Essay on the nature and uses of natural spas : from A first trip to the German spas, and to Vichy / by John Aldridge.

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FROM

"A First Trip to the German Spas, and to Vichy."

By JOHN ALDRIDGE, M.D., M.R.I.A.

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SPRINGS, fountains, the sources of rivers, &c., have always been regarded with superstitious feelings; whether they were supposed to be under the guardianship of the ny nphs of ancient mythology, or sympathetic to the rod f the Rosicrucian diviner. In these latter days, fays and wizards have given way to the mysteries of pseudo-science; and it is with subtle electrical and telluric influences that the natural love for the wonderful and marvellous is principally supplied. With some eminent exceptions, the majority of the writers upon Spas have either ignorantly or wilfully pandered to this appetite. They talk of Spas having their mysterious sources in the bowels of the earth, or in the entrails of the mountains;—of their electricity and caloric being different from any other electricity or caloric, being generated on the volcanic hearth;—of their being concocted by the cunning chemistry of Nature herself;—and of many other specious and unfounded speculations. To show that I am not overcharging the statements of these gentlemen, nor unwarrantably accusing them of investing the subject of Spa treatment with an awful obscurity which does not properly belong to it, I shall quote a few passages from the writings of some of the most distinguished.

Thus, Dr. Peez, speaking of a bathing arrangement at Wiesbaden, quotes approvingly a saying of Dobbereiner's, in which he speaks of the patient "keeping himself in immediate connexion with that great galvanic chain, from which the spring derives its existence and sanative quality." Now, this very Dobbereiner is accused by M. Émile Jacquemin with having given an erroneous analysis of Selters water, for the purpose of countenancing a fabricator of artificial Selters in Paris. So much for the authority of Dobbereiner. "As to the original cause of the mineral springs of Nassau" (says Kastner), "they, especially the hot ones, most probably are of volcanic origin; and it is remarkable that they issue in the vicinity of volcanic mountains, and that the hot ones proceed from the relatively *older*, and the cold ones from the relatively *younger* formation of rocks; that the former are not at all affected by the change of the seasons and the state of the atmosphere, viz., rain, dissolving of snow in spring, inundations, &c., &c., whilst the latter are sensibly influenced by them. I suppose that the hot springs are formed by a continued *oxidation of inflammable gases, rising from volcanic hearths*, in a considerable depth, and thus, not only pure hydrogen, as well as sodium, potassium, &c., &c., are burnt, all at the expense of the oxygen of the atmospheric air, which, having penetrated to a great depth, has been considerably condensed." Now, I need not say to any one possessing an acquaintance with chemistry, that all the assumptions contained in the last sentence of the foregoing paragraph are perfectly gratuitous; yet the feeling left by its perusal on the mind of the unscientific reader would be one partaking of awe and perplexity.

Dr. Granville, writing about the Sprudel at Carlsbad, says:—"The sudden view of the violent, lofty, constant, and prodigal up-pourings of hot water out of the bowels of the earth, foaming in the midst of its clouds of vapour, within 45° of the boiling point, on the very margin of a

cold, placid, and sluggish stream, the Teple, riveted me to the spot for some moments. . . . A central fire! One must see the Sprudel, to be a convert to that doctrine." Again, in another place, he says:—"Be this as it may, the consideration of thermal or telluric heat is one of intense interest, and ought to form, in my opinion, a leading feature in the estimation of the power of a mineral water." And again:—"Heat, therefore, would seem to be specific in its action, and, therefore, dissimilar from ordinary heat." Whatever Dr. Granville's motives may have been, it cannot be denied that the language of the extracts quoted is calculated to invest the consideration of thermal Spas with a high amount of mysterious interest.

Dr. Constantin James, one of the best writers on mineral waters, and also one of the most modern, says, speaking of factitious waters:—"Comme s'il existait la moindre analogie, la moindre comparaison entre les Eaux, soi-disant minérales, qui sortent de nos officines, et celles que la nature elle-même fait jailler de ses merveilleux laboratoires!" It is here intimated that there are two kinds of chemistry, one *artificial*, practised by man; and another *natural*, carried on in certain marvellous laboratories.

It is unnecessary to multiply quotations, for those which I have extracted demonstrate that, in the opinions of their authors, there is something mysterious and awful in the natural mineral Spas; and that these characters appertain—

1st. To their secret electricity.

2nd. To the peculiar nature of their temperature.

3rd. To their origin in the bowels of the earth.

4th. To their composition, by Nature herself, in her own marvellous laboratories.

I shall take the liberty of saying a few words on each of these supposed peculiarities of mineral waters; and, first, as to the secret electricity of the natural waters, there is an old Latin adage which I may thus translate:

"That which has never been proved, you should not suppose to exist." Now, Kastner is the only one who has endeavoured to prove the existence of free electricity in mineral waters, and when his experiments were shown by Walker to be fallacious, he sheltered himself by stating, "that the mineral waters, in the state in which they issue from the earth, exercise no influence upon the unarmed siderometer, but that this influence takes place in a high degree with the *subsequent spontaneous decomposition of the water.*" To be sure it does; we all know that electricity is developed by chemical decomposition. So then, by this admission, mystery No. 1 is got rid of; and we may receive it as a fact, in the present state of science, that the natural mineral waters are not electrical.

Secondly, as to the alleged peculiar nature of their temperature, it is at once admitted that we do not know by what precise means the thermal mineral springs are heated; it may be by a "volcanic hearth" or a "central fire," for aught we can tell. We know that here upon the surface we have many ways of generating heat. But this we also do know, that whatever way we generate it, the heat we accumulate is always the same in its essential nature. It may perform very different functions; it may in one instance increase the bulk of a body, in another raise its temperature, and in a third change its state, but nevertheless it is the same caloric still. Whether you get it from a flint and steel, or from rubbing together two dry sticks, or by boring a cannon, or by concentrating the rays of the sun, or by chemical action, or by combustion, or by the electric current, it will equally expand water to the same amount, boil it at the same temperature, and produce a steam of the same elasticity. Hot dry air, may afford different sensations from hot moist air; but this arises from a combination of influences, not from any difference in the nature of the heat. The Geysers of Iceland will boil a kid, although there is no doubt of their volcanic origin;

and the Urspung at Baden will scald a fowl, just as well as if the water had been heated by an ordinary wood fire. The arguments employed to show that *tellurie* heat (there is so much virtue in a fine name) differs from the ordinary caloric, to which we are accustomed on the surface of the earth, exhibit such an ignorance of physics, that it is really degrading to be obliged to notice them. Thus it is said that thermal mineral waters take a longer time to cool than pure water; certainly they do, and so does every saline solution. We may, therefore, conclude that mystery No. 2 has no real foundation; and that the warmth of a mineral water is due to precisely the same imponderable agent as gives warmth to any other substance at the same temperature.

Thirdly, as to the origin of mineral waters in the bowels of the earth, the majority of writers who use this language only employ it in a figurative sense; Dr. Kastner does indeed speak of "the oxidation of inflammable gases rising from volcanic hearths;" but the observation of the Geysers of Iceland abundantly demonstrates, that in those remarkable instances, the water is nothing more than rain or snow water which is absorbed by the sides of the mountain (Hecla), and, penetrating the soil till it comes to strata rendered very hot by the vicinity of the combustion always going on within its crater, and being thus made to boil, it bursts through openings in the ground, produced partly by its own gravity, and partly by the pressure of accumulated steam; and leaps into the air in the form of a magnificent fountain. When Dr. Granville, absorbed in admiration of the Sprudel at Carlsbad, exclaimed:—"What is it that imparts to this mysterious current that violent impulse, which makes it spring from the bosom of the earth, with an upright jet of eight or nine feet elevation from the aperture in the rocky crust underneath the building raised over it; and which at times even propels it with convulsive and vehement throbs more than one foot above

the height of the spectator, who stands on a floor five feet higher than the lowest level of the source?"—if, instead of jumping to the poetical conclusion of "a central fire," he had asked himself, how would he set himself to produce similar phenomena, I am inclined to think that the place he would put his fire would be under the boiler of a steam-engine, in order to pump water into a sufficiently elevated cistern, from which, being permitted to descend through a pipe by its own gravity, it would, when allowed to escape, spring up in an upright jet, or one at any other angle, according to the direction of the opening; just as we have seen the fountains at Sydenham or Versailles, by virtue of the law which makes water seek its own level; and of a volume and height in proportion to the elevation of the cistern, and the caliber of the tubes. And if he wished to cause this fountain to play at a temperature 45° below the boiling point, or even at a higher heat, what easier than to make a coil of the conducting pipe to pass through a furnace? There is no necessity for a central fire, or any other mysterious assumption, to account for phenomena much more gigantic than the vaunted Carlsbad Spring.

The fact is, people are apt to forget that these Spas, brunnens, mineral sources, or whatever you please to call them, are nothing more or less than springs of water, exactly analogous to those we see trickling or bubbling through the side of a hill; or to the wells which we sink by digging a pit in the ground, and quarrying the rock at the bottom. Do not imagine that there are springs only in this or that locality; wherever you put your foot, except, perhaps, on the very top of some lofty mountain, you place it over what is capable of becoming a spring. A professional well-sinker will tell you that he will undertake to find water in any situation, if you give him license to go deep enough. If you dig a pit in the alluvial soil, and cover it over, it will soon contain water, from the rain-water absorbed by the soil

percolating through the sides of the pit. This water is apt to be impure, from the organic and other matters mixed with the surface soil. If you quarry into the underlying rock, you come, in time, to a stratum full of fissures, or a layer of gravel, and from this, also, a purer and brighter water will flow in greater or less abundance. This also is rain-water, which fell on a soil at a distance from your well, and where the stratum of rock from which it proceeds was the uppermost. The rain or snow-water, absorbed by the superficial soil, sinks until it is arrested by a stratum of rock, unless the latter be porous, in which case it trickles through the pores in the direction which gravity indicates; but if you sink a well into this porous rock, the water will rise in the well, from the tendency that water has to seek its own level, and, of course, the higher, the greater the elevation of the soil into which it originally penetrated. The more extensive the curve formed by a porous rock, the greater the surface from which it derives, and the more abundant the spring of water which it affords. The strata of rocks in a valley may be likened to a nest of bowls, the one within the other, when, of course, the largest bowl will be the most external. An artesian boring yields a larger supply of water, simply because, by penetrating to a great depth, you reach the outermost or largest porous basin. The temperature of the spring will be that of the stratum through which it precolates; if the latter be elevated by its vicinity to volcanic fires, as in Hecla, or by any other heating agency, the spring of water will escape, of a corresponding temperature. I am ashamed to be forced to enter into explanations so very elementary: but when I find instructors of the public mind writing for the educated classes, and talking of mineral waters springing from the bowels of the earth, and generated by the combustion of gases on volcanic hearths, it is necessary to re-enunciate principles familiar to the frequenters of every Mechanics' Institute.

Let the reader compare these simple principles with the description of the apparatus, which I have before suggested, for the production of a thermal fountain similar to that of Carlsbad, and he will find the cases precisely analogous. Water, descending from a height through pipes or pores, heated during its transit, and escaping below through a vent, are the conditions in both instances.

But, it may be said, you have shown that the phenomena are capable of being explained by causes known to be in active operation, in some instances; but you have not disproved the existence of a central fire, nor that water is generated in the interior of the earth; nor have you shown that volcanic action is going on near the trajet of all thermal springs. To these objections I reply: as to the first and second, no man of common sense, not to say a logician, will admit postulates or hypotheses when there are existing facts sufficient to constitute data for his reasoning; and, as to the presence of volcanic action, it is not necessary—any source of heat will do equally well; but in the neighbourhood of most, if not all, of those springs, there are basaltic rocks, the remains, it is said, of extinct volcanoes:—that they are not extinct, the thermal water is to me a sufficient evidence; and, in the instance of the Geysers, we have an undoubted example of volcanic action being the cause of hot springs.

So there is an end of mystery No. 3; and we conclude that the natural mineral Spas are exactly analogous to the most ordinary springs of water. The fourth assumed mystery is all that now remains for our consideration; and we shall find that it has no more foundation, in fact, than any of the others. When a person speaks of the operations "of Nature herself in her own marvellous laboratories," he is, of course, speaking allegorically or symbolically; he does not intend to personify Nature, nor to localize her phenomena, literally; nor does

he mean that man, in the contrast, has any means at his disposal but what are natural: if he truly attaches any distinct or intelligible meaning to his words, it must be that there are certain chemical phenomena observable in the mineral kingdom, which man cannot, with his present knowledge, imitate. I say the mineral kingdom, because, when speaking of the formation of mineral waters, there is no question about animals or vegetables. It will not be asserted that there are *no* chemical phenomena observable in the mineral kingdom, which man can imitate;—because it is very certain that there are many; and, actually, the question limits itself to this: is the composition of a spring-water a phenomenon which man, with his present knowledge, can imitate, or is it not? Can the chemist analyze a natural water, and ascertain what are its constituents? Yes, he can do so, and determine each of them to the hundredth part of a grain, with an accuracy which is not equal to—for that may be looked on as a mere figure of speech, but absolutely is—an algebraic equation; for no chemist, deserving of the name, would be satisfied with less. And what does he find by his analysis? Why, that the natural water is a solution of certain salts and gases in water. Can he make a solution of those salts and gases in water, similar to the natural water? Yes, with quite an equal degree of perfect admixture. And I will now undertake to demonstrate, that he does so by precisely the same laws and forces as the poetically personified Nature herself does, in her marvellous laboratories.

For, how does the chemist procure carbonic acid? He does it by the combustion of carbon—by the decomposition of a carbonate, by means of heat or an acid; or, by the fermentation of organic matter in the presence of oxygen. And, does not Nature prepare carbonic acid in precisely similar ways? Look at the Table of Analysis of the Mineral Waters, and you will perceive the usual

absence, or deficient quantity, of organic matter—the almost constant absence of dissolved oxygen, and an excessive amount of carbonic acid—while the more perfect the examination, the more decided is the presence of nitrogen. In rain-water, oxygen is dissolved in a comparatively greater proportion than nitrogen: carbonic acid is also present in small quantity; and, while percolating the alluvium, a large quantity of organic matter becomes dissolved. These facts mutually explain each other. In flowing along the gravel, between the strata, fermentation takes place, the oxygen is consumed, the organic matter rendered insoluble or destroyed, and an increased amount of carbonic acid generated. It is just what happens to Thames or Ganges water, put into casks for a sea voyage. These most filthy of rivers, after suffering a due amount of putrefaction, during which a black, pitchy matter is thrown down, yield the most brisk, the best keeping, and agreeable of waters that the sailor can desire. I do not say, that the whole of the carbonic acid found in mineral waters is derived from fermentation; but we have seen that Nature has other resources, similar to those employed by the chemist, to aid her in its production.

If the chemist wishes to analyze a siliceous mineral, he decomposes it by an acid, or an alkali, having first reduced it to fine powder; and, in a similar manner, Nature, using the friction of running water, and a solution of carbonic acid as her solvent, decomposes the felspars and micas that lie in her path, washing out the alkalies as soluble carbonates and silicates, and leaving the remainder, as we so frequently see, as an insoluble kaolin.

If the chemist wants to dissolve earths or metallic oxides, he agitates them, under pressure, with an acid solution; and Nature, following the same plan, causes the solution of carbonic acid to force its way, under a

heavy hydrostatic weight, through mixtures of carbonates of lime, magnesia, protoxide of iron, &c., and with the same results.

Or, if one seeks to obtain sulphuretted hydrogen, he acts upon sulphuret of iron, or some other metal, by an acid; or subtracts oxygen from a sulphate by means of carbon; and Nature, in a like manner, acts upon iron pyrites by her carbonated water; or, by the action of organic matter, converts alkaline sulphates into sulphurets: at the same time usually generating carburetted hydrogen.

It is unnecessary to carry the parallel any further. It is quite plain, that there is no such thing as unnatural or artificial chemistry. The chemistry of man is the very chemistry of Nature; except that man, not following blind chance, but bringing reason to play, has succeeded in producing infinitely more diversified results than unassisted Nature has ever exhibited. Nature, as it is called, has been engaged for many cycles, producing about 800 minerals. Any modern book on chemistry will show that man has, in a few years, produced as many thousands.

No place can show the intimate relation between the nature of the strata and the composition of the mineral springs, better than the duchy of Nassau:—in the north, where primary rocks prevail, are found the alkaline springs of Fachingen, Selters, Geilnau, Ems, &c.; farther south, in the grauwacke, iron is superadded; below that is schist; and here, in the springs of Wiesbaden, Salsquelle, Soden, Neuenheim, and Cronthal, and in Homberg and Nauheim, in the neighbouring Margravate, chloride of sodium abounds, while the alkaline carbonates have totally disappeared; lastly, in the tertiary formation, which forms the most southern part of the Duchy, there are only sulphur springs.

If any additional argument be required to prove the simplicity of the process by which the natural waters

are produced, it will be found in the known facts with respect to the Bohemian Spas of Pullna, Seidchutz, and Seidlitz. These are simply pits sunk in the ground, into which the rain-water filters, and are used, when comparatively recent, as wells for drinking water by the peasantry of the surrounding districts: but when they get old, the water becomes disagreeably bitter, and strongly purgative. Now, Professor Struve ascertained, by direct experiment, that he could prepare identical solutions by digesting soil, taken from the neighbourhood of the pits, in distilled water for a certain length of time. In fact, the soil contained the saline constituents of the water, but in a state of combination that rendered the contact of water and a certain interval of time necessary to enable them to become soluble.

There is no knowing what the future progress of discovery may reveal; but, as far as our present acquaintance with mineral waters extends, we have no reason to think that there is any mystery or obscurity about either their nature or origin. Determine, by accurate analysis, what are the constituents of a Spa; and then dissolve identical constituents in the proper proportions, and you regenerate the Spa to all intents and purposes. It is not necessary for the argument that this should ever have been done; it is quite sufficient to admit the possibility. I am quite willing to believe that many factitious waters, professing to imitate the natural, are totally dissimilar to them, both in sensible and medical properties. That it is in the power of a conscientious chemist exactly to imitate the composition of the natural Spas, is all that I advocate.

There is a difficulty in the way of the majority of medical men, which prepares them to admit the obscure pretensions of writers on the subject, and which may be thus stated; if we regard a mineral water as simply a solution of certain known gases and salts, how is it that it produces such powerful physiological effects upon the

human body, while its analysis only reveals very minute proportions of its various constituents; and even these are frequently of a nature which we are accustomed to consider inert, or nearly so? To resolve this difficulty, or to answer this question, it will be necessary for us to consider not only the nature of the elements which enter into the composition of Spas, but also the circumstances under which they are drank, and the conditions which surround the drinker at each watering-place.

In the first place, it is not so certain that the constituents of a Spa-water are, in general, so very inadequate to the effects which they are known to produce, as many physicians are apt to suppose. If you look to the analysis, in the Table at the end, of the Rakoczy at Kissingen, you will certainly see only 2 grains of sulphate of soda, and 2½ grains of carbonate of magnesia, in the wine pint; and if you regard these as the only aperient elements, you may well be surprised at the effects capable of being produced; but the pint of this water actually contains not less than 75 grains of salts, known to possess more or less aperient virtues, although not classed as such in works on Materia Medica; and, inasmuch as the Spa visitor drinks, in a short period of time, two to four beakers of this liquid, or from a pint and a half to three pints, the discrepancy between its action and that observed in the more familiar practice of medicine becomes much less than what one would imagine at the first glance. In a similar manner, each pint of the Pandur contains 66 grains of aperient matter. Each pint of Selters contains nearly 26 grains; and of the Elizabethan, at Homberg, upwards of 8 grains.

Secondly, the physician ought to take into consideration the fact that any table of analysis only presents to him an approximative view of the true composition. The chemist, when he presents such an analysis, does not offer even the actual results of his own investigations. He writes down the names of a number of com-

pounds, as if they were the things which he discovered in the liquid; he says, so much carbonate of soda, so much carbonate of lime, so much sulphate of soda, phosphate of soda, chloride of sodium, sulphate of lime, &c. But this is all hypothetical. What he actually found, by means of his re-agents, were such and such acids, and such and such bases; and then, according to the supposed energies of their mutual affinities, he mentally combines them into the salts displayed on the face of the analysis. He does this chiefly for the physician's convenience; for, if he published his results in the form in which he arrives at them himself, he would only puzzle those who are not familiar with chemical calculations. Even when he does obtain a salt, as such, as when, during evaporation, sulphate of lime deposits, he is not sure that it existed in the same state when dissolved; nay, if alkaline salts are in the liquid, he is pretty certain that it did not; but, on the contrary, was only formed at the instant of its precipitation. Whether it be in the strata of the earth's crust, or in the chemist's laboratory, that a variety of salts, in certain proportions, be dissolved together in water, they will always arrange themselves in an invariable manner; but in neither case can that manner be always determined by means of analysis. It is plain, therefore, that the physician cannot judge of the effect of any given compound said to enter into such a mixture, from experience drawn from its employment by itself, or under different circumstances.

It is very true, however, that there are certain mineral Spas which have maintained, during a prolonged period, a high reputation in the treatment of disease, and which, upon analysis, are proved to contain so small a proportion of mineral ingredients that it is difficult to explain their efficacy, if we confine our attention to those constituents. At the same time, it is not unreasonable to suppose that a much smaller quantity of a mineral will be required to produce a given effect, when

it is exhibited in a very dilute condition, and under circumstances whereby its complete absorption into the circulation is secured. The chemist has ascertained what a very minute proportion of iron enters into the formation of red blood; and the physiologist has shown what a very small quantity of this metal is absorbed, even when large quantities are given as an ordinary medicine. If, then, the mere fractional parts contained in some mineral waters be taken under such circumstances that the whole of it is utilized by the system, it will be quite equal to a very much larger dose, the greater part of which escapes in an inert form. I will have again to return to this consideration.

Every hypothesis, however unphilosophical as a whole, but which has gained an extensive assent, must possess some actual datum as its starting-point; and every quackery, no matter how absurd or mischievous, which has managed to exist for a few years, must have some grains of truth interwoven with it. The signature physicians, whose ridiculous doctrine it was that any natural substance that resembled a human viscus in external form, must be curative in diseases of that organ, were enabled by their theory to discover the real virtues of the *Marchantia polymorpha*, the *Asarum Europæum*, the *Scrophularia nodosum*, and many other valuable medicines. Hahnemann and the homœopathists, the genuine descendants of the signaturists, and the inheritors of their motto, "similia similibus," have not the less taught to the conscientious inquirer after truth, the value of dilution in developing the activity of many remedies. And, finally, Priessnitz and the hydropathists have almost atoned for the mischiefs inflicted by their short-lived popularity, by the increased knowledge which has thereby accrued, of the wonderful power over the human frame which pure water is capable of exerting.

Nothing can be better proved than that pure water, drank in large quantities, may, according to the state of

health, and the accompanying circumstances, act as an emetic, a powerful aperient, increase the functions of the liver, skin, and kidneys, or may even be followed by inflammation of the stomach, or sudden death by fainting or apoplexy. No doubt, temperature has to do with some of these effects, but will not, by any means, explain the greatest number. Thus, when a person exhausted by fatigue drinks cold water, we can understand that the spasm or fainting which ensues may be caused by the sudden application of cold to the weakened stomach, and low general vitality; but the other effects of water, enumerated above, are equally, or sooner, produced by tepid water than by that liquid at a low temperature. Of course, much depends upon the condition of the stomach and intestines. When the stomach is empty, its internal surface is comparatively bloodless; while digestion of food is proceeding, it is red or, in patches, even blackish, from vascularity; in the latter case, it is oozing out the gastric juice from its whole surface, and such a condition is manifestly very unfavourable to absorption. Accordingly, experience has shown that the effect of water-drinking is very different when taken on a full or an empty stomach. Again, the absorption of a quantity of water into the veins necessarily dilutes the blood, and increases its volume; a greater share of work is thrown on the heart to carry on this now plethoric circulation, while the blood, which is to excite its contractions, has become less stimulating. A certain rapidity of the circulation is requisite for the quick separation of those secretions which would relieve this plethora; but that rapidity has been diminished by the distention of the vessels and the dilution of the blood which render it desirable. Hence the necessity for active exercise after the drinking of water, particularly when the stomach is empty; exercise quickens the circulation, and thus promotes the secretions, which, by their separation, restores the blood to its natural condi-

tion. If this is not done, hemorrhages from various parts, or apoplexy, may be the result. You hear at every Spa of cases of hemoptysis, or of insensibility, sometimes followed by death, which have, at some time or other, occurred there; and these are ascribed at one place to the sulphuretted hydrogen; at another, to the iron; and, at a third, to the alkali contained in the Spring. But similar cases have occurred at Gräfenberg and Marienburg, where nothing is drank but the purest water.

But it is not only by the absorption of water, and the consequent dilution of the blood, that this vital current is liable to become impoverished. If this dilution be not quickly removed by a compensating increase of secretion, the red globules will burst, and become converted into an *effete* matter—the fruitful source of disease, if not quickly removed from the circulation. This destruction of the blood globules, by the diminution of the density of the liquid in which they swim, is familiar to every physician; and its effects are very visible at every Spa, where, after a sojourn for three weeks or a month, and a steady and copious use of the waters, the visitors have, in very many instances, to *finish the cure*, as it is called, by going for a week to some especially chalybeate watering-place. This is so notoriously the case amongst Spa frequenters, that you universally find, amongst those interested in the prosperity of any particular watering-place, the greatest anxiety to find, or to impress at least upon the visitors, the existence of an unexceptionable chalybeate spring in the immediate vicinity.

At every Spa you likewise hear of a feverish condition liable to attack the drinkers—the *badsturm*, as the Germans call it. I believe this also to be due principally to the influence of the absorbed water on the blood.

If we, therefore, reflect on the effects which the ingestion of pure water alone is capable of producing—

how it will act as an aperient, rendering unnecessary the use of purgative medicines, and increasing the secretion of bile, when taken in large quantities on an empty stomach—how, in combination with active exercise, it will promote profuse perspiration, and stimulate the kidneys to a copious secretion—how, if exercise be deficient or neglected, it will cause an aqueous plethora, tending to the destruction of the blood globules, to hemorrhage, or even apoplexy,—I think it must be admitted that the mere watery menstruum in mineral springs is an agent of powerful energy for good or evil, and that we are entitled to attribute to its influence very many of the physiological and therapeutical effects acknowledged to be derived from their employment.

In the use of baths, no doubt, much depends upon the temperature, and something upon the salts in solution. Thus the bath will be tonic, cooling, or stimulating to the general system, according as the water is cold, tepid, or hot. The soothing effect of water below the blood temperature may be assisted by fixed alkaline carbonates, or counteracted by acrid salts. But it cannot be denied that some effect is due to the contact and absorption of the water itself; and there is a decided difference in the therapeutic effects of a water-bath in which the volume of the blood is increased by absorption, and a vapour-bath, in which it is diminished by perspiration. It is also well known that a cold or tepid hip-bath used daily, or even a wet cloth wrapped round the abdomen, will, in many instances, regulate the action of the bowels, even in cases of obstinate and habitual constipation. Now, as at the various Spas, bathing of some kind is usually recommended in combination with the internal use of the waters, the physiological effects of pure water, when used in this way, ought to be taken into consideration when estimating the value of the Spa.

We have seen that pure water, when taken in separate draughts on an empty stomach, and alternated with

active exercise, is absorbed, and, permeating the entire system, comes in contact with every tissue, and, finally, is thrown off by increased secretion. Taken with due precautions, it thus becomes a powerful means of depuration, removing from the blood the transitional products of the waste of tissues, whose continuance in the system would be detrimental to health. To produce these effects, seven or eight beakers-full, each containing half an imperial pint, was the quantity habitually employed at Gräfenberg; at most of the Spas a much less quantity will suffice, because the depurative action of the aqueous element is in them aided by the saline constituents in solution. Now, as we have seen that the treatment of disease by the ingestion of water is a measure of great power, and therefore of great danger, this diminution of the quantity required to be drank of a morning, from seven or eight beakers-full to two or three, is a matter off considerable importance, and greatly in the favour of the Spas.

But there is another point of view, and one to which I have already cursorily adverted, which derives great importance from the physiological effects of water taken under the circumstances I have described. There are certain mineral substances which must be supplied to the system in order that healthy nutrition may be maintained. If I may be permitted to quote from a little work which I wrote nine years ago, the following extract will sufficiently explain principles which were at that time novel, but which are now generally admitted in science:—"It will not do to feed the muscles alone, or the cellular tissue, or the secretions; each portion must be nourished in its due proportion, or disease will be the inevitable consequence. It is not enough that food be given, containing sufficient nitrogen, together with oxygen, hydrogen, and carbon, to supply the soft organs; but we must also give the necessary quantity of phosphate of lime for the bones, and sulphur and sodium for

the bile. All the muscular and albuminous tissues contain sulphur and phosphorus as essential constituents; the brain and nerves contain phosphorus and sodium; the blood has iron in one of its elements. In the adult animal, these various solids and fluids are becoming constantly destroyed under the influence of inspired oxygen; and if health and life are destined to be maintained, they must all be restored in equal proportions to those in which they are thrown off. In the young and growing animal, where the increase is greater than the waste, they must be in still greater quantity, especially as regards lime and iron. We have seen that a young animal requires four times as much lime as is requisite to form bone-earth with the phosphoric acid of its food; and without a sufficient supply of iron, the blood globules cannot become formed. The question of nutrition thus reduces itself to simple algebraic equations: the food of an adult must contain elements equal to the waste; the food of the young must contain elements equal to the waste, *plus* the surplus growth."

Now, taken under the conditions which have been described, the whole of a mineral water becomes absorbed into the blood, and the aqueous part is shortly afterwards eliminated by secretion; much of the mineral elements consequently remain in the system, and their importance there the foregoing extract clearly demonstrates. Let us take iron as an example,—it is absolutely essential for the formation of blood; it is incapable of being thrown off from the skin or kidneys; so that, however minute the quantity of it contained in a spa-water, it is all utilized. But when iron is given as a medicine, in some concentrated form, it cannot be taken on an empty stomach, for it would produce headach; very little of it is absorbed, and its effects are consequently much less remarkable.

To turn to another constant constituent of Spas, whose value is not, in general, sufficiently appreciated,—I have

not the slightest doubt but that carbonic acid is a remedial agent of very great importance. To convince one's self of this, one has only to reflect on the poisonous as well as unpleasant physiological effects produced by this gas, and which all have heard of or experienced. Every reader of a newspaper can remember numberless instances of deaths from burning charcoal in close apartments, or from sleeping in too close proximity to limekilns; the Valley of Death in Java, and the Grotto del Cane near Naples, are familiar to our geographical friends; these all owe their noxious influences to the presence of carbonic acid gas; but not only so, but the tendency to fainting, or at least oppression, experienced in crowded assemblies is much more owing to this air than to the heat to which it is commonly attributed; and the headach to which every one is more or less subject, when kept in a room with too many lights, or heated by a badly constructed stove, is due to the same agency. An animal, say a mouse or a rabbit, introduced into an atmosphere of carbonic acid, dies almost instantly, but his death is attributable to the absence of air; it is as if he were strangled: but, if placed in a vessel containing a large quantity of carbonic acid, and along with it a sufficiency of oxygen to preserve life under other circumstances, it nevertheless dies, directly poisoned by the carbonic acid, and presenting very different symptoms, and from a very different cause to that which produced death in the pure gas. Positive poisoning by carbonic acid gas consists in a stoppage of the action of the heart; and when carried only to a minor degree, exhibits a tendency to fainting or palpitation. Now, it is rational to suppose that an agent, which in large quantities produces such powerful effects, should produce proportional influences when brought in smaller quantities and a more diluted condition into contact with the living tissues. From analogy with other mineral acids, we should conjecture it to be a tonic, when given in medicinal doses.

But the observation of its effects when applied to the skin, the warmth and vascularity it produces, as well as the remarkably exhilirating influence of sparkling wines, and indeed of effervescent waters, whether natural or artificial, although, of course, in a very minor degree, would lead us to believe that it is also a stimulant.

I think the foregoing considerations afford us quite sufficient materials of an understood character to enable us to comprehend all the observed phenomena of Spa treatment of disease, without any necessity for our supposing the presence of some unexplored and unintelligible influence, whether galvanic, telluric, or spiritual. We have seen what powerful agents both water and carbonic acid are; that the elements of a Spa water, even when in very minute quantities, have an increased activity given to them from the conditions under which they are ingested; that the mineral constituents, however, are frequently in a proportion nearly or even entirely equal to what they are accustomed to be prescribed; and that the actually potential ingredients are often much larger than the chemist's table of analysis would appear to exhibit. It is necessary to insist upon this view. If it be admitted, we may then proceed to discuss the relative value of the various Spas, by an examination of their ascertained chemical constitution; but if their effects are wholly, or in part, to be attributed to some mysterious element, of inappreciable nature and unknown quantity; then the sooner we abandon the subject altogether to the dogmatism of Spa doctors, the better; for it is one that would, under such circumstances, be incapable of scientific investigation.

If it be admitted that the chemical composition of mineral waters is the proper point of departure from whence to study their effects, we may proceed to inquire as to the nature of the operations, by means of which Spas produce changes in the health of those who drink them. From what has been stated in the preceding

pages, it may be seen that those changes, when favourable, are caused, for the most part,—firstly, by increased secretions from the various glands and surfaces, which favour the removal from the system of the different products of the waste of the tissues; which products, when suffered to accumulate in the blood, poison that fluid, and, moreover, serve as a nidus for the propagation of numerous diseases. Secondly, by the supply to the various solids and fluids of the living body, of those mineral constituents, which are essential to their healthy composition; but which, from various causes—but especially from the too exclusively animal and seminal diet of the higher and middle classes in these countries—are apt to be deficient. But, besides these two modes in which Spas are capable of producing changes favourable to health, there is a third deserving of particular consideration: namely, the specific action of certain ingredients in removing certain diseased conditions—such as the effects of the fixed alkalies in alleviating irritation of mucous surfaces,—of iodine in causing the absorption of glandular enlargements,—of alkaline phosphates as solvents of certain concretions, &c. The hurtful changes, capable of being produced by mineral Spas, are attributable to,—firstly, excessive and weakening secretions, pushed beyond what moderation would suggest, or the strength could endure; secondly, to the effect of the mineral ingredients, which may be such as are calculated to aggravate mucous irritation, or otherwise disagree with the actual condition of the patient; and thirdly and chiefly, to the suppression of the secretions from any cause, whether it be weakened action of the heart, sudden chill, or the supervention of any acute inflammatory attack; under such circumstances, the ingestion of a quantity of Spa water will produce vascular plethora, that may terminate in apoplexy or hemorrhage, and will almost certainly produce an impoverished condition of the blood.

The universal practice at the various Spas sufficiently points out the means which experience has found to be effectual in promoting, to the fullest extent, the good effects derivable from Spa drinking, and in obviating its dangers. This practice consists everywhere in drinking the waters in divided portions, on an empty stomach, and in taking exercise between the draughts. But how is it possible to get patients to adhere strictly to these simple rules? The answer is, by means of discipline. The rule is, to assemble, at an early hour, to drink the first beaker—the matin hymn marks the adhesion to this rule; and the subsequent performances of the band, with the intervals between the pieces, serve to point out, with a certain system and precision, the periods of ingestion, and the times of intervening exercise. We all know the powerful influences of example and companionship. When once one has engaged in any practice, in the society of others, it is natural to persevere through mutual emulation, and you feel ashamed to be thought, even by strangers, as relaxing in the energy with which you commenced. But there are other inducements which make the Spa frequenter steady in his adhesion to the routine practice,—fine music on a summer's morning has its peculiar attractions,—the scenery at most of these watering-places is very charming,—people form agreeable acquaintanceships, which they desire to cultivate,—and there is a pleasurable curiosity in observing whether your co-promenaders will keep up their attendance as assiduously and constantly as yourself. The Spa proprietors, generally, spare no pains to render the promenade agreeable, by abundance of flowers, sometimes by the play of pretty fountains, &c.; and, to obviate all objections, by suitable erections—colonnades to protect from the rain, rows of trees to shade from the sun, &c. Numerous booths and pretty shops soon spring up in the neighbourhood of the promenade, and afford additional profit to the proprietors, as well as amusement to the

visitors;—and, by acting upon the common principles of humanity, by means of these and other influences, the strict rules upon which the utility, and indeed safety, of the use of the Spa depends, are successfully carried into practice.

It must be acknowledged that the accessories to the use of the Spas are quite sufficient in themselves to account for the improvement in the general health, so usually experienced by their visitors, without attributing any influence to the waters. Early hours, regular habits, cheerful occupations, pure air, and the absence of solicitude, are all powerful hygienic agents, which are in constant exercise at these watering-places. There are some cases of broken health or actual disease, which cannot be advantageously treated at home: it occasionally happens that, with such patients, a necessary preliminary to all medication is the breaking up of former associations; the complete withdrawal from business and its responsibilities; and surrounding the invalid by totally new circumstances. In such cases, there are few retreats which present so many advantages as a Spa, particularly in Germany, for obtaining the end proposed; and among these, it is no small recommendation, the prevalence of the kind of discipline to which I have adverted, and to which the patient almost unconsciously conforms.

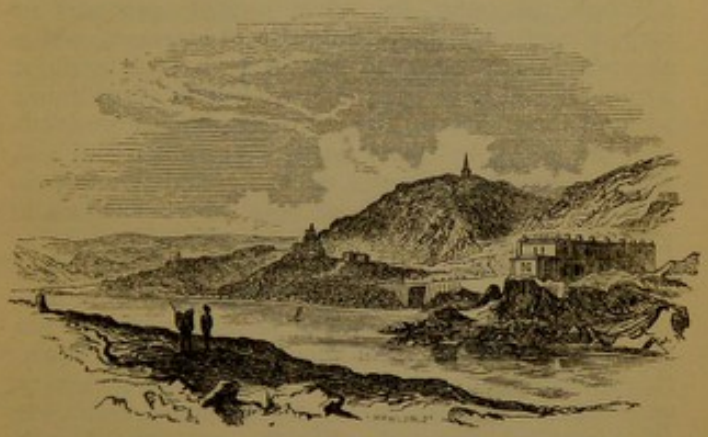
But this separation from all previous associations is not necessary in every case, nor, indeed, in the majority of cases, to secure the benefits of Spa treatment. I have already shown that the water, the carbonic acid, and the salts, are powerful medicinal agents, when taken under proper circumstances; and just as much so if combined by Art, as if prepared in Nature's laboratories. These agents are as capable of producing their healing effects in one country as in another. A temperate climate may aid them, but this is attainable elsewhere as well as in the neighbourhood of Spas. Still, it is generally ob-

served, that neither the genuine waters, imported from the Springs, nor their artificial imitations, are found as beneficial here at home as when they are taken at the watering-places. I believe the reason of this to be, that they are not taken under the proper conditions, enforced by a discipline similar to that which has been described.

An attempt to get up an artificial Spa was commenced many years ago at Brighton. The waters were carefully manufactured according to the analysis of Professor Struve, of Dresden; a sea-coast on the southern shore of England was selected; and house speculators soon built handsome mansions. But, although highly fashionable as a place for sea-bathing and a mild winter residence, it never properly succeeded as a Spa. This may be attributed to several causes, but especially to the absence of what I have called the discipline observable at the natural watering-places. I do not think that this failure ought to prove disheartening. Combine favourable natural circumstances, such as an equable climate, beautiful scenery, and easy accessibility, in the selection of a promenade; have stands sufficiently supplied with imported waters, from the most eminent Springs, or carefully prepared imitations of them; let a good band be employed to play at intervals during a couple of hours, commencing early; and let the physicians of the neighbourhood send their patients there, for whom they consider early rising, exercise, and the Spa system of water-drinking appropriate; and I have no doubt but that, in the vicinity of every large city, a promenade might be established during the summer months, eminently conducive to the health of its inhabitants, and rendering, for the most part, unnecessary, the departure of its wealthier, but ailing citizens, in periodical visits to distant watering-places, or to other lands.

Such a scheme as this is eminently practicable in respect to Dublin. That excellent artist, Mr. W. N. Wilkins, has, at my request, made the accompanying

sketch of the vicinity of Killiney Station, on the Bray Railway, from the opposite island of Dalkey. Here you have all the natural conditions to which I have alluded; the scenery speaks for itself, the station is within half an hour's rail to Dublin, and the locality is everywhere protected. It would be for the interest of the Railway Company to build a colonnade and other proper offices, to plant trees and shrubs, and employ a band during the season. The rent of booths would soon pay the interest



Killiney.

of any capital thus expended, independent of the increased traffic on the line. But if this Company do not perceive its interest in such a speculation, there are many other localities, within a short distance of this city, quite as well fitted for the purpose; and there are other Companies that may, perhaps, exhibit a greater and wiser boldness. I throw out this idea for the consideration of the public and the profession. The establishment of such a hygienic retreat would, I have reason to know, be a considerable boon to the medical

practitioner, who now is too frequently in the position of knowing that a Spa life is the proper cure for his patient; while, from his acquaintance with his circumstances, he feels that to propose it would appear a mockery.

Of the saline constituents of mineral waters, the most important are the carbonates of soda, lime, magnesia, and protoxide of iron, the sulphate and phosphate of soda, the chlorides of sodium, potassium, calcium, and magnesium, and, it may be, the iodides and bromides, although the latter are, when present, generally in very minute quantities. Sulphate of magnesia, which abounds in sea-water, is seldom present in springs. Arsenic is said to be present in very small quantities in some of the waters of Vichy. Some of these constituents are aperient; others astringent; some tonic; and others alterative. We will, probably, find it most advantageous to consider those Spas whose analysis is given in the Table under the head of alkaline, chalybeate, saline aperient, and sulphureous. The waters of Ems and of Vichy are those that best deserve the characters of alkaline Spas. The proportion of aperient salts, such as carbonate of magnesia, sulphate of soda, chloride of sodium, and chloride of magnesium, are so very small in the Kesselbrunnen, for example, that their effect is probably neutralized by the carbonate of lime; and any aperient effects which may be produced are rather attributable to the ingestion of so much warm water, than to the operation of the salts in solution. This is all so much the better, as regards the class of cases that these Spas appear adapted for. The great power which carbonate of soda is known to possess in soothing mucous irritation is thus permitted to act without being interfered with. Accordingly, we find that Ems has always had a great reputation in the treatment of pulmonary affections; and when those were confined to mere inflammation of the bronchial lining

membrane, no doubt that reputation was deserved. The quantity of soda contained in the Vichy sources is much more considerable; so much so, that bathing in these waters is capable of rendering the secretions alkaline. This obviously indicates their use in those diseases which are characterized by an excessive formation of acids in the system, such as gout and rheumatism; still, it must be remembered that the acids are only an effect, and it does not follow that, by neutralizing the effect, you remove its cause. The soothing influence of bicarbonate of soda is not confined to the mucous membranes; it also extends to the skin, and, accordingly, these alkaline thermal waters are also found beneficial in some irritable eruptions; but in these cases, when used as baths, the temperature should be allowed to cool down below 90° F., otherwise the stimulating effect of the hot water would counterbalance the beneficial influence of the alkali.

The chalybeate Spas represented in the Table of Analysis are those of Schwalbach, the Stahlbrunnen at Homberg, and the Tewit at Harrogate. I have introduced the latter as an example of the comparatively very small quantity of carbonic acid gas in British Spas, to that which is contained in most of the Continental. A glance at the Table will show that the Schwalbach water contains nine times as much iron as the Homberg Stahlbrunnen, and five times as much as the Tewit; but I do not dwell much on this circumstance, as I have already shown that a very minute quantity of iron may be available, if the composition of the water in other respects fits it for the purposes of a chalybeate Spa. Now, the ingredients of the Schwalbach water are very fortunate in their nature and proportions in this respect. Thus, the irritating aperient salts are in very minute quantities, especially there is but very little chloride of sodium. The earthy carbonates are large in amount—a circumstance that I pointed out many years ago to have

the effect of retarding the peroxidation of the iron, and thus of obviating the spoiling of the water. And the carbonic acid is dissolved in such vast quantities, as to cover the taste of the iron, and render the water an agreeable beverage.

The saline aperient waters are by far the most numerous. Amongst these, the Wiesbaden and Baden brunnens are hot, the Nauheim and Soden, tepid, the Soolin Sprudel, at Kissingen, a little above the ordinary temperature of the atmosphere; and the Rakoczy and Pandur, at Kissingen, the Elizabethan at Homberg, and the Selters, are cold. The latter is only used internally; the Soolin Sprudel and Nauheim are scarcely employed except for baths; the other waters are both drank and used for baths, with, perhaps, the exception of the Rakoczy and Elizabethan, which are not much bathed in from local causes. It will be observed that there is a very great similarity in their composition; they all contain a large quantity of chloride of sodium, from 7 grains in the wine pint in the Homberg Elizabethan, to 165 grains in the Nauheim—nearly as much as in sea-water. They all contain proto-carbonate of iron, also, from the $\frac{68}{100}$ths of a grain in the Rakoczy (nearly as much as is contained in the Schwalbach chalybeate) to the $\frac{42}{1000}$ths in the Elizabethan. Sulphate of soda is also contained in them all, except Nauheim; in the Soolin it is present in once and a half the quantity that Epsom salts is in sea-water. Selters water is remarkable for containing, besides the other more common constituents of these waters, a comparatively large proportion of bicarbonate of soda, which is, no doubt, beneficial in moderating the irritating effects of the other salts. The influence of the various elements of a medicinal spring in modifying each other's action is well exemplified by the brunnens at Kissingen. It is there notorious that the Pandûr water is much more active as an aperient than the Rakoczy: and I was told on the spot that the reason was on ac-

count of its being more saline. A glance at the Table will show that such is not the case; and the only way I can account for the less aperient effect of the Rakoczy is, by attributing it to the astringent influence of the greater amount of iron present in it.

The comparative chemical examination of these saline aperient waters exhibits so great a similarity, that, in a general way, they may be considered as being solutions more or less dilute of the same constituents. Of course, in proportion to their concentration, a less quantity will be required to be imbibed to produce similar effects. It does not follow, however, that this is always an advantage; we have seen that much of the benefit capable of being derived from a mineral spring arises from the ingestion of a quantity of water, under conditions calculated to assist its absorption, and, subsequently, elimination from the system; it is by this process that a Spa produces some of its most marked alterative and purifying effects. Now, most of the aperient salts are very irritating to the mucous surfaces, unless when in a very dilute condition, and the irritation produced by them, at the same time that it aids secretion, impedes absorption. This is especially the case with chloride of sodium, and, in some of the waters mentioned in the Table, this salt is present in such quantities as to render them quite unfit for use as drinking Spas; such are those of Nauheim and the Soolin. In other instances, as at Kissingen and Baden, the custom prevails, to a considerable extent, of mixing the Spa water with an equal quantity of whey, which has the desired effect of diluting, and thus rendering it more effectual.

Nothing is more prejudicial, when pursuing Spa treatment, than to be exposed to any cause which may produce a chill. This will at once put a stop to secretion; and the overloaded circulation, thus prevented from relieving itself, may give rise to dangerous accidents. Of course, this is not so liable to occur at a thermal, as at

a cold water Spa; but, even there, it is well to be provided with such extra clothing, when going out in the early morning, as will provide against the danger. A very excellent practice, pursued at some of the cold springs, is to have some of the water artificially warmed, which gives the visitor the choice, if the morning be chilly, to mix equal portions of the hot and cold Spa waters. This plan is also said to have the advantage of increasing the aperient activity of the water.

A very near approach to the composition of the German saline aperient waters may be seen in the Tabular View of the constituents of the Montpelier saline chalybeate, at Harrogate. This Spring, which is locally called the Kissingen Spa, from the observation of this resemblance, contains, however, like most of our British Spas, a very small comparative proportion of carbonic acid, and, consequently, is much more disagreeable to the taste, than the majority of the German Spas.

Pullna water, which approaches in composition, at least as far as concerns its constituents, to the saline aperients, cannot, however, be classed amongst them, being totally dissimilar in its properties. It contains such an amount of Glauber and Epsom salts that it can only be regarded as an hydragogue cathartic; has but little chloride of sodium in comparison; and the iron it contains is so minute, that it may be left out of consideration. It is worthy of remark, in connexion with its mode of origin, that it contains a mere trace of carbonic acid, but a very marked amount of organic matter; it is, indeed, merely a surface water, which has not as yet purified itself by fermentation.

How far the presence of iron in those strong saline waters which are used for bathing—such as those of Wiesbaden and Baden—amongst the thermals, and the great Sprudel at Nauheim, and the Soolin at Kissingen, among the cold springs, may increase their efficacy in the treatment of certain diseases, over what is capable

of being effected by simple sea-water at its natural temperature, or artificially heated, is a question worthy of consideration. These Spas have a high reputation for the cure of gout, chronic rheumatism, sciatica, &c.: the thermal being considered preferable for the cachectic: the cold ones for those who have still a certain power of re-action. It is worth the trial, whether equally good effects may not be produced by the addition of a salt of iron to sea-water. All these saline baths are liable to produce eruptions of the skin: these may be sometimes curative, but are at others simply troublesome; and, I may suggest, that, immediately upon coming out of the bath, it would be well to sponge the surface over with warm, sweet water, in order to remove the salt.

The example of sulphureous springs, given in the Table, are those of Weilbach, and of the old Sulphur Well at Harrogate. It will be perceived, that the former water contains more than four times the quantity of sulphuretted hydrogen present in the latter; but the Harrogate spring contains a notable proportion of sulphuret of sodium—a more active compound than the gaseous. In other respects, these waters are totally dissimilar: the Weilbach having a very scanty quantity of aperient or irritating salts among its ingredients, and containing no inconsiderable proportion of carbonate of soda; while the Harrogate water is a stronger brine than even the Soolin, and is powerfully aperient. The physician can easily understand, from these differences, the varieties of cutaneous and other affections for which each is especially fitted.

The non-professional reader may find many omissions, and much that is unsatisfactory, in this essay. I thought it right, however, to exercise my own discretion as to the amount of information which I would afford. I had no mind to write a book which would make every man his own doctor; nor was I willing to swell this work with what might be unnecessary. Spa treatment

is a very powerful means for good or evil, according as it is, or is not, suited to the particular case; or, as it is conducted on principles fitted for developing its virtues, or the contrary; it never should be undertaken, or indeed pursued, except under medical advice; and any more information than what I have given in the foregoing pages would, if not injurious, be at least useless to any not previously and expressly prepared, by education, to understand it.

THE END.

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WATE

SH ND OF

	Ems. Kesselbrunnen.	Ems. Kränchen.	Ems. Fürstenbrunnen.	Weilbach.
Temperature, . .	116·5 F.	90·5 F.	96 F.	. .
Carbonic Acid, . .	16·4480	26·8160	15·6760	5·8000
Azote, ...	. .	. .	. .	0·0050
Oxygen, ...	. .	. .	. .	. .
Sulphur. Hyd., . .	. .	. .	. .	2·9490
Carbur. Hyd., . .	. .	. .	. .	. .
Carb. Soda, . . .	14·7418	12·6108	16·5526	1·5200
,, Lithia, . . .	. .	. .	. .	
,, Strontia, . .	trace	trace	trace	0·0350
,, Lime, . . .	1·4474	1·4400	1·5263	2·1760
,, Magnesia, . .	0·3200	0·4975	0·6206	1·8030
,, Protox. Iron, .	0·0576	0·0096	0·0195	. .
,, Ox. Mangan., .	trace	trace	trace	. .
Sulph. Soda, . . .	0·3538	0·3981	0·3678	. .
Sulphur. Sodii, . .	. .	. .	. .	0·3590
Phosph. Soda, . .	. .	. .	. .	. .
,, Lithia, . .	. .	. .	. .	
,, Lime, . .	. .	. .	. .	
,, Alumina, .	. .	. .	. .	
Silica,.	. .	. .	. .	
Fluoride of Calcium, .	. .	. .	. .	. .
Chlorid. Sodii, . .	7·0216	6·3349	6·8335	. .
,, Potassii, .	. .	. .	. .	1·0520
,, Calcii, . .	. .	. .	. .	. .
Bromid. Sodii, . .	. .	. .	. .	. .
Chlorid. Magnesii, .	0·3318	0·3758	0·5248	. .
Iodid. Sodii, . . .	. .	. .	. .	0·0038
Sulph. Lime, . . .	. .	. .	. .	. .
Sulph. Magnes., . .	. .	. .	. .	. .
Organic Matter, . .	. .	. .	. .	. .