance as well as curiosity, and requires detection to be avoided. Several natural waters contain sulphate of copper in solution to a considerable extent, formed probably like sulphate of iron by the decomposition of copper pyrites, found in the neighbourhood of copper mines, and constituting a valuable proportion of their riches.

xxxiv. *Hydrosulphuret of lime.*

All sulphuretted waters, it has been observed by Descrumb, contain some of this substance in solution, but it is a salt of no peculiar medicinal or chemical character.

xxxv. *Hydrosulphuret of soda.*

This salt is found under the same circumstances as the preceding.

xxxvi. *Nitrate of potash.*

Nitre, a salt of much importance in the arts, has been found in natural solution in some springs in Hungary, but its presence is very uncommon.

xxxvii. *Nitrate of lime.*

Nitrate of lime was first detected in water by Dr. Home of Edinburgh in 1756.

It is said to occur in some springs in the sandy deserts of Arabia.

xxxviii. *Nitrate of magnesia.*

Nitrate of magnesia is said to have been found in some springs.

xxxix. *Borax.*

Borax exists native in some springs in Persia and Thibet, but the nature of these waters has never been thoroughly examined.

xl. *Alum.*

This salt, the sulphate of alumine and potash, is soluble in its own weight of boiling water, but requires a much larger proportion of cold water. It readily forms crystals, which are permanent in the air, and has a very acid and astringent taste. Alum possesses naturally an excess of acid, which is necessary to the constitution of the salt; and therefore it shows with different reagents the same appearances as an uncombined acid. Alum is but rarely contained in mineral waters, and is generally found associated with sulphate of iron. It is produced by the spontaneous decomposition of the aluminous pyrites, being a natural union of sulphur and aluminous earth; and, as this earthy mixture is generally combined with sulphuret of pyrites, any spring of water that flows in the neighbourhood will hence contain both alum and sulphate of iron.

xli. *Iodide of potassium.*

The discovery of iodine in sea water, by M. Courtois, in 1812, will always be regarded as a great era in philosophical chymistry. This gentleman, a manufacturer of saltpetre, in his processes for obtaining soda from the ashes of sea weeds, found his vessels much corroded, and, in searching into the cause of the corrosion, he made the important discovery of this new substance. But for this nearly accidental discovery, one of the most curious substances would probably have remained unknown, since nature has not stored it up in her various kingdoms, but left it extremely sparingly in sea waters, but more largely in what the Roman satirist calls the *vile sea weed.*

Iodine, in combination with potassium, is not only found very sparingly soluble in sea waters, but also in some mineral waters. Such are those of Sales in Piedmont, and in the sulphureous waters of Castelnuovo d'Asti. It has also been detected in certain mineral waters in the Andes.

xlii. *Bromine—probably in combination with potassium.*

This substance is even of later discovery than the last. It is obtained from the mother-water of salt works, and exists in all sea water, although in so small a quantity as only to be detected by the nicest chymical examination. Its probable combination is with potash.

xliii. *Arsenic?*

Arsenic was supposed by the earlier medical writers to be a usual ingredient in many waters. This substance is very sparingly soluble in water, and its presence in natural waters is perhaps rather conjectural than real. Dr. Lambe has lately revived the idea of arsenic being present in all natural waters, and particularly in the water of the Thames.

5. Decomposed Animal and Vegetable Matter.

Animal and vegetable matters, especially undergoing decomposition, are not unfrequently met with in waters, but merely suspended in this fluid. In this latter class bitumen deserves a notice, because several substances were formerly mistaken for bitumen in various mineral waters, where modern investigation has otherwise accounted for the sensible properties which were ascribed to it. The bitumens of some chymists 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 sulphuretted hydrogen gas, as has been already mentioned. The bitumen of other chymists was that which gives the bitter nauseous taste to sea water and many brine springs, which is in fact owing to the muriate of lime and magnesia. Of this kind are those in Arabia, described by travellers, and in particular the celebrated waters of Marah. 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 carburetted hydrogen 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 substances do not apparently mix, the former being found floating on the latter. Bitumen is probably never soluble in water.

Various remarkable accounts of particular waters are on record, which, although they must be deemed fabulous, we shall just enumerate. The Stygian water, said to be the death of Alexander the Great, is supposed to have contained fluoric acid gas. A spring of this kind is said to have been discovered in Prussia, and closed by order of the government. A river is named at Epirus that puts out any lighted torch, and kindles any torch that was never lighted. Some waters, being drunk, cause madness, some drunkenness, and some death. The river Selarus was said in a few hours to turn a root or wand into stone. There is also a river in Arabia where all the sheep that drink thereof have their hair turned to a vermilion color; and one, of no less credit than Aristotle, names a merry river, the river Elusina, that dances at the sound of music; "for with music it bubbles, dances, and grows sandy, and so continues till the music ceases; but then it presently returns to its wonted clearness and calmness." Josephus likewise names a river in Judea that runs swiftly all the six days of the week, and stands still and rests all the Sabbath.

CHAPTER III.

Of the particular waters.

There is a great variety of waters employed in the arts and manufactures, and for domestic purposes. Where the object is to obtain a pure or simple water, all the foreign matter which water contains may be considered detrimental, or at the best but useless. Where, however, the object is to obtain a medicinal water, it is valuable on account of the species and quantity of the salts which it contains. The various earths, metals, alkalies, and acids, along with their several combinations, as found in natural solution in water, have been enumerated, and may be considered as the proper foreign contents of the waters which derive the name of mineral from the nature of their contents, and that of medicinal from their medical uses and qualities. All waters which flow from beneath the surface of the earth are in some degree impregnated. When they flow within a channel over the surface of the ground, they often become much changed in their chymical composition, losing some of their contents by evaporation, others by slow deposition, or by being decomposed through the influence of the light or air. At the same time water often acquires new contents, furnished by the soil over which it flows. 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, of animal and vegetable matters, and carbonaceous matters, and besides are contaminated with an infinite number of living animals, which are perpetually growing, multiplying, and perishing, in the element which gives them birth, habitation, and subsistence.

A distinct notice of each of these waters is necessary, on account of the abundant daily use which we make of them. The various substances which they contain are here mere impurities, some of which are innocent, others prejudicial. Some may be got rid of by simple methods, but others can only be removed by chymical 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 procured by distillation, as every natural water contains some foreign ingredients, and the excellence of these waters being directly in proportion as they approach in properties to that which having been distilled is separated from all foreign contents.

i. *Distilled water.*

This is the lightest of all waters, containing neither solid nor gaseous substances in solution. It is perfectly void of taste and smell; is colorless and transparent; has a soft feel, and wets the fingers more readily than any other. It mixes uniformly with soap into a smooth oxaline mixture, and may be added to a solution of soap in spirits of wine without injuring its transparency.

The clearness of distilled water is not impaired by the most delicate chymical re-agents, such as lime water, barytic solutions, nitrate of silver, or acetate of lead. When evaporated in a silver or platina vessel, it leaves no residuum. If preserved from access of foreign matter floating in the air, it may be kept for ages unaltered in vessels upon which it has no action, as it does not possess within itself the powers of decomposition. As distilled water freezes at 32° of Fahrenheit, and boils at 212° under the barometrical pressure of 29′ 8″, these points are made use of as the standards 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 be procured only from water which contains no volatile matters that will risê in distillation and continue still in union with the vapour when condensed.

Many substances are volatile during distillation, but most of the gases, as common air and carbonic acid, are incapable of uniting with water at a high temperature; when, therefore, they are separated by boiling, they do not combine with the vapour. Other bodies, such as vegetable essential oil, and in general that which gives to animal and vegetable matter its peculiar odour, will remain in water after distillation. The steam of many animal and vegetable decoctions has a certain flavour which distinguishes it from pure water, and the aqueous exhalation of living bodies, a kind of distillation has a similar impregnation. Ammonia may also be formed, during the process of boiling, from the decomposition of the animalculæ, or other animal matters which water contains, and rise over with the water—a circumstance which, although it does not affect the œconomical or medical uses of water, and though to so trifling an extent, is yet found to impair the delicacy of some of the nicest manipulations of philosophical chymistry.

In order to obtain distilled water perfectly pure, much stress was laid by former chymists on repeating the process a great number of times, but it was found by Lavoisier that water, once distilled, rejecting the first and last portions, was as pure as could be procured by any subsequent distillations.

Distilled water possesses a higher power than any other as a solvent of all saline bodies, and 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 chymical analysis which presents the proximate constituent parts of these bodies, and which is effected particularly by the assistance of pure water, not only to present their substances to the action of chymical reagents, but also of substances in the manufactures. A saline, earthy, or otherwise impure water, will impair the texture of some of their parts, alter their solidity, produce material changes on the colouring matter, and be of less value as an agent in experimental chymistry, or in the manufactures, on account of the admixture of foreign contents.

Distilled water is seldom employed to any extent in the preparation of food, or in the manufactures, on account of the trouble of preparing it in large quantities; but for preparing a great number of medicines, and in almost every one of the nicer chymical operations, in which the substances are required in solution, this water is an essential requisite.

The principal cases in which distilled water has been used as an article of drink have been in those important trials of the practicability of procuring it by condensing the steam of sea water, by means of a simple apparatus fitted to a ship's boiler. These have fully shown the ease with which a large quantity of fresh water may be procured at sea, and of the purest kind, at a moderate expense; whereby one of the most distressing of all wants may be relieved. Distilled water has been recommended by some medical writers, particularly Drs. Heberden and Lambe, as an excellent drink, especially in many chronic diseases.

ii. *Rain water.*

The next in purity to distilled water is that which, having undergone a natural distillation from the earth, is condensed again 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 chymical experiments. The foreign contents of rain water appear to vary considerably, according to the state of the air through which it falls; and this is not surprising, when we consider its solvent power over those substances which it meets in the great laboratory of nature, in which chymical processes of combination, sublimation, and distillation, are perpetually going on, and which may also be considered to contain a vague and confused mixture of mineral vapours, of minute particles of bodies, animal and vegetable, and of seminal grains and eggs. The heterogeneous atmosphere of a smoky town will also give some impregnation to rain as it passes through, and these, although they may not at once be perceptible on chymical examination, will yet render it liable to spontaneous change. At different seasons and places rain water differs much in its purity. Dr. Short, in his Chronological History of the Weather and Seasons, gives many instances of rain of a bloody colour. Rain water, even the purest, if long kept, especially in hot climates, acquires a strong smell, becomes full of animalculæ, and in some degree putrid. Margraff long since discovered that the nitric and muriatic acids were almost constantly present in rain water, the latter substance has often been detected even in rain water obtained in an open country by the present author. As rain water is always very soft, it is admirably adapted for dissolving soap, or for the solution of alimentary or coloring matter, and it is accordingly used largely for these purposes. The specific gravity of rain water is so nearly that of distilled water, that it requires a very delicate instrument to ascertain the difference. Rain collected in towns acquires a small quantity of sulphate of lime, and carbonate of lime, obtained from the roof and plaster of the houses. Hippocrates states that rain water should always be boiled and strained when collected near large towns, a fact now well known to chymists.

iii. *Ice and snow water.*

This equals rain water in point of purity, and when fresh melted contains no gas or air, nor saline substances, such having been expelled or precipitated during freezing. In cold climates, and at high latitudes, thawed snow forms the constant drink of the inhabitants during winter, and the vast masses of ice which float on the Polar Seas afford, by melting, an abundant supply of fresh water to the mariner. It is well known that in weak brine, exposed to a moderate freezing cold, it is only the water that congeals, leaving the unfrozen liquor proportionably stronger of the salt. The same happens with a dilute solution of vegetable acids with fermented liquors, and the like, and advantage may be taken of this to reduce the alcoholic or acid parts of liquors to a more concentrated form, and thus procuring acids or alcohol of a greater strength at a moderate degree of trouble.

Snow water has long laid under the imputation of occasioning those strumous and glandular swellings in the neck which deform the inhabitants of the Alpine valleys, but this opinion is not supported by indisputable facts, and is rendered improbable, if not entirely overturned, by the frequency of the disease in Sumatra, where there is no snow, and by its being quite unknown in Chili and Thibet, though the rivers of these countries are chiefly supplied by the melting of the snow with which the mountains are covered. This prejudice is however a very ancient one. Hippocrates observes that snow or ice water is unwholesome, on account of its finer particles being evaporated and lost during solution. The futility of these imputations was satisfactorily shown in the experiments of Captain Cook.

iv. *Spring water.*

Under this comprehensive class is included every water that springs to the surface of the earth from some depth beneath the soil, and is used at the fountain head, or at least before it has run any considerable distance exposed to the action of the soil or air. The contents of spring water, it is obvious, will be as various as the substances that compose the soil through which it flows. When the ingredients are not such as to give any peculiar medical or chymical characters, 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 medicinal reputation from their mere purity, as those of Matlock in Derbyshire, and Holywell in Flintshire.

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 at all seasons of the year, 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 during winter or summer.

One of the principal inconveniences in almost every spring water is in its hardness, owing to the presence of earthy salts, which, in by far the greater number of cases, are only chalk or gypsum, 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 perfect 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 in spring water 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 in the household arts or manufactures. The water of deep wells is always much harder than that of springs which overflow their channels; for much agitation and exposure to the 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 kind of water, that of the sea excepted. Springs that overflow their channels, and form to themselves a limited bed, pass insensibly into the state of steam and river water, and become thereby altered in some of their chymical properties. Dr. Percival observes that bricks harden the softest water, and give it an aluminous impregnation. The common practice of lining wells with them ist herefore very improper, unless they be covered with cement.

v. *River water.*

River water 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 many cases an increase of temperature, it loses both common air and carbonic acid, and with the last much of the lime or magnesia which it formerly held in solution. The specific gravity hereby becomes less, the taste not so harsh, but less fresh and agreeable ; and out of a hard spring, by mere exposure to the atmosphere and the action of the soil, 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 clear siliceous rock,an d flow in a sandy or stony bed, are from the outset remarkably pure. Such are the mountain lakes and rivulets in the rocky district of Wales, the source of the beautiful and romantic waters of the Dee, the Usk, and the Clwyd, and numberless other rivulets that flow through the hollows of every valley in that delightful country. Switzerland has long been celebrated for the purity and excellence of its waters, which pour in copious streams over the mountains, and give rise to some of the finest rivers in Europe. Some of them never freeze in winter, the probable cause of which is, as the illustrious Haller, an excellent observer of nature, remarks, in picturing the rivers of this romantic country, " that they spring at once from a subterranean reservoir, so deep as to be out of the reach of frost, and during their short course, when exposed to day, they have not time to be cooled down from 53°, their original temperature, to below the freezing point."

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

The mention of the water of the Thames will naturally introduce an enquiry into the composition of a fluid which has so long interested a great portion of the public. A perusal of the several publications, would almost persuade even the least credulous that, wherever this staff of life is drank, death is ready to mark the thirsty victim for his prey; but, as on every other public occasion, objections have been here carried to a most ridiculous and absurd excess.

No attempt at an accurate analysis of the water of the Thames appears to have been made previous to the recent experiments of Dr. Lambe. This eminent physician, justly distinguished for his well known medical publications as well as chymical investigations, made a series of elaborate analyses upon the water of the Thames, the results of which he communicated to the public in the year 1828. It was the intention of the present author further to prosecute the subject, and he had already commenced the investigations, when he was disabled from continuing his professional duties by severe indisposition. From the analyses of Dr. Lambe it appears that the water of the Thames, taken from Teddington, Twickenham, and London, contain the same quantity of saline substances in solution (a fact verified by the present author), but a considerable superabundance of animal and vegetable exuviæ in that taken up in the Thames at London.

The principal saline contents of the Thames water are sulphate of lime, carbonate of lime, carbonate of magnesia, and muriate of soda, but in very small proportions, not exceeding three grains in the pint. The quantity of animal and vegetable exuviæ held in suspension, and derived from the common sewers and other channels of impurity which are perpetually emptying themselves into the river, render it indeed unfit for many of the nicer domestic purposes. All impurities may be removed by mere filtration, and water thus purified is rendered very palatable and wholesome, and fitted for the nicer processes in the arts. This great and public disadvantage is, however, being removed by the liberality of the water companies, and, on examination, a considerable contrast will be found in the improvement in the water supplied to the metropolis by the improved mode of filtration which they have introduced into practice.

It may, perhaps, be doubted whether the nature and quality of the supply of water to the metropolis were such as required a parliamentary commission, except as pointing out to the water companies, by the distinguished authorities constituting that commission, the extent of the evils and the mode of remedy. The water with which the inhabitants of Southwark are supplied contains much animal and vegetable exuviæ, and is undoubtedly very unfitted for the purposes of domestic economy, without undergoing the process of filtration. The water supplied by the New River Company is the best in the metropolis; its solid contents the author has found to resemble in quantity those of the Thames, but it contains much less animal and vegetable matter.

The water of the Thames is excellently fitted for a sea store, but here it is said to undergo a remarkable 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 into large vessels (oil jars are commonly used for this purpose), and exposing it to the air, it gradually deposits a quantity of black slimy mud, becomes clear as crystal, and remarkably sweet and palatable.

The river Trent runs over a strata of carbonate of lime, and contains much of this salt in solution: a circumstance which appears favorable to the perfection of ale, for which Burton is so justly celebrated.

The Seine has a high reputation in France, and appears to be a river of great purity.

Some doubts having been thrown on the salubrity of this water, the faculty of medicine in 1775 appointed a committee of chymists to examine it. By their report it appears that the Seine water is purer than any of the tributary streams which surround it, and is very pure. It does not contain more than five grains of solid matter in the pint.

It might be expected that as with the Thames any river which passes a large town and receives its impurities, and is used by the numerous dyers, tanners, hatters, and other manufacturers, who crowd to its banks for the convenience of the water, it should thereby acquire a foulness perceptible to chymical examination for a considerable distance below the town; but the most accurate examinations prove that, where the stream is at all considerable, these kinds of impurities have no influence in permanently altering the quality of the water, and, as they are only suspended, that mere rest will restore the water to its original purity.

vi. *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 matters undergoing decomposition, and during that process becoming in part soluble in water, and thereby affording a rich nutriment to the succession of living plants and insects, 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 aquatic plants. As these standing waters are in general shallow, they receive the full influence of the sun, which further promotes the changes that are going on within them. The taste is generally vapid and destitute of that freshness, and agreeable taste and coolness, which distinguish spring water. Stagnant waters are generally soft, and many of the impurities, being only suspended, are thereby removed by filtration; but their unpalatableness as a drink has, perhaps, caused them to be in worse credit than they deserve for 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.

vii. *Sea water.*

The water of the ocean contains by far a larger portion of saline contents than any other water which presents itself to the notice of the chymist, except, indeed, the brine springs and salt lakes, from which the common salt is obtained by the evaporation of the water, with the heat of a tropical sun.

The water of the sea, as it washes the shores of Great Britain, is a very heterogeneous compound, containing a considerable quantity of saline substances, and holding an infinite number of minute animal and vegetable exuviæ in suspension, composed of all the marine productions that people this element.

Sea water taken up near a rocky or clear sandy coast, or at a considerable distance from the shore, is quite clear and colourless, and shows no marks of an unusual quantity of air of any kind ; its taste is highly saline, nauseous, and very bitter ; by keeping, it grows highly offensive, owing, doubtless, to the decomposition of the animal and vegetable matters which it contains in suspension; these like all organic bodies being peculiarly liable to change, and the salt with which they are surrounded not being sufficient in quantity to prove antiseptic.

The temperature of the sea, although it varies considerably in different seasons, is however, on the whole, more uniform than that of any inland water that is ever exposed to the atmosphere, and that is not a hot spring. The sea seems to possess in itself a peculiar source of caloric, owing to a variety of peculiar causes, the operation of which are unknown to us. The vast body of the water, and the perpetual agitation to which it is exposed, render it less liable to be affected by outward 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 at different seasons of the year. On the shores of England the surface of the sea is seldom, in the severest weather, lower in its temperature than 40°, or higher in the hottest summer than 65°; whereas the heat of rivers, especially when they are shallow and their currents slow, rises higher and sinks lower than either of these points.

It has been found by many accurate experimentalists that the proportion of salts in water varies considerably at different depths, and different latitudes. In general the water of the tropics is salter than that at the poles. The quantity of salt is from one-twentieth to one-thirtieth the weight of the water; and in some inland seas, especially the Baltic, it is less. The Dead Sea contains much more; indeed the specific gravity of this water is so great that it is said to prevent a man from sinking. The water of our own coasts may be reckoned at an average as containing one-thirtieth of its weight of salt.

We have yet no accurate analysis of sea water. Its chymical composition, as far as regards the nature of the salts, and the proportion which they bear to each other, may be considered as nearly the same in all places. In freedom from extraneous substances, especially of organic matter, the deeper water is in general the purer.

Bergman was the first who made the attempt to analyse sea water. That which this illustrious chymist analysed was taken up at 50 fathoms below the surface, about the latitude of the Canaries. This water had no smell; and its taste, though intensely salt, was not so nauseous as water taken from the surface. Its specific gravity was 1·0289. An English wine pint of 28·875 cubic inches contained

	Grains.
Muriate of soda	241·
Muriate of magnesia	65·5
Sulphate of lime	8·
Carbonate of magnesia, a trace	
	314·5

According to the analysis of Dr. Thomson, the water of the Clyde in 1000 grains contains 1·3 grains of foreign matter, or

	Grains.
Muriate of soda	0·369
Muriate of magnesia	0·305
Sulphate of soda	0·114
Carbonate of lime	0·394
Silica	0·118
	1·300

CHAPTER IV.

On the chymical action of water.

The quality of water is of the first importance, not only in medicine, but in several of the manufactures, and for domestic use, and the effects produced by some of the ingredients which they contain are more than might be expected from the smallness of their actual quantity. Several of the arts and manufactures have acquired a superiority in particular places from an excellence of 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.

The chymical combination of some substances with water takes place in all proportions, with others in every proportion to a certain limit. The union of water with alcohol and the liquid acids is an example of the first, and the union of salts and water an example of the second. The solution of each of these is the result of combining affinity, and the only effect of water in its chymical action is to deprive such substances as it dissolves of their cohesive attraction. The power of solution thus appears to be separating the particles of matter from each other, an interesting object both with the natural philosopher and the chymist, enabling the former to exhibit, and the latter to operate upon matter in one of its most useful and interesting forms. The power of solution ceases as soon as the cohesion of the solid becomes too strong for the force of affinity. Some substances unite with water in every proportion without the affinity being diminished, whilst with the particles of others water has no affinity.

This species of chymical combination is peculiarly distinguished by the elements having a feeble affinity, and preserving always some of the properties which they possess in the solid state. If the solvent be removed, they are obtained again in the same state as previous to solution.

Although, in a scientific point of view, these compounds are of minor importance, they are of the first practical consequence. They enable the operator to present bodies to one another under the most favourable circumstances possible for acting with effect, the liquid form being communicated to them, whilst the affinity of the menstruum which holds them in solution is not sufficiently powerful to interfere with their attraction for each other. From the extensive range of its affinity, water is likewise one of the most powerful agents which the chymist possesses; and, from the nature of its composition, there are but few complex chymical changes which do not give rise either to its production or decomposition. Its combinations, however, are independent of the elements of which it is composed.

The purity of water is an essential consideration in many cases, where it is required to extract the soluble parts of animal and vegetable matter. The admixture of earthy, neutral, or metallic salts will, in many cases, not only alter the power of water as a solvent, but produce essential changes on some of the substances when dissolved. Water affects the colouring matter of vegetables, by the salts which it contains.

Salts with an earthy basis oppose the solution of colouring matter; they cause various kinds to precipitate in consequence of combining with the earth, and render the colour deeper and fuller. The carbonates of lime and magnesia precipitate their earth upon the stuff during boiling, and thus prevent the access of the colouring particles. It is essential, therefore, that the dyer should be select in his choice of water, and use that which is soft, clear, without smell, and does not curdle soft soap. Some of the earthy salts are indeed used in dyeing, but with the intent of altering and heightening particular colours. Hard water is also improper for bleaching, as it decomposes the soap employed in that process; the oily earth adheres to the stuff, and leaves a yellow stain, difficult to be got out.

Hard water possesses a certain astringent property, and it is this which contracts the fibres in the flesh, as is observable in attempting to wash in them by soap. This effect it likewise produces upon the fibres of vegetables; for in bleaching linen it is well known that, after washing it with soft water, by being thrown into hard water it obtains a peculiar firmness, whilst the soft water would leave the fibres lax. For this reason muslins and cottons are thrown into pump water after washing.

In the preparation of animal skins, and in some other arts, water is used to extract all that is soluble in this liquid, and to leave the remaining substance proportionably clearer, or in some cases to bring on a certain degree of fermentation and putrefaction, and thereby to alter the texture of bodies. In all these cases it is evident that a soft water is preferable to one whose salts render it somewhat antiseptic, and diminish its solvent powers. Hard waters are, however, of use in many manufactures. Pump water alone is used in them anufacture of starch, and the hardest is preferred by masons for mixing mortar. Hard water is necessary for making gypsum into plaster, as rain water will not answer this purpose. In China a particular sort of water is used to mix the porcelain earth into a paste, which water is impregnated with a peculiar sort of salt, said to purify and refine the clay. In some processes of dyeing, likewise, hard waters are preferred. Well water is preferred in dyeing red, and other colours that want astringency, as well as in the dyeing of stuffs of loose texture, as calico, fustian, and cotton.

Soft water, from its power of dissolving the extractive and saccharine matter of the malt, might be considered of the most value to the brewer; such however is not the fact, and it is not likely that pure water would answer his purpose. The choice of water is however a matter of considerable consequence to the brewer, more particularly as the different saline substances which it contains in solution in some instances prove a useful adjutant to beer, whilst in others they injure both its colour and taste.

Hard water is found in many instances favourable to the manufacture of beer; the Barnstable and Liverpool ales, which are considered excellent in quality, and some others, are brewed with hard water. The Derby malt, much used in Lancashire, is found to make better beer in that county than in Derbyshire, and it may be supposed that the Lancashire waters generally containing much carbonate and sulphate of lime occasions the difference. The river Trent has long been celebrated for the excellence of the ale made with its waters, Burton, Nottingham, and the other towns that lie upon it, being famous for their malt liquor all over England, occasioned by the calcareous strata over which this river runs. The same brewer cannot with the same malt produce an equal beer in any other part of the kingdom.

Any solution that would affect the colour of the ale would show itself in the water. The month of October, so famous from time immemorial for the manufacture of good English beer, is that in which river water is most unfitted for use. It is then loaded with vegetable decompositions and living animalculæ, neither of which are favourable to the vinous fermentation. A circumstance so extremely incongruous may probably be otherwise accounted for by the peculiar time of year being favourable to the manufacture.

The carbonates of lime, magnesia, and potash, are well known to be correctors of acidity. As such the former of these substances, in the form of marble dust, crabs' claws, or egg shells, is often put into spring brewed ales, for the purpose of absorbing the first germs of the acid fermentation. Carbonates of lime and magnesia are more frequent in well, than in river water. The river Trent contains much carbonate of lime in solution, and hence probably one reason why Burton should be famous for its ale. Water containing sulphate of lime in solution has a less extractive power than that which contains carbonate of lime, but this substance is also supposed to act as a preservative. Much of the water with which the Burton ale brewers is supplied takes its rise in a rock of gypsum, and is almost saturated with this salt.

Sulphate of iron is often used in the preparation of beer, and it may be observed that the prohibition of the legislature and vigilance of the excise officer are often singularly put into defiance by nature; whilst the latter is threatening or prosecuting one brewer for putting a small portion of sulphate of iron, gypsum, or carbonate of lime, into his porter; another, perhaps under the eye of the same officer, may have ten times the quantity naturally dissolved in the water which supplies his brew-house. Similar to this a curious circumstance lately occurred in connexion with one of the able treatises published by the Society for the Diffusion of Useful Knowledge, in "The Treatise on Brewing," the author of which stated that gypsum and chalk were used in the manufacture of Burton ale. The Burton ale brewers, considering themselves aggrieved by this charge of sophistication, commenced an action against the Society in the Court of King's Bench. This action was however withdrawn, when it was stated by Mr. Brougham that the talented author of the treatise had stated this as a fact because he had been unable to prepare ale similar to the Burton without the admixture of these ingredients. The Society has since sent an experienced chymist to Burton, to whom every facility was afforded by the brewers, and who found that these substances were largely contained in natural solution in the water with which the brewery was supplied, and which takes its rise in a gypsum rock. With an understanding that this explanation should be published in each succeeding edition of the treatise, the action was withdrawn by the counsel to the prosecution.

The purest and softest water makes the best bread. When the waters are hard they are found to retard fermentation, and the bread becomes less wholesome. The author has analysed several samples of bread, for the peculiar appearance of which no adequate cause could be assigned, but in which he has detected sulphate of lime to some extent, and probably accounting for the unusual appearance. At Paris, where the water is hard, the same baker cannot make so good bread as at Gormes. The purity of the waters at Beaume in Burgundy is the cause why this bread was long celebrated as the whitest and best in France.

Pure waters are found most valuable in bleaching wax, and in the manufacture of white paper; in consequence that such waters require the less alkali and soap in cleansing and whitening the rags, and the paper made with soft water is thus found firmer and to require less sizing than that made with hard water. This circumstance is said to give the French paper a preference to the English or Dutch, whose waters, being harder, require more soap and lime, become more tender, and require more sizing than the French.

In culinary purposes water is used either to soften the texture of animal or vegetable matter, or to extract from it and present in a liquid form some of its soluble parts. Soft pure water will fulfil both these objects better than hard water, and at the same time the colour of the substance employed will vary as well as its solution. In boiling beef and mutton the use of these waters is particularly to be avoided, as they are generally reddened by the salts which they contain. In dressing fish, particularly a fresh cod, hard water is of singular use. By cutting the fish in small pieces and letting it lie in cool spring water about an hour, and then boiling it in the same sort of water, it will harden, curdle, and keep its whiteness, and cut almost as firm as beef. 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 modified by the chymical action of the earthy or neutral salts. Hard water is less powerful in softening the texture of vegetable leaves than soft water, and is never able to exert its full effect in heightening their colour till assisted by heat.

Pure water is essential to the manufacture of most chymical and pharmaceutical preparations, and the earthy matters which it contains, although small in quantity, are found to have considerable effect in impairing the medicinal as well as the chymical characters of the most important preparations. It is also of much importance, as is well known, in the domestic operations of the laundry. Hard water affects even the productions of the soil, and gardeners let it stand to soften before they throw it on the plants.

Various methods have been suggested to correct certain defects in particular waters, to make them approach more nearly in their properties to pure soft water.

Both chymical 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 very unfit for drinking, although it may be used for other purposes. Of the mechanical means, filtration has already been spoken of. It is a very extensively applicable mode of purification. 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; by this means every substance 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, limped, and free from all substances but those which it contains in chymical solution. This is a process which is performed largely within the earth, and hence the reason why the purest waters are those which arise through clear sand or a 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 other 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. Water sometimes contains putrescent vapours, which are not removed by this kind of filtration. By filtering through charcoal, however, these may be removed, and so far this must be preferable to the other species of filtration.

It is to be observed that filtration will not produce any change in the chymical composition of the water, that in fact it will not render water less saline, or separate any thing that is truly dissolved, but only what is suspended. It has been supposed 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 very 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. Such 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, and which 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.

There are also 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.

A turbid brine by passing through a tub of clean sand will run off perfectly clear, but quite as salt as before. It appears, however, that an earth suspended by carbonic acid, as for example the carbonate of lime, will in a considerable degree be separated by 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 be sometimes rendered softer as well as clearer by filtration.

Simple boiling may be called a chymical process for purifying the water. It will soften those waters whose hardness consists in the carbonates of lime and magnesia, as may be known by the crust of a tea-kettle; for as the carbonic acid is expelled, by boiling, the earth subsides. This, however, will not remove sulphate of lime, and, as this is almost constantly present in water, boiling is but a partial mode of purification.

The chymical means for the purification of water are common but very inadequate. They consist in the decomposition of the salts which hard water contains. All the earthy salts which oppose the solution of soap may be decomposed by the addition of an alkali, which will cause the earth to precipitate, whilst the neutral alkaline salt which is left does not injure the solvent power of the water. It is for this reason that pearl-ash, or the ashes of fern or wormwood, which contain a good deal of carbonate of potash, are often used for softening hard water for the purpose of washing. Alum clears the foulness of water very readily. This salt is decomposed by the carbonate of lime, and the alumina carries down all sensible impurities. Experience has not shown the utility of any other mode of chymical purification. Distillation is the only mode of obtaining a pure water. Its salubrity has been put beyond a question long ago, and repeatedly by the experience of navigators whose names are celebrated throughout the civilized world—Cook, Bougainville, Phipps, Hamelin, and many others. The use of it is established in the naval service; and so much is it used at sea, that a large manufactory has been established for the supply of vessels with an apparatus adapted both for cookery and the distillation of water. Captain Cook also proved the wholesomeness of ice water beyond a doubt; in the high southern latitudes he always found a salutary supply of fresh water in the ice of the sea.

CHAPTER V.

On particular mineral waters.

In this chapter I propose to give an account of some of the celebrated mineral springs that are employed medicinally, in our own country, and are of acknowledged efficacy and established reputation. A complete history of every circumstance which is interesting to the medical enquirer relating to any mineral water embraces a number of particulars, all of which contribute to give a clear idea of its properties.

The history of any celebrated spring, the first discovery of its remarkable powers, the gradual steps by which it has acquired a high degree of fame, and the elegant baths or other buildings which have contributed to its convenience and embellishment, are particulars which are entertaining and often instructive, and the scientific enquirer 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. Its use as a bath will generally be found to have preceded its employment as an internal remedy.

Many springs owe their medicinal properties, according to tradition, to the reputed influence of their patron saint, or some other peculiar or interesting circumstance. Thus St. Patrick is said to have healed all the springs in Dublin, which before his time were so brackish as to be quite unpalatable ; and the water at Holywell took its rise from where the head of St. Winifrede fell.

Another collateral branch of enquiry is that of *site*, under which term may be included all that refers to soil, the general state of the atmosphere, purity of the air, and face of the country around. The nature of the strata through which the spring runs are also circumstances connected with, and often throwing much light on its chymical composition. In examining the water itself, the sensible properties claim the first notice, as by these a pretty accurate idea of the nature of the contents of the water may be formed. The appearance to the eye, whether sparkling or quiet, clear, turbid, or with a slight shade of colour; the taste, whether saline, chalybeate, or bitter; the smell, whether fetid, sulphureous, or scentless; all these are circumstances of great importance, and naturally precede the chymical enquiries.

The temperature of water, as determined by the thermometer, is also to be particularly noticed, as it sometimes forms the distinguishing feature of a separate class of natural waters, and is independent of their chymical composition. Springs of different degrees of heat are found dispersed through the several parts of the world, deriving their heat from latent causes of caloric at present unknown to philosophers. Of these the most peculiar are in the neighbourhood of volcanoes, and with these may be classed the boiling springs in Iceland. The number of hot springs which abound in Italy, Naples, and Sicily, seem evidently to owe their rise to the subterranean fires in those parts, and they are often accompanied with flame and smoke. The most famed of these are the burning rivers of Cocytus and Phlegelon, through which, according to the poets, the wicked pass into hell, and which are heated by the subterranean fires near Puteoli. Many of these waters emit flames of sulphuretted hydrogen gas. When cold, however, they are not unpalatable, but fit for drinking. Several of the springs formerly celebrated in Italy are now dried up. What was formerly the lake Avernus, famous for its poisonous streams, is now plentifully stocked with fish and fowl.

The temperature of natural springs varies considerably. Some of the waters near Aix-la-Chapelle are said to be so hot that if either pigs or fowls be immersed in them they will take the bristles from the former and feathers from the latter. The waters of the River Salerdo, in Chili, are so hot that they cannot be drank. In the island of Melos, the springs are of a temperature sufficient to burn the fingers if immersed in them.

Some of those in Tuscany will boil a piece of flesh sooner than if heated by culinary fires; and those of Iceland are so hot that one quarter of an hour is sufficient to boil great pieces of beef in them. Those in the island of Manilla, and the waters of a lake near Rome, are so hot that they will kill any animal that falls into them. The hottest water in the world is said to be in Japan, which no fire can equal, and which keeps hot thrice as long as boiled water. But this is a statement of which the truth, and particularly the former part, may very properly be questioned.

Hot springs are also common in Mexico and the south parts of Peru, and in Jamaica and St. Christophers. In Terceira are some waters hot enough to cook eggs. In Egypt is the hot well called Gundeli; besides which are others in the caverns of Mount Atlas, and different parts of Africa. The chymical composition of these hot wells is various; some of them contain sulphuretted hydrogen, which catches fire over the surface of the well, when a lighted torch is applied Of this kind was the burning well at Wigan, now extinct; and one also at Brosely in Shropshire.

This country contains several waters, of great esteemed medical value, which are of a higher temperature than the surrounding atmosphere. The most celebrated of these are, Buxton, Bristol, Bath, Matlock, and Mallow in Ireland. The principal continental hot-wells resorted to, for their medicinal uses, are those of Aix-la-Chapelle, Bourbon, Vichy, Bareges, Baden, and the Caroline Baths, in Germany. The date of the discovery of most of these springs is very ancient, and their medicinal reputation has been confirmed by long practice. The use of the baths of Melos in Greece, yet resorted to, was prescribed by Hippocrates.

After each of these sensible properties has been ascertained, the nature and foreign contents of the water must be determined by an accurate chymical analysis, as it is by this alone we can arrive at a knowledge of the composition of any particular water. In the analysis, each of the different ingredients must be collected in a separate state, and their quantities carefully noted

The foreign contents of a mineral water being known, the next and last object of enquiry 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 uses to which a mineral spring can be applied. To determine this with precision, and especially to point out to which of the foreign contents the medicinal properties of mineral waters are to be attributed, often requires much judgment and observation, and is, in fact, one of the most important subjects connected with the history of a mineral water. These, with the requisite duration of the course, and certain local circumstances, are generally laid down with great judgment and discretion by the medical writers and practitioners on the spot, who may be safely referred to as the best authorities.

A classification of mineral springs, based upon their natural contents, although, undoubtedly, the most scientific and the best, is yet attended with some difficulties. Indeed, such an arrangement may scarcely be considered of any value to the medical practitioner, as the medicinal value of a spring may be owing to the combination of some substances which are of minor importance in the chymical arrangement. The classification which I shall adopt will be founded upon the predominant chymical ingredient. There are, however, a vast number that are but little known and enquired into, and the analysis of which are consequently very imperfect. This arrangement will then include,

1. Nearly pure, or containing but little of the salts of lime.

2. Acidulous, in which carbonic acid is predominant.

3. Sulphurous — their peculiar distinguishing properties arising from sulphuretted hydrogen.

4. Chalybeate, containing carbonate or sulphate of iron.

5. Saline—including the largest variety of waters.

Of the first class of waters, the most celebrated in this country are those of Bath, Buxton, Bristol, Matlock, Malvern, and Holy-well in Flintshire.

Bath Waters.

The city of Bath has been celebrated, for a long series of years, for its numerous springs, which, for their purity and excellence, are rarely equalled. The temperature of these waters is higher than any in the kingdom, being ordinarily 114°; and, indeed, these are the only natural waters which this country possesses that are hot to the touch, all the other thermal waters being of a heat below the animal temperature, and only deserving that appellation from being above the general heat of common springs. These waters, which were the first occasion of celebrity to this spot on the banks of the Avon, have been the means of erecting and supporting a splendid city, and are now eminently accommodated to the use of invalids, by the erection of elegant baths, and various other buildings calculated for convenience or amusement.

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. 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 city is of considerable antiquity, being noticed by the earliest British historians, and many interesting Roman remains have been found upon 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 a very constant 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. This circumstance makes it appear highly probable that these thermal waters were much in use even with the Romans, when in this island, and establishes the antiquity of the Bath waters over all the other mineral waters in the kingdom.

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, and not far from the

Avon, into which the hot water flows 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.

The sensible properties of the Bath water are the following:—When first drawn it appears quite clear and colourless, and remains perfectly quiet, without sending forth any bubbles or giving any briskness or effervescence. On standing exposed for some hours, it becomes somewhat turbid by the separation of a pale ochrey precipitate, which gradually subsides. 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 pungency, and is not accompanied with any saline taste. As soon as the water cools, even before any precipitation appears, the chalybeate taste is entirely lost, and there is then no distinguishing difference between it and common hard spring water.

The specific gravities of the three waters, the King's Bath, the Hot Bath, and Cross Bath, at 60°, are stated by Dr. Scudamore as,

Hot Bath	. . . .	1002·45
King's Bath	. . .	1002·38
Cross Bath	. . . .	1002·31

The following analysis of King's Bath water is given by Dr. Scudamore. In a pint

Carbonic acid	. .	1·2 inches.

		Grains.
Muriate of lime	. . . .	1·2
Muriate of magnesia	.	1·6
Sulphate of lime	. .	9·5
Sulphate of soda	. .	·9
Silica	. . . .	·2
Oxide of iron	. . . .	·01985
Loss	. . . .	·58015
		14·00000

The quantity of iron is thus about one-sixth of a grain in a gallon.

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, presenting a rude character of country.

Buxton has long been celebrated for its warm springs, which 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 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 the fountain was not unknown to that people.

The vicinity of Buxton is not devoid of interesting scenery, and affords the opportunity of some agreeable excursions to gratify the lover of nature in her rude attire. The most interesting objects are emphatically called the seven wonders of the Peak. The mountains around contain large chasms and clefts, and some remarkable cavities have been penetrated into, whose stalactitical grottoes are great objects of interest and curiosity to the visitors who frequent this place. This is likewise the part of Derbyshire that has for many centuries been famous for its lead mines: some of the most ancient works in the kingdom are to be found in this district, though now they are but little wrought.

The thermal water of Buxton takes its rise in one of the calcareous hills which surround the town. The water is conveyed to the well of St. Anne, appropriated for drinking, through an artificial sandstone channel; thence it falls into the well, concealed under a large marble bason, enclosed in a handsome stone building, conveniently constructed for the protection of the invalid, and closed with an iron gate.

In its passage from the spring to the well, the water loses five degrees of temperature, being at the head 82°, but in the basin 77°; it also loses a considerable proportion of its nitrogen.

The analysis of this water is thus stated by Dr. Scudamore. In one gallon,

	Grains.
Sulphate of soda . . .	·63
Muriate of lime . . .	·57
Muriate of soda . . .	1·80
Muriate of magnesia . .	·58
Carbonate of lime . .	10·40
Extractive matter and loss	1·20
	15·00

In addition to the tepid springs of Buxton, there is also a chalybeate, which arises from a bed of shale in the neigbourhood of the town, but is a very weak impregnation.

Bristol.

The celebrated hot-well at Bristol 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 theBristol Channel.

By the lover of picturesque beauty, the banks of the Avon have been long cherished, as 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 may be seen the wide estuary of the Severn. The site of Bristol hot-well appears to be one of those choice and favoured spots that are peculiarly well fitted for the health and comfort of the invalid. High ridges of dry limestone cliffs shelter it from the sleek north and east winds, and from the boisterous west, 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.

St. Vincent's Rock, from the bottom of which the hot-well 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, known by the name of Bristol stones. This spring is a very fine, clear, copious, 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 decided taste, at least none that can be well distinguished by a common observer. The average temperature of this water may be reckoned at 74°, and this does not very considerably vary either in winter or summer.

The specific gravity of Bristol water is only 1·00077, which, approaching so near to that of distilled water, shows that it contains a very small admixture of foreign contents. Dr. Carrick found the quantity of solid contents in a wine gallon 47·75, or

Muriate of magnesia	. .	7·25
Muriate of soda	. . .	4·
Sulphate of soda	. . .	11·25
Sulphate of lime	. . .	11·75
Carbonate of lime	. .	13·5
		47·75

Matlock.

The temperature of the spring at Matlock being 66° claims its admission to the rank of British thermal springs, of which it is the lowest in temperature. Until these thermal waters began to attract notice, about the year 1698, this sweet retreat was only occupied by the cottages of miners. The village is known to the lover 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 river Derwent, whose steep banks are covered with thick woods.

A number of springs issue from this

limestone rock, all possessing the clearness and purity that distinguish mountain streams rising from a clean rocky soil. 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.

Many of these springs coat their borders with calcareous deposit, and vegetable substances are thrown into them, in their course, in order that they may receive an incrustation from carbonate of lime, which the water, by exposure to the air and agitation, freely throws down.

The supply of the tepid waters is very copious. In their sensible properties, these springs scarcely differ from common water. When first taken up this water is found to curdle soap, but the effect goes off after standing a few days, owing to the deposition of carbonate of lime. The taste is that of good pure water, without any acidulous flavour or unusual briskness, nor does it send forth any considerable bubbles when first poured out. Its specific gravity is but little more than distilled water. No accurate analysis of the contents of this water has yet been made.

Malvern.

The village of great Malvern, situated about mid-way between Ledbury and the city of Worcester, on the extensive range of the Malvern hills—and which runs through a country which for rich cultivation and natural beauty is inferior to none that England can produce, 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 their valuable medicinal uses. The *Holy-well* issues high up the hill, from a soil which is chiefly limestone, but interspersed with a large quantity of quartz, and a hard red siliceous earth. The waters were examined by Dr. Wall, of Oxford, in 1756, and by Dr. W. Philip, of Worcester, in 1805. There is also another spring, giving rise to what is called the St. Anns well.

The Malvern water is considered as the best specimen possessed by this country of a remarkably pure natural spring, which has acquired a high reputation as a medicine. When first drawn it is quite clear and pellucid, and does not become sensibly turbid on standing: the mean temperature is considered at 51°, the specific gravity 1·0002.

Dr. Philip in his analysis, made in 1805, gives the following table of the composition of the water in a gallon:—

	Grains.
Carbonate of soda	3·55
Carbonate of lime	0·352
Carbonate of magnesia . .	0·26
Carbonate of iron	0·328
Sulphate of soda	1·48
Muriate of soda	0·955
Residuum	0·47
	7·395

This water, it will be seen, is found to contain a smaller proportion of foreign contents than any other water.

St. Winifred's Well.

St. Winifred's well, in the parish town of Holywell, in the county of Flint, is one of the finest and most copious springs in the kingdom. It rises from the lower extremity of a limestone rock, and issues up with great vehemence through the crevices of a handsome stone reservoir. This is enclosed in a beautiful polygonal building, of the form of a temple in Gothic architecture, dedicated to the tutelary saint of the fountain, and 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 course of two miles to the Dee, where it terminates, assists in turning the machinery of corn-mills, cotton-mills, and numerous works belonging to the Anglesea Copper Company.

St. Winifred's Well is a remarkably clear well-tasted water, and is used by the inhabitants around for all domestic purposes. A century ago the virtues of this well were more celebrated than at present, and the town of Holywell, on account of containing this spring, was crowded with visitors from every part of North Wales. Though its utility now is principally confined to the inhabitants, and to the purposes of manufacture, its medicinal efficacy in certain complaints is not doubted. It is a singular circumstance that mill wheels, and other machinery, if made of wood, are rotted remarkably soon by remaining in this water. This is found to be owing to a species of moss which attaches itself to the wood, to the production of which this water is unusually favourable, and which inconvenience compels the manufacturer to use cast iron wheels.

Of the second class of waters there are none of particular fame in England, except indeed that of Kilburn, in Middlesex. Of this kind are particularly distinguished the waters of Seltzers Spa, Carlsbad, and Pyrmont, and the great quantities of carbonic acid found present in excess, over the quantity necessary to dissolve the carbonates of iron and lime, render this distinction necessary in their classification.

The peculiar properties of carbonic acid gas have been particularly explained, and now, therefore, render any further observations unnecessary.

The next class of mineral waters is the sulphureous, an extensive and important class; they are those which are so strongly impregnated with sulphur, united either to hydrogen or an alkali, or to both, as thereby to acquire very sensible qualities of smell and taste, and become very powerful agents on the human frame. Several varieties of these waters are met with, such as hot and cold, simple, saline, and the like.

All these waters are at once detected by the smell, which is very fetid, resembling the scouring of a foul gun barrel, or rotten eggs. They have, besides, a taste which is rather peculiar and sweetish, and altogether constitutes a drink at first very unpalatable, but which is soon reconciled by habit to the drinker.

Sometimes the water is so strongly saturated with sulphur as to deposit it readily, in the form of pure sublimed sulphur, on the upper coverings of wells and other places through which it passes for any considerable time. In all cases the quantity of sulphur is in very small proportion to the water, considering the intensity of the sensible properties. None of these waters will bear carriage well to any distance, as the gas is decomposed, sulphur separating by mere rest even in close vessels.

The only sulphureous waters which this country possesses are cold. The principal of these are the waters of Harrowgate and Moffat.

Harrowgate Water.

The villages of High and Low Harrowgate are situated in an agreeable country, in the centre of the county of York, adjoining the town of Knaresborough. The whole of this district abounds with mineral springs of various qualities, but principally with the sulphureous and chalybeate. Harrowgate in particular possesses valuable springs of both species.

The sulphureous springs of Harrowgate are four in number, all appearing to take their rise from a large bog at a short distance from the wells. This bog consists of the remains of decayed vegetable matter, forming a black, fetid, half fluid mass, in many places four or five feet in thickness, which every where rests on a bed of clay and gravel. From hence the water appears to pass under ground through strata of shale, and, having undergone a natural filtration in its passage, runs perfectly transparent into the wells, where it is received for the use of the numerous invalids that frequent this place. The four sulphureous springs in Harrowgate resemble each other closely in all their properties and distinguishing characters; but, as one of them is more largely impregnated with sulphur than the rest, it is the only one used for drinking, whilst the others are devoted to the supply of the baths.

An account of the properties of the drinking well will be found sufficient for our present purpose.

This water when first taken up appears perfectly clear and transparent, sending forth a few air bubbles, but not in any considerable quantity. It has a very strong, sulphureous, and fetid smell, and to the taste is bitter, nauseous, and strongly saline. The water loses its transparency when exposed for some hours to the open air, and becomes somewhat pearly and greenish to the eye, 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 composition of this water long excited the attention of several ingenious chymists. Short and Rutty each give copious observations. Dr. Garnett wrote a treatise on these mineral waters, and their composition has since been investigated by Drs. Lambe and Scudamore. The analysis of this last gentleman makes the contents of the old sulphur well to be, in one gallon,

	Cubic Inches.
Of Gaseous contents	13·716
Carbonic acid	9·529
Nitrogen and carburetted Hydrogen in about equal proportions	5·800
	29·045

Of solid contents,

		Grains.
Muriate of soda	. . .	760
Muriate of lime	. . . .	32
Muriate of magnesia	. .	28
Sulphate of lime	. . .	8
Carbonate of lime	. . .	12
Carbonate of magnesia	.	3·2
Loss	. . . .	4·8
		848·0

Besides the old sulphur well, Harrowgate contains some other springs, the principal of which are the Crescent water and Oddy's Saline Chalybeate. The former spring was some years ago held in such estimation, by Dr. Garnett, that he bestowed a separate essay upon its waters. It contains, however, but little sulphuretted Hydrogen, and its specific gravity being but 1·0008 shows it to contain a very small proportion of saline contents. It is slightly impregnated with carbonate of iron.

Oddy's Saline Chalybeate is an important spring. It is obtained for drinking by means of a pump, the whole arrangement of which is very neat; but for the use of the invalid it were much to be desired that the water should rise from the spring into an open basin, having an aperture in its side for the excess of water to flow away. At present the water is often pumped up in a flaky state, in consequence of the deposition of its iron in the bucket.

The composition of this water is stated by Dr. Scudamore as in a wine gallon,

	Grains.
Muriate of soda	300·4
Muriate of lime	22·
Muriate of magnesia . .	9·9
Sulphate of lime . . .	1·86
Carbonate of lime . . .	6·7
Carbonate of magnesia . .	·80
Oxide of iron	2·40
Residue, consisting chiefly of silex	·40
	344·46

Dr. Adam Hunter, of Leeds, recently published an analysis of this water, and the following is his statement respecting the quantity of saline ingredients:—

Muriate of soda	. . .	434·
Muriate of lime	. . . .	30·
Muriate of magnesia	. .	13·
Sulphate of lime	. . . .	9·
Carbonate of iron	. . .	5·
Carbonate of lime	. . .	3·
Loss	. . . . . .	2·5
		496·5

The Hewit Well is situated in the forest of Knaresborough, at a short distance from upper Harrowgate. It appears to have been discovered in the year 1571, and is recorded to have been the only mineral water in the neighbourhood known for a considerable time. It was named Hewhet or Hewit Spa, from the great number of Lapwings which formerly frequented that part of the forest. The distance of the spring not being so convenient to the visitors of Harrowgate as the Old Spa, it is now seldom used Its medical properties and chemical characters closely resemble those of the Old Spa.

Although this north part of the country presents the appearance of much natural wildness, yet Harrowgate and its vicinity can boast of a great share of interesting scenery, and there are many objects to tempt the visitors to almost daily excursions.

Besides the sulphur wells of Harrowgate, several are met with in different parts of this country. The principal are those of Durham, Askeron in Yorkshire, Crickle-spa and Cunley-house in Lancashire, Dudley in Worcestershire, Costorphine in Scotland, Codsalwold in Staffordshire, Gainsborough in Lincolnshire, Keddleston in Derbyshire, Loansbury, Ripon, and Normandy, in Yorkshire, Llandiddad in Wales, Sharpmoor in Westmoreland, Dardrew in Northumberland, Road in Wiltshire, and Notington in Dorsetshire.

Moffat Water.

The village of Moffat is situated in a valley on the banks of the Annan, about fifty-six miles south-west of Edinburgh. It is surrounded by hills, some of which are very lofty; of these the Hartfell mountain is noted for the chalybeate water which springs from its basis. The sulphureous water which has given much celebrity to Moffat, and rendered it the Harrowgate of North Britain, issues from a rock a little below a bog, whence it derives its sulphurous impregnation. This is contained within a stone building, enclosing a pump, and the quantity of water is amply sufficient to supply every demand.

Moffat water, even when first drawn, appears rather milky and blue coloured; the smell is precisely similar to that of Harrowgate; the taste is simply saline and sulphureous, without any bitter; it somewhat sparkles on being poured from one glass to another; when exposed to the air it becomes more turbid, and throws up a film of pure sulphur, being thereby deprived of all its distinguishing properties as a sulphureous water. This change takes place even in closed vessels, so that it cannot be exported with any advantage.

Moffat water is very simple in its composition. According to the analysis of Dr. Garnett, the whole solid contents of a wine gallon is

	Grains.
Muriate of soda	36

And of gaseous,

	Cubic Inches.
Carbonic acid gas	5
Nitrogen gas	4
Sulphuretted hydrogen . . .	10
	19

In order to produce any medicinal effect, this water requires to be drank in considerable quantities. The quantity usually prescribed is from one to three bottles every morning: the common people frequently take in one morning from three to five scotch pints, or from six to ten English quarts. One instance is mentioned by an author of 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-ache.

The continent contains many sulphuretted waters of note. The principal are those of Aix-la-Chapelle, Bareges, and Borset.

Another comprehensive and interesting class of mineral waters are those which owe their properties to iron, dissolved either in the carbonic or sulphuric acids, and generally either in conjunction with some native saline sulphuret or other substance. The properties of iron, and the nature of its solutions, have been already explained; it constitutes one of the leading distinctions amongst all writers on mineral waters, and very justly, as iron is the only metal which is ever found in any considerable number of springs, and as it imparts very distinguishable sensible properties, and medicinal virtues.

Tunbridge Wells Water.

This mineral spring may be selected as a good example of a very numerous class of waters, which is sometimes termed the simple carbonated chalybeate, or those that differ from other springs in no other respect than in containing a small portion of iron, held in solution entirely by a small quantity of carbonic acid, which is yet not so abundant as to render the water brisk and acidulous. It is merely to the iron, and this solvent, that such mineral springs owe their medicinal properties; such are however very considerable. When the carbonic acid is in excess, it forms the highly carbonated chalybeates, such as the Spa and Pyrmont waters.

The most noted chalybeate in this country is that of Tunbridge Wells, a populous village, situated in a sandy valley, in that part of Kent called the Weald, about thirty-six miles south of London. This valley is surrounded by hills of a moderate height, composed chiefly of a crumbling, ferruginous sandstone, naturally barren; but from its neighbourhood to the metropolis, and the number of opulent inhabitants that reside in the vicinity, it now for the most part presents the appearance of a very pleasant and cultivated country.

The rocks in the neighbourhood of this valley appear to belong to that series of beds which were deposited immediately before the chalk. In this part of the country, however, those beds are not covered with the chalk, which has been most probably carried off in one of those revolutions to which this planet has been subjected; but they may be traced passing under the chalk foundation along the bottom of the north downs. This sandstone contains scarcely any fossil shells, but frequently iron in such abundance, that, before the discovery of the rich iron ore now procured from our gold mines, this metal was procured in the Wealds of Kent and Sussex, where the remains of many ancient forges are yet to be seen. This ferruginous sandstone also alternates with thick beds of a tenacious clay, which forms a great part of the soil of this neighbourhood.

Tunbridge contains many chalybeate springs, all of which resemble each other very closely in chymical 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. 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 so much used, the water overflows the stone bason into which it rises, and forms a small stream, the track of which is marked by an ochrey deposition.

The sensible properties of this mineral water, as it is first taken up from the reservoir, are the following:—it is quite clear, colourless, 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 quantity 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 encrusts the surface, like a very thin scum, and in twenty-four hours the water has entirely lost all its chalybeate properties; the same effect takes place quicker if the water is heated, a circumstance which shows that all the iron is suspended by the carbonic acid alone.

According to Dr. Scudamore, the Tunbridge Well water contains in one gallon 7·68 grains of solid matter, or

Muriate of soda	2·46
Muriate of lime . . .	·39
Muriate of magnesia . .	·29
Sulphate of lime . . .	1·41
Carbonate of lime . . .	·27
Oxide of iron	2·22
Traces of manganese, insoluble matter, vegetable fibre, silex, &c. . . .	·44
Loss in processes . . .	·13
	7·68

And of gaseous contents,

	Cubic Inches.
Carbonic acid	8·05
Oxygen	.50
Nitrogen	4·75
	13·30

Islington Spa.

There is scarcely a county in England which does not possess some chalybeate water, and by far the most common of these is the carbonated chalybeate. These are often very pure waters, in every other respect. Some of them, such as the Malvern chalybeate, are very simple in their composition. That of Tunbridge Wells is, perhaps, one of the weakest of all chalybeates. Others, especially several in the neighbourhood of the metropolis, contain iron to a much greater extent. It is perhaps merely an advantage of situation, or other accidental causes, that have given some of these a preference 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 individual to perform daily exercise, and giving that irresistible charm to the spirits which the sight of a beautiful or romantic country almost always excites.

The exact period when the spring at Islington was first discovered is not left on record, but it is certain that as early as the year 1640 it was highly in esteem. Boyle then considered it equal to any chalybeate spring known. The next author who takes any notice of it is Dr. Allen, in his "Natural

History of the Chalybeate and Purging Waters of England." Dr. Linden, Dr. Rutty, and Dr. Short, speak highly of its properties.

It is well known that the neighbourhood of London contained many springs formerly of high repute. That at Shadwell was considered to be the strongest carbonated chalybeate known. It was formerly situated in what were called the Sun Tavern Fields, about half a mile from the Thames, but it has long been extinct, and its remembrance does not now exist with the oldest inhabitant.

London has been supplied not only with the water of the Thames, but with many clear and wholesome springs of water, from which several parts of the city and suburbs derive their names, the streets and other places being distinguished by the termination of basins, brooks, pools, wells, conduits, &c., which either supplied water to the inhabitants, or were considered beneficial in the restoration of health. Such as were, however, really medicinal might it is probable, in those early days of intellectual bondage, have had their real merit robbed by their efficacy being ascribed to the power of the patron saints, to whom they were dedicated, a kind of religious excise imposed upon the people by interested friars.

Stow the antiquary, in his *Survey of London*, in a distinct chapter, describes about thirty of these wells and springs. Amongst these, however, Shadwell is not named. Fitzstephens in his short description of London, under the chapter "*de Fontibus*," says, "Near this city in the suburbs, on the north side, are some special wells of sweet, wholesome, and clear water, streaming forth among the glittering pebbles, of which Holywell, Clerkenwell, and St. Clement's well are most famous, and frequented by youths of this city in summer evenings, when they walk forth to take the air." In the days of queen Elizabeth, when the citizens began to supply their houses more regularly with water, and the New River was completed, many of these wells, brooks, and rivulets, were neglected and dried up.

Hence it may be conceived that they were resorted to for pleasure instead of medicinal purposes, and it is not improbable that some were merely tippling places as at the present. Clerkenwell was four centuries ago much resorted to by priests and clerks, and to draw company to them they probably used to act religious interludes, as at Sadler's Wells and other places they now practise theatrical representations.

It is probable that Shadwell took its name from some particular spring, but of which nothing is however left on record. The last spring is of a much later date. An elegant bath and pump soon succeeded their discovery, but no vestige or remembrance of whose existence is now extant.

The chalybeate spring at Islington, although it has partaken of much of the caprice of fashion, is yet extant. The author was agreeably surprised to find, on a visit to the spot, that this water yet partakes of much of those romantic associations and beautiful scenery which distinguish other springs now in more renown; and, if it does not partake of those advantages which distance of time and scene so peculiarly present, it has at least one useful adjutant in all that nature and taste can afford, in addition to being strongly impregnated with carbonate of iron; and, whilst participating in those medicinal benefits which the water affords, the languid citizen will find himself agreeably relaxed in observing some of the beauties of the surrounding scenery.

This water rises to the surface of the earth in a marble basin. It has neither colour nor smell, but the bottom of the basin is covered with an ochrey precipitate. It sends up numerous bubbles when poured into a glass; its taste is at first strongly chalybeate, leaving a pungency upon the tongue, but the taste of the water is altered by its being exposed to the air, oxide of iron precipitating to the bottom of the vessel. These facts show that the iron is held in solution by the carbonic acid. It contains a small proportion of sulphate of magnesia and muriate of soda.

It appears rather surprising that a mineral water, situated so near the metropolis, combining many advantages in medical value, beauty of situation, and proximity to the metropolis, should have attracted so little share of public attention, that a visit to the spot is necessary to ascertain that it is now extant, and also delightfully suited for medicinal purposes. Its use is recommended not only by many esteemed medical writers, but also by some eminent physicians of the present day. No attempt at an analysis has been made since the recent improvements in chymical science.

Lady Mary Montague takes credit in one of her letters for having introduced the waters of Islington to the world of fashion. Since then they have been visited by many persons of quality. During the latter part of the last century the neighbourhood of Islington was honoured with the periodical and repeated visits of two princesses of the present royal family to these waters, and who are reported to have received much benefit from their use.

Sir Samuel Romilly bears great testimony to the waters of Islington in a letter to a friend.

Hampstead Water.

This water was the subject of a separate treatise, was published in the year 1740 by Dr. Soame, who resided on the spot several years.

This water was formerly in as much repute as that of Tunbridge. Its chymical characters are oxide of iron, held in solution by carbonic acid with a small quantity of some other saline substance. The former of these may be recognised by the ferruginous deposits on the stones and wood in the course of the water. It is not so valuable as the Islington water.

Of chalybeate waters are those of Cobham in Surry, Lincomb in Somersetshire, Chippenham in Wiltshire, Astrope in Oxfordshire, Witham in Essex, and Dunse in Scotland.

In pursuing the plan, as far as can be attained, of considering mineral waters in the order of the degree of their sensible properties and simplicity of their composition, as far as regards the active foreign contents, we now arrive at the last and most extensive class of waters, the saline. These differ from common water only in being impregnated more or less strongly with some neutral salt, either with an alkaline or earthy basis. Some neutral salts have been enumerated as producing a purgative effect, and when these are present in a water in such quantity that they render it purgative when taken in a dose that the stomach can bear without being much incommoded, denote a purgative water. Those salts which give the characteristic effects are the muriates and sulphates of soda and magnesia. Of these, two are well known in medicine, since they form important articles in the materia medica, and are familiar to every one under the names of Epsom and Glauber's salts.

Much difficulty, however, arises in an enumeration of those waters which may be designated saline, as some are strongly characterised by chalybeate properties. Such are the waters of Cheltenham and Scarborough, but in each of these the iron is held in solution by sulphuric acid, forming the sulphate of iron or green vitriol of commerce, and in these the chalybeate properties are only of secondary consequence.

Cheltenham Water.

Cheltenham 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 springs to which this town owes its celebrity issue slowly, and in a scanty stream, from a bed of sand intermixed with blue clay. The Cotteswold Hills, in the neighbourhood of Cheltenham, are composed of calcareous rocks. Dr. Jameson remarks, "that the valley of Evesham, now more frequently called the Valley of Gloucester, is not excelled in beauty and sylvan scenery by any country whatever, and derives vivacity from the Severn winding in its centre, and embellishment from the numerous rural villages and plentiful orchards which every where adorn its surface.

Formerly a great deficiency existed in the supply of water to Cheltenham, but no such fault now prevails. The original Spa is so named from being the oldest mineral well at Cheltenham, and was accidentally discovered about a century ago. It is situated in the centre of a beautiful avenue of elm trees, not five hundred yards from the middle of the town. 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 one of the characters of the water. The supply of this chalybeate is stated to be only about thirty-five pints in an hour. When fresh drawn, the water is tolerably clear, but not perfectly transparent.

This water is called by the proprietor "*The strong ærated chalybeate saline.*" Its composition is thus stated by Dr. Scudamore:—

In a wine pint,

Muriate of soda	58·20
Muriate of lime	6·21
Muriate of magnesia . . .	2·54
Sulphate of soda	14·56
Oxide of iron a minute proportion.	
	81·51

Another water is described as the *strong sulphureous saline.* Its taste is saline and very slightly chalybeate, but the smell is very perceptibly sulphureous.

It contains, in one pint,

	Grains.
Muriate of soda	22·60
Muriate of lime	3·68
Muriate of magnesia . . .	5·16
Sulphate of soda	52·32
Oxide of iron, a minute portion.	
Sulphuretted hydrogen in very considerable proportion.	
	83·76

The third water is described as *magnesian saline.* Its taste is saline and chalybeate, and it contains in a pint,

Muriate of soda	17·60
Muriate of lime	3·08
Muriate of magnesia . . .	3·30
Sulphate of soda	43·20
	67·18

Oxide of iron probably a grain in a gallon.

Why this water should be appellated magnesian, it is difficult to discover.

The fourth water is described as *pure saline*, and contains in a pint,

Muriate of soda	47·80
Muriate of lime	4·29
Muriate of magnesia . . .	7·30
Sulphate of soda	59·20
Oxide of iron a trace.	
	118·59

The properties of this last are increased by the proprietor adding a concentrated solution of the salts to the water.

Soon after the discovery of the Cheltenham waters, they were treated of by many medical writers; and, between the years 1770 and 1780, they had acquired so much reputation that they were resorted to from all parts of England. As the celebrity of these waters increased, it was found that they could not keep up with the demand, and serious apprehensions were hence entertained that the company who had for many years been in the habit of visiting Cheltenham would meet with such frequent disappointments from the failure of the springs that they would be induced to look out for some other watering place, and that in a short time the town would be entirely deserted by the strangers who had formerly visited it, either for purposes of health or pleasure.

In the year 1806 a gentleman of the name of Thompson, who had purchased a great part of the land in the vicinity of Cheltenham, determined to search for a mineral water on his own estate in order to remedy this deficiency. Being successful in his efforts, he built a pump room, and water was obtained in sufficient quantity for the supply of whatever company might resort to the town and neighbourhood.

The following is the analysis of these wells :—

No. 1. The strong chalybeate saline water. In a pint,

	Grains.
Muriate of soda	41·3
Sulphate of soda . . .	22·7
Sulphate of magnesia . .	6·
Sulphate of lime . . .	2·5
Carbonate of soda and iron	1·5
	74·

Carbonic acid gas 2·5 cubic inches.

No. 2. The strong sulphuretted saline water. In a pint,

	Grains.
Muriate of soda	35·
Sulphate of soda . . .	23·5
Sulphate of magnesia . .	5·
Sulphate of lime	1·2
Oxide of iron	·3
	65·

Gaseous contents.

	Cubic Inches.
Sulphuretted hydrogen .	2·5
Carbonic acid	1·5
	4·

No. 3. The weak sulphuretted saline water. In a pint,

	Grains.
Muriate of soda	15·
Sulphate of soda . . .	14·
Sulphate of magnesia . .	5·
Sulphate of lime . . .	1·5
Oxide of iron	·5
	36·

Gaseous contents.

	Cubic Inches.
Sulphuretted hydrogen .	2·5
Carbonic acid	1·5
	4·

No. 4. The pure saline water. In a pint,

	Grains.
Muriate of soda	50·
Sulphate of soda . . .	15·
Sulphate of magnesia . .	11·
Sulphate of lime . . .	4·5
	80·5

No. 5. The sulphuretted and chalybeate magnesia spring, or bitter saline water. In a pint,

	Grains.
Sulphate of magnesia . .	36·5
Muriate of magnesia . .	9·
Muriate of soda	9·5
Sulphate of lime . . .	3·5
Oxide of iron	3·5
Loss	1·
	63·

No. 6. The saline chalybeate water. In a pint,

	Grains.
Muriate of soda	22·
Sulphate of soda	10·
Oxide of iron	1·5
Loss	·5
	34·

Carbonic acid about 10 cubic inches.

The Sherborne Spa Wells are situated at the top of the long walk from the colonnade in the High Street, between

Thompson's Spa and the Old Well, and are connected with a spacious and elegant pump room. There are four wells.

No. 1. Sulphureous and chalybeate. In a pint,

	Grains.
Muriate of soda . . .	3·31
Muriate of lime . . .	1·23
Muriate of magnesia . .	a trace
Sulphate of soda . . .	4·37
	8·91

Oxide of iron probably half a grain in a gallon.

No. 3. The pure saline water. In a pint,

	Grains.
Muriate of soda . . .	72·8
Muriate of lime . . .	4·29
Muriate of magnesia . .	·59
Sulphate of soda . . .	6·76
	84·44

No. 4. The magnesian water. In a pint,

Muriate of soda	1·67
Muriate of lime . . .	1·85
Muriate of magnesia .	a trace
Sulphate of soda . . .	2·43
	5·95

Epsom Water.

We shall proceed now to consider the Epsom water, which, though scarcely ever employed in medicine, deserves a particular notice as being one of the first saline purgatives brought into use, and because the salt to which it owes its property was long prepared from the water, and known over England and the continent by the name of Epsom salt, and to the chymist as sulphate of magnesia. The source whence it is at present obtained has been previously described.

The spring that yields this saline water is situated about half a mile from Epsom, in the county of Surrey, about sixteen miles from 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 tasteless, but leaves a decidedly bitter and saltish taste on the tongue. It does not change materially by mere exposure to the air, and it keeps well for months in bottles if closely shut. It has never, however, been analysed with any considerable accuracy, but the contents are principally sulphate of magnesia, with but a small portion of the muriates of lime, soda, and magnesia.

Barnet Water.

We might enumerate several other simple saline springs, all of which agree with that of Epsom, in containing as their most active ingredient a notable proportion of some purging salt. This is for the most part either Epsom or Glauber's salt, or both. The neighbourhood of this metropolis abounds with many such waters, and we may particularly mention the waters of Barnet in Hertfordshire, of which the following analysis was published in 1812. In one gallon,

	Grains.
Sulphate of magnesia . .	96
Muriate of magnesia . . .	12
Carbonate of lime	16
Sulphate of lime	24
Extractive matter	7
	155

Of this kind are also the waters of Streatham in Surrey, even now in some resort, Richmond in Surrey, Acton, Kilburn, Bagnigge, and St. Chad's wells. The Dog and Duck in St. George's Fields acquired formerly much reputation from the recommendation of Dr. Fothergill. These are probably not sufficiently saline to be certain in their operation on the bowels, except when taken in excessively large quantities. It is therefore a common custom to quicken their operation by the addition of some of the same salts which give to them their properties, but by this means they must be considered to lose all pretensions to the title of natural medicated waters. Mineral springs possess their rise and fall, and possibly the time may soon come when their use, or perhaps the notion of their efficacy, may be exploded altogether.

CHAPTER VI.

On the internal use of water as an article of diet.

Having treated of the various waters which may be obtained either naturally or artificially, and of those natural waters which have acquired medicinal reputation either from their purity or the nature of their mineral or saline contents, it will not perhaps 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 *injecta* must be supposed to have a constant and powerful agency upon the animal machine at all times. The share which water has in assisting the process of digestion claims the first attention, and in this the obvious use of water is that of holding in solution and conveying in a proper form the other materials which constitute the solid food of animals. Water should therefore be the fluid the most fitted of all others for suspending in a liquid state all the varieties of animal and vegetable matter; and its peculiarities as such an agent we have described in the former portion of this work. But, besides being subservient to the preparation of food within the stomach, water is itself an aliment highly necessary, in order to preserve that due proportion of solid to fluid matter on which depends the preservation of life and the proper performance of the animal functions.

The process of digestion may be described as a complete chymical operation, performed by the solvent power of the gastric juice, and the action of the stomach itself upon its contents. It may thus be considered whether or not an undue deficiency or excess of water may not weaken the action of the gastric juice; but this, and the utility of water as an article in the materia medica, are subjects interesting for the physiologist, and not within the range of the phenomena which it belongs to the chymist to elucidate.

It is not, however, in the process of digestion alone that water is an important auxiliary, but it enters largely into the composition of the animal body, assists in the evolution of the solids, and composes the greater part of the fluid excretions. During the whole course of circulation, the fluids are becoming unfit to remain a healthy part of the living animal, and when become detrimental are regularly removed by the excretories of the lungs, the skin, and the kidneys,—a removal of noxious matter as essential to the health of the body as the daily supply of food to the mouth. What strongly proves its necessity as such an agent is supplied in the many well authenticated instances of persons having lived long on water alone in situations where they were prevented from receiving any supply of solid aliment from without. Persons unfortunately buried in the snow, or miners shut up from the air by the falling in of the earth whilst at work under ground, have lived for many days and survived such an accident.

Much has been written by eminent medical practitioners concerning a proper selection of the water to be used in various forms as common drink; and our 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 strong grounds for this caution; for any considerable impurity in a liquid which makes so large a portion of our diet must undoubtedly in some way be found to affect the animal economy. Dr. Heberden, an accurate observer and judicious practitioner, and more recently Dr. Lambe, particularly insist upon this point, and recommend, 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. Experiments do not, however, yet satisfactorily determine what are the inconveniences really produced by using a water loaded with foreign ingredients. It is certain that the salts which give the quality of hardness to spring water are always to be found, in one form or other, in the fluids of the body in the best state of health, and appear to be necessary to the constitution of these fluids. Thus the component parts of selenite and common salt are found in the serum of the blood, in the urine, and other secreted fluids; and, even if they may be considered merely excrementitious, it would appear that in common cases, and a healthy state of body, the usual course of circulation is sufficient to throw them off in the excretions. Hard and impure waters have long laid under the imputation of producing calculous complaints, and have therefore been strictly forbidden to patients labouring under these disorders; and it is unquestionable that in many instances such are found to increase the painful symptoms of this most distressing complaint. It must, however, be confessed that the chymical analysis of these concretions throws but very little light at present on their formation, except to render it certain that it is by no means to a simple deposition of the earthy salts of water that we can date the formation of calculi. Sometimes hard waters appear to be decidedly noxious, particularly in producing dyspeptic and other complaints.

Water drinkers are in general longer livers, are less subject to decay of their faculties, have better teeth, more regular appetites, and less acrid evacuations than those who indulge in a more stimulating dilutent as their common drink. This liquid is undoubtedly not only the most fitted for quenching the thirst and promoting true and healthy digestion, but the best adjutant to a long and comfortable life. Its properties are thus summed up by Hoffman:—"Pure water is the fittest drink for all ages and temperaments: and, of all the productions of nature or art, comes the nearest to that universal remedy so much sought after by mankind, and never hitherto discovered:" an opinion in which he is supported by most scientific and intelligent men.

The superiority of pure soft water is proved in many respects. Horses always prefer soft water: and when by necessity, or inattention, they are confined to hard water, their coats become rough and ill-conditioned, and they are frequently troubled with complaints. Hard water is known to produce a tendency to disease in the spleen of animals, particularly of sheep: and it is refused by pigeons, when they can procure that which is soft.

Vitruvius informs us that the ancients inspected the livers of animals in order to judge of the nature of the water of a country and the salubrity of its nutritive productions. From this source they derived instruction respecting the choice of the most advantageous sites for building cities. The size and condition of the liver is, in fact, a pretty sure criterion of the healthiness or unhealthiness of pasture grounds, and the salutary or deleterious quality of the water; bad water, especially that which is stagnant, producing in cows, and more particularly in sheep, fatal diseases, that have often their seat in the liver; as, for instance, the rot, which in marshy countries not unfrequently destroys whole flocks.

Great droughts, it is well known, have always been found highly noxious, if not in their immediate, yet in their ultimate effects.

It has been stated that in the East Indies the servants decline going to particular situations, on account of the injurious quality of the water. In Batavia the water is productive of fevers: and, in the parent state of Holland, it is so bad that it is generally abandoned for beer. In lord Anson's Voyage it is stated that the island of Luconia is remarkably healthy, and that the water found upon it is the best in the world. Lind tells us that the water of the river St. Lawrence occasioned fluxes in the crews of the fleet of Sir Charles Saunders. In Canada the water is bad; and at Senegal, and through the whole coast of Guinea, it is very unwholesome. In the island of Antigua there is no water but such as is preserved in tanks, from the rains, which corrupts in dry seasons, and swarms with vermin: and hence the Spaniards called it Antigua, signifying old, dry, and parched. Van Swieten writes that the scurvy, which he treated in Holland, was usually much abated in spring and autumn by making use of whey for common drink, and thereby avoiding the stagnating unwholesome water so general in that country.

During the winter, there runs through Mancona, a village in Spanish America, on the road from Quito to Truxillo, a small rivulet of fresh water, to the great relief of the mules; but in summer it is so brackish that nothing but absolute necessity renders it tolerable. In Curtis's Diseases of India, he remarks, "no water was found here, except a little on the sea shore at Morebar on the coast of Arabia Felix; and the inhabitants of the fishing village from which the bay derives its name bring all they use from wells, several miles inland, on the backs of camels. The resource of the natives of Africa, in opening the stomachs of camels for a supply of water, is well known.

Nor is this want of water excluded from our own country. In many places in Essex the inhabitants suffer much from want of water. In the islands called Wallis, Fontness, and Cawey, the inhabitants have no other means of obtaining water than that of preserving rain water in pits, which they line with chalk, forming a kind of cement; and in this way they are compelled to keep it for months, especially in summer. When this water corrupts it produces very injurious effects. The air and site of Buckinghamshire is considered very healthy, yet considerable mortality took place a century ago from the badness of the waters.

The rivers Ganges and Nile are at particular seasons of the year very unwholesome. Alpini informs us that elephantiasis is endemial in Egypt. Galen ascribes this to the waters of the Nile, and Lucretius adopted the same opinion.

The chymical means that may be adopted for the improvement of impure water have been already explained. Some toasted biscuits put into the water of the river St. Lawrence were found serviceable in preventing its bad effects in the fleet of Sir Charles Saunders. At Senegal, where the water is extremely unwholesome, unslaked lime has been used to purify it. The mischievous tendency of impure waters, where they cannot be corrected by chymical processes, seem best to be counteracted by bitter vegetables, and Virey supposes that it was this fact which first induced the Chinese to infuse the leaves of the tea plant, and led to the introduction of this now common and popular beverage.

In Hayne's India, a person of the name of Beaumont is said to have offered for £25,000 to disclose the secret of converting salt into fresh water in a large quantity without heat and at very little expense: the process is, he says, so simple that he can scarcely speak of it without betraying the secret; other plans similar to this have been proposed but they are too ridiculous to be noted.

Public attention has been very recently called to the state of the water supplied to the metropolis, by the publication of a pamphlet called the Dolphin, the object of which was to prove that water is supplied to the Metropolis in a very unwholesome and polluted condition. The excitement produced in the mind of the public, it is well known, terminated in the appointment of a Parliamentary commission of Dr. Roget, and Messrs. Brande and Telford.

It will be curious to observe how much excitement was produced, and interesting to peruse the evidence which has been brought forward respecting the unwholesomeness of the water. They are as follows.

Sir *Henry Halford* pronounces the water sent into his house to be a filthy fluid, with which he is disgusted. Mr. *Thomas*, the surgeon, tells us it is saturated with decayed vegetable matters, and other substances prejudicial to health. Dr. *Hooper* is convinced that such matters in the stomach greatly contribute to the production of that state of faulty digestion, and impurity of blood, of which the inhabitants of the metropolis are constantly complaining. Mr. *Keate*, the surgeon, avows it to be his opinion, that it is so filthy and impure as to be unfit for the breakfast table and for culinary purposes, and that it adds so much to the other unwholesome constituents of bread as to render every meal injurious to the health of thousands. Dr. *Turner* asserts that the water sent into his cisterns, during the hot weather, frequently became quite putrid; and Dr. *J. R. Hume*, of Curzon Street, has no doubt that the continued use of it without filtering is capable of producing deleterious effects.

Dr. *Yeates* says that the Thames water is *extremely bad, foul, dirty*, and *unwholesome*, from the great quantity of filthy matters continually pouring into it from *numerous sewers*. He instances a disease which prevailed to a very serious extent, which he had himself traced to the impurities of the water of domestic use.

Dr. *Kerrison* makes us acquainted with a fact, the perusal of which will excite the same disgust in the mind of the reader as we ourselves feel in narrating it. On inspecting the Thames near the landing at Chelsea Hospital, he says, he saw "the foul and black stream from the Ranelagh sewer, passing between the Company's steam engine and the Dolphin, loaded with no small portion of UNDIVIDED FLOATING FILTH FROM PRIVIES;" from which he concludes that "a *considerable quantity of human excrement, in a subdivided and undecomposed state, actually passes into our cisterns.*"

Dr. *Summerville*, the physician to Chelsea Hospital, states the water to be very impure. "The tide," he says, "stirs up the MASS OF IMPURITY produced by all that is corruptible in the animal and vegetable world, together with the noxious filth of gas and other manufactories, that constantly flow into the Thames from Battersea down to Gravesend." Alluding to the water supplied to his late residence in Hanover Square, he adds, that "it was not only frequently, but generally, *extremely impure, fœtid, and offensive;* that it deposited much mud, and often enough to render its colour blackish.

Dr. *James Johnson,* the author of the "Treatise on Indigestion," pronounces the water to be disgusting to the sight, and the effluvia to affect the senses. Until he changed his residence he was affected with pain after taking his breakfast, which he attributes to the water. He states the fact of several young females who had been affected with bowel complaints from the same cause. If they went out of town a few days, and drank other water, the complaint subsided, but often returned on their again drinking this water. There was a scum on the surface of the water of an oily nature, and the deposit is immense. When his cisterns were cleaned out, the smell rendered the house very uncomfortable. "We sneer," says the doctor, "at the delicacy of the Hindoo, who slakes his thirst at the same tank where his neighbour is sacrificing to Cloacina; but what shall we say to the delicate citizens of Westminster, who fill their tanks and stomachs with water from the Thames, at that very spot into which *a hundred thousand cloacæ, containing* EVERY SPECIES OF FILTH AND ALL UNUTTERABLE THINGS, are daily disgorging their hideous and abominable contents. It is absolutely astonishing that in these days of refinement, and in a metropolis whose inhabitants pride themselves on delicacy and cleanliness, a practice should obtain, at which posterity will shudder, if they can credit it. A time *must* come when the people will open their eyes to this scene of corruption, veiled and concealed as it is by iron tubes and stone pavements. It is probable that part of the insalubrity of the metropolis, as compared with the country, may be owing to this cause."

The last professional gentleman to whose evidence we shall refer is Dr. *Paris,* the author of the popular work on diet. He pronounces the water to be *impure and offensive,* and says that it stinks shortly after it has come in. Large quantities of matter are mechanically suspended in it. The

Company send in mud with the water, and then complain that the cisterns are not kept clean. He states that a family whom he attended last autumn were all ill, and he believes it arose from drinking this water. "As a physician," he says, "I cannot find terms sufficiently expressive of *the awful effects it may be likely to produce upon the health, and even lives,* of the inhabitants of the metropolis." And in the last edition of his work he goes still further, and asserts that, "if a remedy be not applied to the evil, *the ravages of some epidemic may be fairly anticipated.*"

Mr. Mills, the engineer, tells us that the Thames is neither more nor less than THE COMMON SEWER OF LONDON, so far as it receives the contents of all the sewers; which on the north side are ninety-nine, and on the south forty-six. The water taken up opposite some of the sewers at the time of discharge is nearly the substantive contents of those channels of human ordure. Mr. Joseph Evans has often seen the sewers discharging black slimy liquid, with gas, oil, dead animals, entrails from the slaughter-houses, and other filth too disgusting to name. Mr. Goodhugh, the fishmonger, says that the Company's water is muddy and offensive: if fresh fish are put into it, they will not live more than six hours, and turn of a yellow colour. Mr. Butcher, a fish-salesman, states that he considers the water to be very bad, and that he has known three parts of a cargo of eels to die by the gas-water passing the vessel. Mr. Newland, the master of a Dutch vessel, says, that out of 26,000lbs. of eels, the cargo of two boats, only 9000 lbs. were marketed alive: they became sick on being put into Thames water, and soon died; they changed colour, and became spotted like snakes. Another captain says that he has known 3000 lbs. weight to die in half an hour, and that, if the water get worse, they must give up the business.

The last evidence we shall quote from is that of Mr. Goldham, who has held the respectable office of Inspector and Clerk at Billingsgate market for 25 years. He says he has known 50,000 smelts brought daily to Billingsgate, and 3000 salmon in the season caught in the Thames. He adds that they are now all destroyed, and this fishery gone; and this he attributes to the impure state of the water, from *the refuse of the gas-works*, from *all the common sewers running into it*, and the steam boats constantly stirring up the filth. He has seen 4000 eels alive at night in the Dutch boats, and the next morning three-fourths have been dead. Many fishermen have been ruined by the change.

This publication was followed by the introduction of filtering machines by different proprietors. The principles of filtering, and the effects of this mechanical operation in removing those substances which are held in suspension by the water, have been already explained. It is impossible to decide upon the respective merits of these different machines: those of James and Robins I have found to be most successful in removing gaseous impregnation, and these filters produce a water of great purity and value.

The practice of bathing is of very great antiquity, and its external medicinal application long preceded the internal administration of water. In this way it was either used for simple ablution or for purposes of medicine, but its application and uses belong to the medical enquirer.

CHAPTER VII.

Of water as named in Holy Writ.

As there can be no task more truly delightful to the devotional philosopher, who is animated with proper feelings to the great author of his Being, than to pay the proper tributes of science to the oracles of his God, and make every study subservient to that pleasure which only such contemplation can afford, so I trust that the introduction of some observations upon water as named in Holy writ, not being irrelevant to the design of the present work, may be interesting to the devotional reader.

The inspired record is entirely silent as regards the first creation of this fluid, designed for such great and important uses in the economy of animated structure; but, as the completion of the great schemes of Omnipotence contained no less *power* in execution than it did *might* in design, the celestial mandate was probably of equal interest to that which said, "let there be light." The issue of the command that the waters should be separated from the waters was nobly answered by the firmanent, without which this fluid could not possibly exist upon the earth, and animated nature must have been extinguished by a drought.

The mention of water often occurs in sacred writ. It was the instrument of that signal vengeance of the God of nature, against a rebellious and sinful world, than which nature never saw a grander phenomenon throughout its duration, and which has left so many monuments on earth of what his Almighty power can do, and of his manifest displeasure to all the workers of iniquity.

The nature of rain, which was one cause of this grand catastrophe, is beautifully expressed in the book of Job: "From the place whence the waters came, thither they return again." Rain is known to be produced by the evaporation of water from the earth and seas, and which vapour, being condensed, is precipitated in this form. But little is expressed in divine revelation respecting the meteorology of the antediluvian world; but the following passage affords grounds for belief that rain was then unknown:—"For the Lord God had not caused it to rain upon the earth, and there was not a man to till the ground; but there went up a mist from the earth and watered the whole face of the ground."

This assumption is likewise supported by another probable opinion, that, before the by flood, the earth was a sphere of uniform heat. Were such the case, atmospheric commotions could not exist, and rain would be unknown, but instead of it copious dews would precipitate, to irrigate the surface of the soil. The commotions which attended the globe at the time of the flood would, however, introduce a new order of things. And now came the meteoric ensign of placated deity. Had there been rain before the flood, according to the laws of refraction and reflection, the phenomenon of the rain-bow must always have existed, but its probable first appearance after this event is sanctioned not only by the sound doctrines of philosophy, but by the records of Christian faith.

Water is often named in sacred writ under circumstances of great interest, as the medium of a peculiar display of the power of Divine Providence. Such was the time when Pharaoh was troubled by the waters being turned into blood. The water of the Nile, although celebrated for its peculiar salubrity and excellence, is yet at the periods of its overflow rendered extremely turbid by the alluvial matters which it contains in suspension. On such occasions the Egyptians are compelled to filter the water, and for this purpose they use vessels of wood, and vessels of stone, and thus the fouled water is made clear and salubrious. It is probable that these are what are meant by Moses, when he names the vessels of wood and vessels of stone, and that, on the occasion referred to, the water was not merely fouled as before, but coloured permanently as with a mineral solution, which their usual practices could not remove.

This, and other miracles, must be considered as supernatural dispensations of Providence, on such occasions as required an extraordinary exhibition of Almighty power, either to show the capability of his omnipotence to perform, or his willingness as a God of mercy to assist the children of men. When performed through the medium of mortal agency, such miracles were always preceded by a solemn appeal to the feelings of the witnesses, and attended with an equally solemn exhibition of supreme power.

The subsequent observations on certain cases in which this important fluid was a peculiar agent will, I trust, be found to throw some light upon what may otherwise be considered obscure passages of Holy writ.

"And Moses took the calf which they had made, and burnt it in the fire, and ground it to powder, and strewed it upon the water, and made the children of Israel drink of it." Exodus xxxii. 20.

There are perhaps few passages of Scripture which meet with more cavil from sceptics than this; yet the only point which is apparently tangible is that, as here no miracle is implied by the sacred writer, the act was merely suggested by the wisdom of Moses; and this, by taking the passage in its literal sense, implies him possessed of more knowledge than chymists of the present day.

It is here asserted that Moses burnt the golden calf in the fire. Gold it is well known will endure the most intense heat long continued, without being oxidised, even although kept in a state of fusion. By burning it in the fire, we are not, however, to understand that any actual combustion took place. Chymistry, both in the language of the Arabians and the Egyptians, had a name which signified the science of fire, as it was from this agent that the most important changes in their operations were produced.

There is no reason for believing that the chymical knowledge of Moses was limited to the action of heat upon substances, as this passage may be considered rather to imply that he submitted the gold to a chymical process. It was long since observed, by Stahl, that gold, when fused with an alkali, formed a compound soluble in water. Gold is also soluble in nitro-muriatic acid, and the compound thus obtained is crystallizable, and also soluble in water. Each of these solutions is intensely nauseous to the taste, and the children of Israel were probably compelled to drink the water in which the golden calf had been strewed, because it was by this means rendered disgustingly nauseous to their palate.

"And when they came to Marah they could not drink of the waters of Marah, for they were bitter; therefore the name of it was called Marah. And the people murmured against Moses, saying, what shall we drink? And he cried unto the Lord, and the Lord showed him a tree, which when he had cast into the waters, the waters were made sweet." Exodus xv.

Bitter waters, similar to those of Marah, are recorded by travellers as very common in Arabia. They were formerly supposed to owe their bitterness to bitumen, and, as such, they are described by most biblical writers, but may more properly be considered solutions of muriate of lime and magnesia, two salts often present in water and peculiarly distinguished by their bitter taste, and which have been detected in the waters in Persia. In the description of this event, no particular interposition of an Almighty power is recorded, and it might be performed merely by what the chymical knowledge of Moses would suggest.

Carbonate of potash is contained largely in all plants: of some it constitutes the largest proportion of their ashes. This, if thrown into the water, would decompose the muriates of lime and magnesia, the carbonates of these earths would precipitate, and muriate of potash remain in solution, this being a salt which would not render the water at all unpalatable or unwholesome.

"And the men of the city said unto Elisha, behold I pray you the situation of this city is pleasant as my lord seeth, but the water is naught, and the ground is barren. And he said, bring me a new cruse, and put salt therein; and they brought it to him. And he went forth unto the spring of the waters, and cast the salt in them, and said, thus saith the Lord, I have healed these waters, there shall not be from thence any more death or barren land. So the waters were healed unto this day, according to the saying of Elisha, which he spake." 2 Kings ii. 19—22.

The effects of the water complained of by the men of the city will answer the description of a water saturated with sulphate of lime. Where this salt is present to much extent, the water is not only noxious to the health, but unfit for all purposes of domestic economy, and for vegetation.

Besides common salt, such as is generally used for culinary purposes, trona or carbonate of soda, as being very common in Egypt and Arabia, is extensively used in the arts, and for purposes of domestic economy. This might probably be the salt supplied to Elisha, and which by its being thrown into the water would produce a decomposition of the sulphate of lime, carbonate of lime would precipitate, and sulphate of soda (Glauber's salts) remain in solution; and the spring would not only be softer and more fitted for all domestic purposes, and for vegetation, but would even contain some medicinal efficacy peculiarly valuable in this climate. Here then we may account for the phenomenon with great propriety upon chymical principles, but, as the effect of an experimental agency can only occur when under its immediate influence, the water could only remain so by a peculiar interposition of DIVINE POWER, which defied all human attempts to imitate, and the illimitable extent of which was rendered more forcible by its being contrasted with the feeble results of the efforts of human intelligence.

"If I wash myself in snow water, and make my hands never so clean."—Job. ix. 30.

That the beauty of the sacred writings is best perceived by referring to the minuteness and simplicity of its details, is an observation to which the consideration of the above passage necessarily leads. The detersive or cleansing quality of water is lessened in proportion to the quantity of earthy or saline matter which it contains. Every natural water contains more or fewer impurities; rain or snow water, or that which having undergone a natural distillation from the earth is condensed again in this form, is the purest, and as such is the most fitted for cleansing. Soap was probably unknown in the time of Job, and therefore the strongest simile which he could use was that of the purest water.

"For though thou wash thee with nitre, and take thee much soap, yet thine iniquity is marked before me saith the Lord God." Jeremiah ii. 22.

If instead of nitre (nitrate of potash) we read kali (carbonate of potash), the meaning of this passage is very obvious. In soap the causticity of the alkali is weakened by its dilution with oily or fatty matters, but it yet retains a detersive quality without the liability of injuring the animal texture. The detersive quality of the soap arises from the combination of the alkali with the resinous matters which soil the skin. Kali is much more detersive. The strength of the simile is increased by saying we have used much soap which is detersive; but, as that fails, we have tried the caustic and uncombined alkali.

A list of the most celebrated Medicinal Waters in Great Britain.

Aberbothwick,	Scotland,	Chalybeate.
Acton,	Middlesex,	Saline.
Agbaloo,	Tyrone,	Chalybeate.
Agnahinch,	Leitrim,	Sulphureous.
Alford,	Somersetshire,	Saline.
Anaduff,	Leitrim,	Sulphureous.
Arbroath,	Scotland,	Saline.
Ashton, West,	Wiltshire,	Chalybeate.
Askeron,	Yorkshire,	Saline.
Ashwood,	Enniskillen,	Sulphureous.
Astrope,	Oxfordshire,	Chalybeate.
Athlone,	Roscommon,	Chalybeate.
Balemore,	Worcestershire,	Chalybeate.
Ballycastle,	Autrim,	Chalybeate.
Ballydwood,	Dublin,	Saline.
Ballymurtogh,	Wicklow.	
Ballynahinch,	Down.	
Ballynphelik,	Cork.	
Ballyspellan,	Kilkenny.	

Bandwell,	Lincolnshire.	
Banden,	Cork.	
Barnet,	Hertfordshire,	Saline.
Barrowdale,	Cumberland,	Saline.
Bartholomew, St.,	Cork.	
Bath,	Somersetshire,	Saline.
Bilton,	Oxfordshire.	
Braughton,	Lancashire,	Saline.
Bromley,	Kent,	Saline.
Brownston,	Kilkenny.	
Broughton,	Yorkshire,	Sulphureous.
Bristol,	Somersetshire.	
Brighton,	Sussex,	Saline.
Bromley,	Lancashire.	
Broseley,	Shropshire.	
Brentwood,	Essex.	
Buxton,	Derbyshire.	
Carrickfergus,	Belfast.	
Cwergyle,	Wales.	
Cape Clear,	Cork.	
Carrick-more,	Cavan.	
Cartmall, New,	Lancashire.	
Castlecormell,	Limerick,	Chalybeate.
Castlemanil,	Kerry.	
Cawthorpe,	Lincolnshire,	Saline.
Chadington,	Oxfordshire.	
Chinkwell,		
Chippenham,	Wiltshire,	Chalybeate.
Cliff,	Northamptonshire.	
Clifton,	Oxfordshire.	
Cobham,	Surrey,	Chalybeate.

Cormer,	Berkshire.	
Coolauran,	Fermanagh.	
Cashmore,	Waterford.	
Crickle Spa,	Lancashire,	Sulphureous.
Cronebau,	Dublin.	
Croft,	Yorkshire,	Saline.
Crosstown,	Waterford.	
Cunley House,	Lancashire,	Sulphureous.
Castle-cormer,	Kilkenny,	Chalybeate.
Coal-cullen,	Kilkenny.	
Corville,	Tipperary.	
Coventry,	Warwickshire,	Chalybeate.
Clonmell,	Tipperary.	
Codsalwold,	Staffordshire,	Sulphureous.
Castleted,	Scotland,	Sulphureous.
Cawley,	Derbyshire,	Saline.
Colchester,	Essex,	Sulphureous.
Costorphine,	Scotland,	Saline.
College Spa,	Kilkenny.	
Canal Spa,	Kilkenny.	
Cheltenham,	Gloucestershire,	Saline.
Cheshunt,	Middlesex,	Saline.
Deddington,	Oxfordshire.	
Derry Inch,	Fermanagh.	
Derrindaff,	Cavan.	
Denylister,	Cavan.	
Digwell,	Cumberland.	
Drumasmane,	Leitrim.	
Dudley,	Worcestershire,	Chalybeate.
Donemaile,	Cork.	
Dunnard,	Dublin.	

Dunse,	Scotland,	Chalybeate.
Durragh.		
Dulwich,	Kent,	Saline.
Dublin,		Several springs.
Drumgoon.		
Derby,	Derbyshire,	Chalybeate.
Dropping Well.		
Durham,	Durham,	Saline.
Epsom,	Surrey,	Saline.
Fairburn,	Ross-shire	
Felstead,	Essex,	Saline.
Filah,	Yorkshire,	Chalybeate.
Galway,	Galway,	Chalybeate.
Glanmile.		
Glassenbury.		
Granshaw.		
Garry-Hill,	Carlow.	
Gainsborough,	Lincolnshire,	Chalybeate.
Glastonbury,	Somersetshire.	
Gundy,	Scotland.	
Haigh,	Lancashire.	
Hampstead,	Middlesex,	Chalybeate.
Hanbridge,	Lancashire.	
Harrowgate,	Yorkshire,	Sulphureous.
Hanley,	Shropshire,	Saline.
Hartfell,	Scotland.	
Hartlepool,	Durham,	Chalybeate.
Hermitage.		

Holt,	Wales.	
Howth,	Ireland.	
Holywell,	Flintshire.	
Holt,	Wiltshire.	
Huntingdon,	Huntingdonshire,	Saline.
Irmington,	Warwickshire,	Chalybeate.
Inglewhite,	Lancashire,	Chalybeate.
Islington,	Middlesex,	Chalybeate.
Joseph's Well,	Surrey,	Saline.
John's Town,	Kilkenny,	Chalybeate.
Kensington,	London,	Saline.
Kanturgh.		
Kilbrew.		
Killasheen,	Fermanagh.	
Killinshanvally.		
Killow.		
Killroot.		
Kilroran,	Clare.	
Kinatton,	Nottinghamshire,	Saline.
Kingscliff,	Northamptonshire.	
Kirby Tower,	Westmoreland,	Chalybeate.
Knaresborough,	Yorkshire,	Saline.
Killagee,	Down.	
Kellistone,	Derbyshire.	
Keddleston,	Derbyshire,	Sulphureous.
Kilburn,	Middlesex,	Acidulous.
Kincardine,	Scotland.	
Knowsley,	Lancashire.	
Kilkenny,		Sulphureous.

Loansbury,	Yorkshire,	Sulphureous.
Luz,	Essex,	Chalybeate.
Lincombe,	Somersetshire.	
Lisbleak.		
Lochness.		
Lough Neah.		
Lough Shenny.		
Leamington,	Warwickshire.	
Llandiddad,	Wales,	Sulphureous.
Lancaster,	Lancashire.	
Latham,	Lancashire.	
Mallow,	Cork.	
Malton,	Yorkshire.	
Mawdsley,	Lancashire,	Sulphureous.
Malvern,	Worcestershire,	Pure.
Moffat,	Scotland,	Sulphureous.
Moreton,	Shropshire.	
Mount Campbell.		
Milltown,	Clare.	
Mallay,	Clare.	
Markshall,	Essex,	Chalybeate.
Millar Spa,	Lancashire.	
Moss House,	Lancashire,	Chalybeate.
Neville Holt,	Lancashire,	Saline.
Newton Dale,	Yorkshire,	Saline.
Northall,	Hertfordshire,	Saline.
Nottington,	Dorsetshire,	Sulphureous.
Newton Stewart,	Tyrone.	
Newnham Regis,	Warwickshire.	
Normandy,	Yorkshire.	

Oily Well,	Edinburgh.	
Onston,	Northamptonshire,	Chalybeate.
Owen-breun,		
Oakfield,	Cavan.	
Oulton,	Norfolk,	Chalybeate.
Peterhead,	Aberdeen,	Chalybeate.
Pitakailly,	Scotland,	Saline.
Queen Cartmell,	Somersetshire.	
Road,	Wiltshire,	Sulphureous.
Ripon,	Yorkshire,	Sulphureous.
Richmond,	Surrey,	Saline.
Stanfield,	Lincolnshire,	Chalybeate.
Scarborough,	Yorkshire,	Saline.
Shale,	Westmoreland,	
Shapenoor,	Westmoreland,	Sulphureous.
Smith Quarry.		
Stornger,	Cumberland,	Chalybeate.
Stoke Common,	Surrey,	Saline.
Streatham,	Surrey,	Saline.
Sydenham,	Kent,	Saline.
Shuttlewood,	Derbyshire.	
Shipton,	Yorkshire.	
Swadlingbar.		
Swansea,	Wales.	
Sulton Bog.		
Scool,	Clare.	
Somersham,	Huntingdon,	Chalybeate.
Sende,	Wiltshire,	Chalybeate
St.Bornforth's Well,	Leeds	Saline.

St. Bernard's Well,	Edinburgh,	Chalybeate.
St. Erasmus Well,	Staffordshire.	
Thirsk.	Yorkshire.	
Tilbury,	Essex.	
Thore,	Westmoreland,	Saline.
Thorp Arch,	Yorkshire.	
Thetford,	Norfolk,	Chalybeate.
Tibsheff,	Derbyshire.	
Tralee,	Ireland.	
Tobben-bonney.		
Tewksbury,	Gloucestershire,	Saline.
Tullagham.		
Thetford,	Norfolk.	
Tunbridge,	Kent,	Chalybeate.
Thornston,	Nottinghamshire,	Chalybeate.
Tarlton,	Lancashire,	Chalybeate.
Tarlington,	Lancashire.	
Upminster,	Essex,	Saline.
Wallingford,	Northamptonshire,	Chalybeate.
Westwood,	Derbyshire,	Chalybeate.
Wexford,	Ireland,	Chalybeate.
Wigglesworth.		
Witham,	Essex,	Chalybeate.
Withesslack,	Westmoreland.	
Wardrew,	Northumberland,	Sulphureous.
Wilksworth,	Derbyshire,	Sulphuret.
White Acre,	Lancashire,	Chalybeate.
Wight, Isle of,		Chalybeate.
Wakefield,	Yorkshire,	Saline.
Windsor,	Berkshire,	Chalybeate.

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FINIS.

J. Haddon, Printer, Castle Street, Finsbury.