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SCHULTZ & WARKER'S



# MINERAL SPRING WATERS,

THEIR CHEMICAL COMPOSITION, PHYSIOLOGICAL  
ACTION AND THERAPEUTICAL USE;

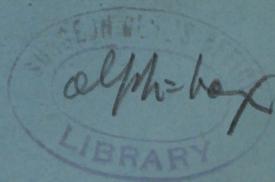
WITH A SHORT REVIEW OF THE HISTORY

OF

## MINERAL WATERS.

BY

CARL SCHULTZ.



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BY

CARL SCHULTZ.

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MINERAL WATERS are the only medicines offered to us by nature, in a state fit for immediate use. They are admirably suited for various diseases and constitutions, and the experience of three thousand years has proved them, in many cases, far superior to the artificial compounds of our pharmacies. The scant knowledge of natural laws, in former times, ascribed to them the remarkable power of curing all diseases, and the superstition and mystery in which everything was shrouded that could not readily be explained, was increased by the intentional perversions and exaggerations of local physicians, who desired to attract crowds of patients. The numerous semi-scientific publications which annually went forth from European watering places deserve, indeed, little credit, and it is only lately that strict and reliable researches have been made into the chemical composition of mineral springs, and their physiological effects upon the healthy and diseased body.

It is the purpose of this pamphlet to collect those investigations, as far as they more immediately concern our preparations, and to put them before our patrons in a readable form. In enumerating the therapeutical uses of mineral waters, I have, of course, followed the best medical authors, and have omitted all applications which seemed to have no good foundation in the nature of the spring, or for which Spas of another class are more suitable.

## HISTORICAL REVIEW.

The principal difference between a mineral and an ordinary spring is to be found in the larger volume of gases, especially carbonic acid gas, dissolved in the water, and in the mineral ingredients which are held in solution by both; also in the temperature of the water, which varies from  $33^{\circ}$  to  $212^{\circ}$ . They often present remarkable appearances when relieved from subterranean pressure, by losing their gases with more or less rapidity, according to the tension to which they had been subjected, and by parting with a portion of their mineral ingredients. Some of them issue from the earth with rumbling, gurgling or hissing noises; others do so only at regular intervals, and rise to a height of from twenty to forty feet; some ascend from the bottom of the sea, of lakes and rivers; others appear many thousand feet above the level of the ocean; some break at a boiling heat through a crust of ice and snow; others issue with icy coldness near shrubs and flowers; some destroy vegetation in their immediate neighborhood, while others penetrate and cover organic structures with calcareous incrustations, and preserve them for the study of future generations.

Such phenomena were replete with wonder to the uneducated, and attracted the attention of philosophers from an early period. Supernatural properties were ascribed to the springs. Strange theories were propounded regarding their origin, and wonderful tales and fables were current of their curative powers.

Strabo relates that the springs of Hierapolis imparted a red color to the roots of trees and shrubs, and that the juices of the latter, when mixed with the water, produced a purple liquor which was used for dyeing wool. Philostratus, when speaking of the sanguinary battle which the Greek army fought with Telephus, on the banks of the river Caicus, states that the wounded Greek soldiers who resorted to Agamem-

non's spring, near Smyrna, were all restored. According to Herodotus, a spring in the country of the Ichthyophagi or fish-eaters prolonged life to beyond 120 years; it made the skin shine as if polished, and had the perfume of violets. A spring in Chios caused insanity; another in Magnesia improved the voice of singers; and the spring of Alysson was a specific for hydrophobia. The springs of Lethe and Mnemosyne are often mentioned in classical literature; the former gave oblivion and the latter memory.

Little is mentioned of mineral springs in the Old Testament. According to the Genesis, Anah, the father of Esau's wife, discovered some thermal springs in the desert, and in the second book of Kings, we find mention made of a spring at Jericho which made the ground barren, and was made wholesome by the Prophet Elisha throwing salt into it. But from the New Testament we learn that the Jews, before Christ, used thermal waters extensively. "*There lay a great multitude of impotent folk, of blind, halt, and withered, in the porches of the lake of Bethesda, by the sheep-market at Jerusalem, waiting for the moving of the water; and whosoever first after the troubling of the water stepped in, was made whole of whatsoever disease he had.*" This water had a reddish brown color, from a sediment of ochre, probably deposited by the escape of carbonic acid gas; sulphur was also found in the mud, and the more rapid disengagement of carbonic acid and sulphuretted hydrogen, when the water was stirred up, may account for its increased curative power at such time.

The most important of the sulphurous thermals of Palestine are those of Tiberias, near the lake of Genesareth. Their temperature varies from 86° to 130°. They were used by the Romans, and are visited by patients from all parts of Asia Minor even at the present time. There was another thermal spring near the Dead Sea, in the country of the Edomites, called Calirrhœ, or beautiful spring, which was used by the King Herod, in the hope of being cured of his sickness. According to Josephus, he caused himself to be carried across the Jordan to use the thermals of Callirhoë, which flow into the Lake Asphaltites. He, however, found it a hard road to travel, and failed to recover his health.

Mineral springs play also an important part in the religion of the ancients. When temples were erected to the god of medicine, the priests of *Æsculapius* took good care to locate them in the vicinity of mineral springs, and such places were destined both for worship and the cure of the sick. They were not only provided with theatres and places of amusement which perfectly outstrip the modern contrivances of our fashionable resorts, but also with hospitals and medical schools for the instruction of students. The most important of these were the springs of Nauplia, in the sacred grove of *Æsculapius*. They have been described by Pausanias, and from the remains of their structures we can, even at the present day, judge of their former greatness. The water of Nauplia has been recently analyzed by M. Landerer, and found to contain chiefly chloride of sodium, carbonate of lime, and carbonic acid.

We should also mention the Castalian spring, which had a temperature of only 33°, and in which Pythia had to bathe before ascending the tripod in the steaming cave in Apollo's oracle at Delphi. There are copious exhalations of carbonic acid gas in that cave, and from the short and incoherent sentences which the priestess uttered in her excitement and paroxysms the most important prophecies were drawn by a cunning priesthood. Such were also the gas springs of Dodona, the most ancient oracle of the Greeks, and the places where Odysseus and *Æneas* communicated with Hades to meet the spirits of the departed.

Roman literature tells us of the magnificence and splendor of the bathing places of Italy in the time of the emperors, the most fashionable of which was Bajæ. They were embellished with the costliest statuary and paintings. Laocoon, from the baths of Titus, the Farnesian Hercules, from those of Caracalla, and the horse-tamer, from those of Constantine, are masterpieces which have never been equaled. To judge from the ruins of Caracalla's baths, they must have resembled a small village. There were over two hundred marble columns found in them, some in a good state of preservation, and over 1600 seats cut out of solid marble.

The fashion of bathing in hot springs gradually became

almost a necessity with the Romans, and in the course of their warlike expeditions they discovered many of the most important thermals of Europe, and used them as stations for their armies. We will only mention Baden-Baden (Thermæ Aureliæ), Wiessbaden (Aquæ Mattiacæ), Bath (Aquæ calidæ), Aix-la-Chapelle (Aquæ Granenses), and Spa, in Belgium (Aquæ ad civitatem Tungriam).

The philosophy of springs—the theories held by natural philosophers of different ages on their origin, composition, specific properties and therapeutical use—would form one of the most pleasing and instructive chapters of literature, but it is clearly beyond the compass of these pages to do the matter justice. These theories were based upon the state of natural science at the time. According to the great thinker Aristotle, there were in the interior of the earth a multitude of large caverns containing air. The air at the roofs of these caverns was, by the cold, condensed to water, and the water broke forth at the surface, wherever it could find an outlet; and his theory throughout antiquity and the middle ages was believed in implicitly. Even good old Origenes, who ascribed the origin of springs to the tears wept by fallen angels, could not materially shake the belief in Aristotle. His supposition certainly bears some improbable features. If we consider that the springs of Vichy alone discharge three millions, and those of Carlsbad another three millions of cubic feet of water annually, the fallen angels must either weep very abundantly, or their number must be legion. Hippocrates was very skeptical on the use of mineral waters. He accused those persons of ignorance who asserted that saline waters excited the action of the bowels, and readily passed off with the fæces, because they had just the contrary effect. Waters that issued from rocks were considered as indigestible, and thermal springs heated the system, and dried up the juices, as, amongst other unwholesome ingredients, they contained copper, silver and gold. Galenus held the same views as Hippocrates, but his disciple, Cælius Aurelianus, who lived at the end of the second century, already prescribed the alkaline saline waters of Ischia for stone in the bladder. Paracelsus called the gases ascending from springs wild spirits, and remarked in his work, *de*

*aquis mineralibus*, 1562, that their heat was caused by the burning of certain minerals; and Hufeland and others, who called it volcanic heat, believed it to be entirely distinct from ordinary caloric, and possessed of specific curative effects not shared by ordinary water of the same temperature. Great stress was also laid upon the electricity of thermals, though a delicate multiplier was necessary to prove its presence; and the nature of the water itself was doubted, on account of the variations which were observed to exist in the boiling point of different springs, which, however, can be readily explained by the varying quantity of salines kept in solution, and by the difference of elevation. Thus Gastein water, which boils at  $207\frac{1}{2}^{\circ}$  at an elevation of 3000 feet above the level of the sea, was actually taken down by Von Graefe to the plains of Albano, in Lombardy, in order to prove that it would boil there at  $212^{\circ}$ . Baumgartner and Hessler even went so far as to claim for Gastein water a chemical composition entirely different from ordinary water. According to those savans, it contains one part of oxygen to *three* parts of hydrogen; and a law was enacted in the Duchy of Salzburg, in 1797 (not yet repealed), threatening with the penalty of one guilder all persons who should have the temerity of calling the Spa water.

Real progress in the knowledge of the composition of mineral springs was only made by the discovery of the alkalis and fixed air by Van Helmont, in 1648. The demons of the ancients, and the wild spirits of Paracelsus, were then found to be our familiar carbonic acid gas. The great philosopher Arago proved the temperature of the springs to correspond with the depth from which they ascend; and Bergmann, Berzelius, Bischof, and Struve showed their composition to depend upon the amount of carbonic acid and other gases which are dissolved in them, and upon the nature of the rocks and strata which they permeate. Struve proved this by direct experiment. By powdering the clinkstone of Bilin, and subjecting it to the action of carbonic acid water, under a small hydrostatic pressure, he succeeded in producing an artificial water which was identical in composition with the natural spring of Bilin. Having himself been cured by the use of a gas spring, or rather by the escaping gases, he devoted his

life to the investigation and reproduction of mineral waters, and must be called the father of artificial spring waters. His artificial Carlsbad water which he sent to Faraday, and his artificial Friedrichshall bitter water which he sent to Liebig for examination, were pronounced by those distinguished philosophers to be identical in chemical composition and physiological action with the natural springs they represented.



### ON THE USE OF MINERAL SPRING WATERS.

According to Althaus,\* "*Spas are only suitable for patients suffering from chronic diseases, and in these only, if the composition of the blood has not become too much altered, and in the absence of considerable structural changes of important organs.*" Their use is not limited to any season, as the patient is not now required to undertake a long journey to a watering place; the spring comes to his bedside,—the mountain comes to Mahommed.

Their physiological action depends upon the water itself, and upon the carbonic acid gas and saline substances dissolved in it. It was formerly believed that the beneficial action of a Spa corresponded to the amount of water taken, and that crises and critical excretions were necessary to a successful treatment; but that idea has been happily abandoned by all enlightened physicans. There are cases on record, where from 20 to 40 pounds of water have been taken daily, and a consumption of 6 to 10 pounds constitutes the rule even now. The stomach becomes overloaded, digestion is impaired, and the constitution of the blood is much altered. A large portion of the water, especially if free from salines, is directly absorbed by the intestines, and excites the skin and kidneys to morbid action, and dropsy and general prostration are often the result.

Another widely spread error is the belief that a glass of

\* The Spas of Europe, London, 1862. A work of great excellence and profound research.

any mineral water must produce a strong laxative action, and the value of artificial preparations is often, but very wrongly, estimated by their purging power. Nothing could be further from the truth. It would be indeed a very simple matter to impregnate a solution of some purging salts with carbonic acid, and name it after some celebrated Spa; but it is after all a fact that most Spas, even Kissingen, only purge if over-doses be taken, and that violent evacuations are usually followed by obstinate constipations. Their object is mainly to regulate the functions of the different organs, to reduce the constitution of the blood to its normal condition, to promote the assimilation of food, and to stimulate the excretion of metamorphosed matter.

It will therefore, in most cases, be found advisable to use the Spas in moderate quantity, in place of common water between meals, after liberal exercise has been taken, and when the feeling of thirst will make them quite acceptable. If an action upon the bowels be contemplated, or for persons who indulge in the luxuries of the table, and suffer rather from an excess of health than the opposite, a glass of their favorite Spa will be just the thing before breakfast; but persons of regular habits, who take a light and early supper, have usually an aversion to cold water in the morning, and their stomachs require indeed food more than anything else. It may properly be stated in this place, that the *best time for drinking mineral waters is in the evening*, a practice which was first recommended, and on excellent grounds, by Dr. Heidler, of Marienbad, and approved of by most of the German physicians of note, who are conversant with mineral water treatment. Effects of this practice are to promote sleep, and to cause a considerable appetite, almost hunger, in the morning. In delicate constitutions, with pulmonary affections or where cold water does not agree with the stomach, the Spa should be mixed with its own bulk of hot milk. There are of course waters which have a specific action, where it must be left to the care of the attending physician, to prescribe them according to the condition of the patient; but, as a general thing, the above rules will be found sufficient in most cases. They will be instrumental in restoring health gradually, but surely, and

without those much-praised violent and barbarous perturbations of the whole system.

As carbonic acid is the most important constituent of all Spas, we will treat of it separately, before entering into a detailed description of the various mineral springs.



## CARBONIC ACID GAS AND CARBONIC ACID WATER.

Carbonic acid consists of one equivalent of carbon and two equivalents of oxygen. At the ordinary temperature and pressure it is a colorless gas, and about one and a half times heavier than atmospheric air. By pressure and cold it can be condensed to the liquid state. If liquid carbonic acid is exposed to the air, it evaporates with an enormous reduction of temperature, the remaining portion freezing into a snowy white solid.

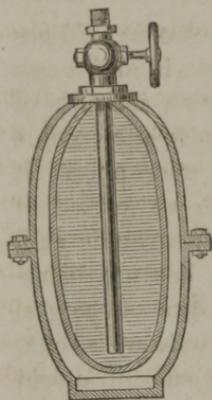
Water absorbs about its own volume of carbonic acid gas at 60°, but its coefficient of absorption increases in an inverse ratio to the temperature of the water.\* By an increase of pressure, water absorbs more gas, but not quite one volume for each additional atmosphere. At seven atmospheres it absorbs five volumes. Water charged with an excess of carbonic acid, under great pressure, is called carbonic acid water, and frequently misnamed soda water, because bicarbonate of soda is sometimes used for the generation of the gas. The water contains no soda, and has nothing to do with soda. Priestley first produced it, by pouring dilute sulphuric acid over carbonate of lime, and impregnating the water with the gas, a method which is now generally followed, and the name of lime water would therefore be much more appropriate than that of soda water. We call it, what it really is, carbonic acid water.

Carbonic acid converts the carbonates of the alkaline earths into bicarbonates, and dissolves also iron, copper, zinc and lead, and attacks the best Banca tin, which is never free from

\* Bunsen. Gasometrische Methoden. Braunschweig, 1857.

those impurities. The custom of keeping carbonic acid water in metallic fountains for any length of time must be highly prejudicial. The action of carbonic acid goes continually on, and we finally get a water highly impregnated with poisonous metallic salts, the carbonates of copper and lead rendering carbonic acid water not only worthless, but absolutely injurious.\* In France, the use of metallic fountains is prohibited by law.

Various contrivances have been used to remedy the injurious effects of metals, but without success. The only effective way, viz., using glass fountains, seemed to be precluded by the deficient resisting power of glass, if vessels of large capacity are required. We have succeeded in constructing glass fountains containing ten to fifteen gallons, which will resist as great a pressure as any metallic fountain. It is done by surrounding the glass fountain with a strong and air-tight metallic casing, and providing a gas communication between the inner and outer surfaces of the glass fountain. The pressure is thus equalized, and the fountain is only affected by the *weight* of water it holds. The water itself is only in contact with glass. They have the great practical advantage of having their gas reservoir outside. While only two-thirds of the common fountains can be made useful, these can be filled up to the neck. We hope that this notice will be sufficient to recommend them for general use. Arrangements have been made with a manufacturer † who will be able to fill all orders.



But it should not be inferred that a good glass fountain is sufficient for the manufacture of good carbonic acid water, as the gas evolved from sulphuric acid and limestone is quite impure. Oil of vitriol contains sulphurous and arsenious acids, and a considerable amount of sulphate of lead; and the limestones are contaminated with iron pyrites and bitumen; ‡ and

\* E Parrish's Pharmacy, 1864, p. 349. † JOHN MATTHEWS, of New York.

‡ James D. Dana. A System of Mineralogy, p. 438.

if chalk be used, with nitrogenous organic matter. Besides that, the process takes place in a leaden vessel (or lined with lead), and by the violent effervescence which ensues, a considerable amount of sulphuric, sulphurous, and arsenious acids, and of lime and lead salts are carried along with the spray, and are only very imperfectly arrested by a common dip-pipe. The organic matter of the limestone adds its portion to the flavor, and the whole mass is then incorporated with the water, and makes up what is called *a refreshment*. Gas companies might, with the same right, deliver to their consumers illuminating gas in the condition in which it comes from their hydraulic main and condensers; but they have to go to considerable expense and labor to deprive it previously of its impurities; because they can be readily detected by the nose, and spoil pictures, books, and furniture; but with soda water the matter is quite different. Our free-and-easy people have made up their minds that plain soda water is a vile drink, which must be mixed with syrups and brandies, and, if the matter be left to the routine of the trade, their opinion promises to be of long continuance.

The purification of carbonic acid gas has seemed to us from the beginning a subject of the greatest importance, and we have labored conscientiously to invent and construct proper apparatus, and to find suitable reagents for the perfect removal of its contaminations; and we hope that our methods will be generally adopted at some future time. Our waters are kept in glass fountains, from which they flow bright and sparkling, preserving their purity and effervescence to the last drop. They are constantly found at the bedside of the sick, and are generally preferred in their plain state. We have been often asked the question, "*What do you put into them to give them their pleasing taste?*" They are found on the table of the rich, and have to a great measure displaced wines and brandies, and have thus become an important auxiliary in the establishment of general health and temperate habits.

Carbonic acid is exhaled in great quantities in volcanic regions where fissures of the earth provide it with an outlet, and when such fissures become accidentally obstructed, it sometimes breaks forth with great violence. Near the lake of

Laach, there are over a thousand gas springs in a circular valley which is probably the crater of an extinct volcano, and some of them produce gurgling and hissing noises which can be heard at a great distance. Carbonic acid accumulates also in grottoes and caves, where the diffusion of gases is impeded.—When pure, or when mixed with an equal volume of air, it cannot be inhaled, because the glottis is spasmodically closed by it. But if mixed with a large proportion of atmospheric air, it can be inhaled in considerable quantities without any injurious effects. In Ems a special pavilion has been erected, where patients suffering from chronic catarrh of the air passages, have to breathe air mixed with carbonic acid. The gas is obtained from a jet of mineral water which is constantly thrown up by means of a steam engine, and converted into spray.

If a mixture of carbonic acid gas with a large proportion (90 per cent. M. Herpin) of atmospheric air be inhaled for some time, a state of anæsthesia is gradually produced without suffocation, without pain, and apparently without grave perturbations. The insensibility manifests itself without any alterations in the appearance of the face, and the subject can easily be brought to life again, even after some time of apparent death.\* Mr. Herpin recommended the use of such mixtures for the continuance of the anæsthetic condition produced by chloroform.

There can be little doubt that anæsthetic agents act by an accumulation of carbonic acid gas in the veins. They either supply the blood with an inordinate amount of oxygen (Nitrous Oxide), which, by the consequent combustion of animal tissue, produces more carbonic acid than can be eliminated by the lungs; or they consist of easily decomposed hydrocarbons; or are administered in the form of heavy vapors, like chloroform, which, apart from their internal action, increase the amount of carbonic acid by impeding its egress. To Dr. William Detmold, of this city, belongs the credit of first taking this view of the action

\* E. Salva. Du gaz acide carbonique comme analgésique et cicatrisant des plaies. Paris, 1860.

of anæsthetic agents, and of recommending the use of carbonic acid. In a manuscript, from which we are kindly permitted to quote, he says, "*It is not improbable, if by experience the safe and necessary proportion between carbonic acid and atmospheric air can be established, that carbonic acid gas will supersede all other anæsthetics as the safest and most reliable; because we may then measure the actual amount of gas introduced into the system; and in its administration, escape the preceding stage of excitement which is unavoidable in the administration of all other anæsthetics.*" This view gains great strength from the fact that oxygen cannot be used as an antidote in anæsthesia, because it finally augments the already too large proportion of carbonic acid in the blood. The object must be to eliminate that gas. It is most readily given out from the lungs in an atmosphere of hydrogen, and it is not improbable that the substitution of hydrogen for the nitrogen of the atmospheric air, by giving a mixture of very small density, will prove the most efficient means for the termination of the anæsthetic condition.\*

Mixtures of air with carbonic acid gas in large proportion benumb the system, by paralyzing the nerves; first affecting volition and sensation, and, if the application be too long continued, proving fatal. Carbonic acid, on that account, has enjoyed the special honor of being classed among the poisons, but we should not overlook the fact that that property is shared by all gases, not excepting oxygen when inhaled in a pure state. The blood, in its normal condition, contains one volume of carbonic acid in solution; and according to the researches of I. Sachs† the *free* gases of *arterial* blood contain 70 per cent. of carbonic acid gas. It is as necessary to animal as it is to vegetable life, but overdoses prove fatal to both. Even plants, although built up by the assimilation of carbonic acid, die if immersed in an atmosphere of that gas.

The effects produced by the inhalation of carbonic acid gas

\* Regnault and Reissing placed a rabbit and a dog in such an atmosphere; the rabbit remained in it 20 hours and the dog 10 hours without any obvious injury, excepting that the respiration was augmented in force.

† Archiv für Anat., Physiol. u. wissenschaft. Med. 1863, p. 345.

were known to the ancients, who ascribed them to a demonic power. Pythia on her tripod, in the cave of Delphi, labored under the influence of this gas, and it is no wonder that Apollo's priests were often accused by the unbelieving and vulgar, of having great trouble in finding a good Pythia. Sibyl gave her oracles under similar circumstances, in the grotto of Cumæ, where a spring rises which contains carbonic acid gas and a little sulphuretted hydrogen. In the famous grotto del Cane, near Vesuvius, the gas accumulates near the bottom, while the upper strata of air remain sufficiently pure for respiration, and travelers are treated to the suffocation of a dog, in precisely the same manner described by Pliny nearly two thousand years ago; and if that writer, Rip Van Winkle-like, could wake up again, he would be astonished at the small change which has taken place with some habits during his long nap. Such a cave, near New York, would be a regular benefit. It would do away with the "cruel pond," and many a lady would be reconciled with the loss of her pets by the consolation that they have met with an unconscious, anæsthetic, and instructive death.

Carbonic acid, when applied to the eye, produces an irritant action; a burning sensation is felt, tears flow freely, and the cornea becomes very brilliant. The mobility of the iris is increased with various disturbances of vision. The effects would probably be greatly modified, by using a mixture of carbonic acid and atmospheric air, or by applying carbonic acid water.

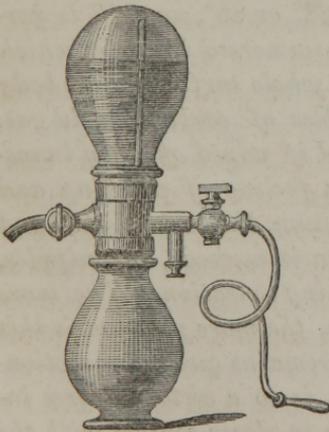
By applying a carbonic acid douche to the ear, tinnitus aurium is produced; the external meatus becomes turgid and red, and sometimes the hyperæmia spreads to the face. The secretion of cerumen is augmented, and the sense of hearing is rendered more acute. The gas is absorbed by the drum of the ear, and carried to the brain, and often great sleepiness follows the operation.

A few drops of carbonic acid water, poured into the ear, are kept in lively motion, the gas being liberated by coming in contact with warm surfaces, and strange noises are produced. It is as if listening to some celebrated gas spring, and the magnificent impetuosity of "*a tempest in a teapot*"

is brought close to the hearing. A large quantity of cerumen is dissolved, and an agreeable sensation of heat is felt for several hours.

Carbonic acid produces an acidulous and astringent taste in the mouth, a burning sensation in the uvula, and an increased flow of saliva. When applied to the nose, it causes tickling and sneezing, and augments the mucous secretion of the Schneiderian membrane, but it does not seem to affect the olfactory nerve.

Carbonic acid gas is used in intestinal obstructions, produced either by an accumulation of faecal matters, or by internal strangulations, intussusceptions and twistings. Apart from its mechanical and endosmotic effects, it acts upon the muscular coats of the organs by absorption, and excites in the neighborhood of the affected parts peristaltic contractions, by which the obstructions may be removed. It has been applied by Dr. J. Schnetter, of this city, in several cases, with marked success. Great care is necessary in these operations. Harm may also be done by the use of faulty apparatus which supply impure gas under great pressure, whereby irritation and undue distension of the membranes may be produced. The anæsthetic apparatus of Mr. Thomas Warker corrects these objections, and can therefore be safely recommended.



It has achieved great reputation with the physicians of Paris, and has been most favorably reported upon by Professor Gavaret before the Academy of Medicine. Dr. E. Salva, in his large practice and remarkable researches on the anæsthetic power of carbonic acid, uses Mr. Warker's apparatus in preference to all others, and he ascribes the ill success of other practitioners to the circumstance that by the application of highly

compressed and impure gas, the beneficial effects of carbonic acid are overbalanced. He expresses the hope that by the aid of Mr. Warker's apparatus, carbonic acid gas will soon

find universal application as a therapeutic agent.\* The wood-cut illustrates the working of the apparatus, and minute printed descriptions will be furnished to all who may desire to use it.

For the anæsthetic effects of carbonic acid upon ulcerated surfaces, cancer, wounds, etc., and for its influence upon the expulsive power of the uterus, we must refer the reader to professional publications.

*A bath in dry carbonic acid gas* produces a feeling of heat in the skin; the abdomen, the generative organs and the lower extremities being especially affected. The skin becomes ruddy, the sentient nerves are irritated, and in delicate persons it may even result in inflammation of the skin. By a too prolonged stay in the bath, the gas is carried to the brain, and a feeling of oppression and drowsiness is perceived. According to Welsh, the gas distends the intestines, and after the bath, flatus and a considerable discharge of fæces often take place. Such baths are generally followed by copious perspiration, and by a feeling of increased vigor and comfort.

*A bath in carbonic acid water* has somewhat different effects. According to Althaus, "*these vary very much according to the temperature of the water. If the bath is cold, a sensation of burning in the skin and an internal chill is felt; but if the temperature is 86° or 88°, no chill is perceived. As soon as the patient is immersed in water which contains much carbonic acid, the whole surface of the body becomes thickly covered with bubbles of carbonic acid gas, which are in constant motion; and if wiped off, they immediately reappear. In the skin, a feeling of pricking and heat is produced, which, on the scrotum, the back of the hand and of the forearm, the face (when immersed), the nipples, and the labia, amounts to a burning sensation. The more carbonic acid the water contains, the more pleasant is this 'champagne bath.' If the patient remains quiet and motionless in it, the burning sensation is to a certain degree increased, as the gas bubbles remain in closer contact with the skin; but if he moves about, a feeling of cold is perceived;*

\* Gazette Medicale de Paris, 1861.

and in many cases this continued change from cold to heat tends to strengthen the skin. During the bath the pulse becomes fuller, but not accelerated, the skin appears firm and red, its papillæ swell, the scrotum is drawn upwards and considerably contracted, and many persons feel a burning sensation for many hours afterwards. In males, even in such as are past the prime of life, the generative organs are powerfully stimulated. The bath has also a remarkable effect upon the bladder. The same patients who can sit in a common warm-water bath for half an hour, without feeling an inclination to pass the urine, are compelled to do so after having been immersed for only a few minutes in a carbonic acid bath. The inhalation of the gas which, of course, takes place in the bath, is by no means so unpleasant as might be supposed—the carbonic acid not being sufficiently concentrated to extinguish a candle floating on the water; but if sensations of vertigo, oppression, etc., are produced, it is merely necessary to stand up in the bath now and then, and to breathe the pure air in the higher strata of the atmosphere, in order to obtain immediate relief.”

“The after-effect of a carbonated water bath is, in most cases, a feeling of increased power in the limbs; and semi-paralytic persons are observed to walk briskly afterwards. This effect is chiefly marked in females suffering from hysterical paralysis, and even in the commencement of atrophy of the cord, amelioration may be produced; while in cases of longer standing, in which the nervous matter is changed into ‘veritable starch,’ of course, no good can be expected.”

By remaining too long (for an hour or so) in a strong carbonic acid bath, respiration and the movements of the heart are much accelerated (*Salva*), the skin gets of a scarlet color, and its strong burning sensation forces the patient to leave the water. Great febleness, which may last for two or three days, often follows such experiments.

The great therapeutical importance of these baths is at once apparent, and we have made the necessary arrangements to produce them artificially. By adding to 10 or 15 gallons of Croton water of 110° an equal quantity of very strong carbonic acid water from a highly charged fountain, and by

finely dividing the escaping gas, by means of an apparatus especially constructed for that purpose, a carbonic acid bath of the desired temperature, and of great strength, can be readily prepared. Patients will also have the additional comfort of enjoying the luxury of a carbonic acid bath at home, thanks to the march of modern improvements. The addition of salts, especially of chloride of sodium, with chloride of magnesium, for the preparation of brine baths, at once suggests itself. They exert a stimulating surface action upon the skin, but are not absorbed by it, as has been often supposed. Numerous and carefully conducted experiments on that point have at least failed to prove their absorption. But their stimulating effects continue after the bath, on account of the hygrometric nature of chloride of magnesium, the skin retaining a moist and sticky touch, an observation which has been often made on the sea shore.

The most important of the hot acidulous brine springs of Germany are those of Nauheim. Their composition resembles strongly a concentrated Kissingen Rakoczy. The Curbrunnen which is used internally, is often too strong for ordinary constitutions, and is therefore diluted with its own volume of a common acidulous spring. Their physiological effects have been minutely described by Dr. F. W. Beneke, in his admirable researches: *Ueber Nauheim's Soolthermen, etc.*, Marburg, 1859.

The Serpent's Spring, of Schlangenbad, in Nassau, has also achieved great reputation. Since the publication of the facetious volume, "*The Bubbles of the Brunnen*," by Sir Francis Head, a great number of his fair countrywomen have annually flocked to the spring to regain health and beauty, and of late even "*crowned heads*" have deigned to immerse their limbs in its waters, but, perhaps, for a different object. According to Althaus, "*the water of Schlangenbad has a soft velvety feel, if taken between the fingers, and imparts a most pleasurable sensation to the skin. It renders this exceedingly soft, supple, and delicate, and is therefore extensively used by ladies, especially by those of a somewhat advanced age. Eruptions are scarcely ever caused, but the bath leaves a feeling of vigor and suppleness in the whole frame.*"

By referring to its analysis, by Fresenius, its invigorating effect is found to be due to carbonic acid gas. It issues from quartzite, at a temperature of 87°, and is very pure water, with a small amount of alkalies, and a rather unusual percentage of *silicic acid*; and its soft velvety feel must be ascribed to silicate of soda or so-called "*mineral soap*," which leaves on the skin a fine, shiny, varnish-like glazing, and beautifully covers over the indentations of the tooth of time. A little of it can be readily put in for the ladies.

Carbonic acid water, when drunk, produces an exhilarating effect upon the system; it accelerates the pulse, renders the head clear and the mind cheerful. It has a pleasing, cooling, and pungent effect upon the palate. Carbonic acid forms the chief spice of all cold drinks. It imparts a sparkling freshness to fermented liquors, and the quarter of a cubic inch, which is usually dissolved in a pound of common spring water, is sufficient to make it agreeable. Rain and river water are also slightly impregnated with it, while boiled and distilled water, having lost their carbonic acid, have a heavy and unpalatable taste. Carbonic acid water stimulates the gustatory nerves, the flow of saliva and the secretion of gastric juice, and it is easily borne by persons with whom common water produces heaviness in the stomach, and dyspepsia. It essentially promotes digestion by facilitating the assimilation of food, and re-dissolving its mineral ingredients, which may have become insoluble by cooking, thus performing the same functions which must be ascribed to its presence in the blood, namely, of keeping the phosphates and carbonates of iron, lime and magnesia in solution. Carbonic acid water is the main vehicle in the absorption of those, else insoluble combinations, and should be pre-eminently used *at and after meals*.

It checks too great acidity in the stomach, cures nausea, and is the most natural and effective anæsthetic known to overcome a chronic disposition to vomit. It promotes the peristaltic motions of the stomach and intestines. Part of it is generally brought up by eructation, another part is absorbed and eliminated by the lungs and skin, and a portion remains in the intestinal canal, augmenting its watery secretions, and facilitating the discharge of fæcal matters, which, in some

persons not accustomed to its use, may amount to a strong purging action.

Carbonic acid water, like all good things, can be taken in excess. The symptoms in such cases remotely resemble those produced by the inhalation of the gas, and indeed are often due to an actual inhalation, especially if large tumblers be used, and a great deal of time be taken in drinking the water. The gas acts mechanically, like young beer and sweet cider in which fermentation is going on, by distending the stomach and intestines, and impeding circulation. It is carried to the brain, benumbs the nerves, and produces drowsiness and vertigo. In delicate persons, with very impaired digestion, almost anything—a glass of cold water or a small piece of tenderloin—will cause similar symptoms; and they should, before drinking the water, add to it a teaspoonful of crushed sugar, when the excess of carbonic acid gas will escape with brisk effervescence.

Carbonic acid water is a much esteemed remedy in acute febrile diseases, and is ardently desired by patients on account of its cooling power, which is perceptible at once in the mouth and stomach. This cooling effect is due to several causes. Carbonic acid is dissolved in the water in a *liquid* state. By the heat of the membranes it is partly liberated, and converted into a gas, with a corresponding reduction of temperature, all the heat necessary for the change becoming *latent*. This phenomenon is observed in all bodies when undergoing a similar change in the state of their aggregation, and is more fully explained in hand books, under the appellation of *latent heat*. Another portion of carbonic acid is carried to the blood in solution, and exerts its cooling power when evaporated from the lungs. But while in the blood it must naturally increase its normal proportion of carbonic acid, and retard its formation, or, in other words, retard the combustion of animal tissue, and the heat consequent upon it. And carbonic acid actually presents many of the phenomena of a more active disintegration of tissue, *with the exception of heat*. The movements of the heart are accelerated, the pulse becomes harder and fuller, and it seems to act as one of the main-springs of circulation.

Carbonic acid is the chief remedy in *chronic catarrhs*, not only of the stomach, intestines, kidneys, and bladder, but also of the air passages. The mucous membranes of those organs easily absorb it, and resemble in that respect the tegumen of fishes, which enables those dwellers of the deep to assimilate the insignificant fraction of gases dissolved in the water. In colds which affect the whole skin of the body, a sponge bath of equal volumes of tepid and carbonic acid water will speedily produce an amelioration. It would be natural to treat here more fully of the application of carbonic acid in chronic catarrhs, but as all our waters contain an excess of it, and the muriated alkaline Spas present the additional feature of fluidifying mucus, and aiding its elimination, we refer the reader to them.

Carbonic acid water, mixed with syrups, is extensively used as a summer beverage under the name of soda; it also forms a constituent of many of the compound drinks which are pre-eminently an American institution, and looked upon with pride by every intelligent barkeeper. Their vocabulary has filled with wonder the toppers of the old world, and duly impressed them with the genius of American invention. It greatly improves a claret punch, imparting to it a refreshing and champagne-like taste, which is at present an item worthy of consideration. Mixed with clarets, it is the usual table drink in Paris, and during the last decade its use has spread in such a prodigious manner that the decrease in the mortality of the French capital has been ascribed, by statistical report, to the increased consumption of *eau gazeuse*.

And herein lies the great social importance of carbonic acid water. It is not only the best antidote for alcohol, but also lessens the desire for spirituous liquors, and it will be the most effective advocate of healthy and temperate habits as long as people must drink something.

## ARTIFICIAL MINERAL WATERS.

All our artificial mineral waters contain an excess of carbonic acid gas, and their effects upon the system partake of the general character of carbonic acid water, as modified by the mineral ingredients dissolved in it. They contain the gas in three different states. It is either *free*, and escapes at the ordinary temperature when the pressure ceases under which it was kept in the bottle. But this escape is not so rapid as is generally supposed. Only the excess of gas goes off with violent effervescence. The remaining portion parts very gradually with the water, which, being a true base, must have a great affinity for any acid; and bubbles can be seen rising in the morning from a glass of mineral water which has been poured out the evening before. Even after rapidly heating it to the boiling point, a perceptible quantity of carbonic acid will still remain in the water. Or the gas is *half bound*, forming bicarbonates, from which one equivalent of carbonic acid gradually escapes when the water is exposed to the atmosphere. These compounds, being soluble only in an excess of carbonic acid, are precipitated, and the composition of the water is thereby much altered. In this state the imported European waters usually arrive in this country. Or it is *bound*, forming carbonates, from which the gas does not escape, and which remain dissolved when the water is heated.

Mineral waters have been classified according to the ingredients from which they derive their specific importance. They are represented by alkaline springs, muriated alkaline springs, alkaline saline springs, muriated springs, bitter waters, chalybeate waters, lithia waters, etc., and we will consider them in this order.

## ALKALINE SPRINGS.

Representative : *Vichy* (grande grille).

Allied Springs : *Fachingen and Bilin*.

The baths of Vichy are situated in the Auvergne, on the right bank of the river Allier, 787 feet above the level of the sea. They were known to the Romans, who used them as a bathing station ; they were also popular in the time of Louis the Sixteenth, but their great fame is coeval with the present imperial family. The great Napoleon planted the park of Vichy, and the present emperor has laid out the fine promenades on the banks of the river, and done much to embellish the town, and elevate it to a first class watering place. He favors Vichy with an annual visit, and Vichy favors him with a handsome revenue. The bathing establishments and the sale and exportation of the waters are managed by a company which is under the supervision of the crown. There are quite a number of springs at Vichy which, though they differ a great deal in renown, are nearly the same in composition. Their chief difference is to be found in their temperature, which lies between  $50^{\circ}$  and  $108^{\circ}$ , and in the amount of free carbonic acid. The *puits d'Hauteville* which is the coldest, contains about three times as much carbonic acid gas as the famous Grande grille, and has of late made rapid strides in popular favor. The composition and temperature of the same springs, at Vichy, is much influenced by the amount of rain that may fall in a season. The Grande grille, for instance, had in 1843 a temperature of  $89^{\circ}$ , while at present it is  $107\frac{1}{2}^{\circ}$ .

If we could follow our own predilection, we would express the chemical composition of a spring in cubic centimeters and grammes or their fraction, the relation between a cubic centimeter—the space occupied by a gramme of distilled water—and the gramme itself being so beautiful and simple ; for the convenience however of the majority of our readers, we will not deviate from the usual custom, and express *in grains* the *anhydrous* saline constituents which are contained in 16 ounces of water.

According to Bauer, *Vichy* (grande grille) contains :

Sulphate of Potash.....	1.567	grains.
Sulphate of Soda .....	0.904	"
Phosphate of Soda.....	0.0324	"
Chloride of Sodium... ..	4.445	"
Bromide of Sodium.....	0.001	"
Iodide of Sodium.....	0.0002	"
Carbonate of Soda.....	29.194	"
Carbonate of Ammonia.....	0.036	"
Carbonate of Lime.....	1.9277	"
Carbonate of Strontia.....	0.0178	"
Carbonate of Magnesia.....	0.271	"
Carbonate of Iron.....	(0.009)	"
Carbonate of Manganese .....	(0.003)	"
Alumina.....	0.006	"
Silicic Acid.....	0.492	"
	<hr/>	
	38.9061	grains.

Carbonic acid 6.97 grains or 14.7 cubic inches.\*

It will be seen at a glance that carbonate of soda forms the predominant feature of *Vichy* water, and in whatever way its action may be modified by the other ingredients, it decides the character of this Spa. The excess of carbonic acid gas which our preparation contains, imparts to this very unpalatable water a pleasant taste. The carbonate of soda, like all other carbonates, is contained in it in the form of a bicarbonate.

Carbonate of soda is a normal constituent of the blood, rendering it alkaline and increasing the solubility of its albuminous matter. It is also found in the saliva, the bile, the mucus of the throat and intestines, the milk, etc. By administering it internally, the alkalinity and fluidity of the blood are increased; the urine is rendered alkaline (by 33 grains, d'Arcet), the secretions are increased, and menstruation is promoted.

\* Bouquet found also 0.01 grains of arseniate of soda and traces of borate of soda.

Vichy water stimulates the stomach, and increases the appetite, but acts only as an aperient, if large doses be taken; *its action is diuretic*. The mucus secretion of the bladder is rendered less tenacious, and small deposits are frequently loosened and discharged with the urine, which by a fountain of Vichy, will generally become quickly alkaline. The amount of acidity in the stomach influences this action; if excessive, the alkali will become neutralized in the primæ viæ, and the reaction of the urine will not be altered. Slight febrile symptoms, weariness, lassitude and a feeling of intoxication often appear for a few days; but they soon give place to a feeling of increased vigor. Should they recur, the use of Vichy must be discontinued; but this rule will hardly find any application in New York, and mainly concerns the patients who at the Spa itself, drink such prodigious quantities of water. An excessive use of Vichy causes indigestion, often inflames the membranes of the stomach and kidneys, retards the pulse and may induce general prostration. These effects, with artificial preparations, are often enhanced by a deficiency of carbonic acid, of chlorides and sulphates of the alkalies, and carbonates of the alkaline earths, which are necessary for the normal condition of the blood.

Vichy water proves very useful in certain forms of *indigestion*—aversion to food, depression after meals, nausea, vomiting, flatulence, heartburn, constipation alternating with diarrhoea etc.—*provided* the symptoms arise from excessive acidity in, or chronic catarrh of, the stomach, or from deficient innervation and secretion of gastric juice.

In *jaundice* caused by catarrh of the hepatic ducts, and *gall stones*, Vichy proves often curative; but if there be a tendency to congestion and hæmorrhage, and great irritability of the nervous system, the carbonic acid may prove too exciting, and its quantity should be reduced. (Hot milk and a teaspoonful of crushed sugar.) The ducts again become pervious, the mucus is fluidified, and after a week or a fortnight, gall stones are frequently discharged, and the pain ceases. The use of the water should be continued for some months, in order to prevent a recurrence of the disease. Wa-

ters containing a larger amount of sulphates and chlorides are often more efficacious.

Vichy water has a great reputation of curing *gout*, especially *tonic gout* connected with febrile symptoms, inflammation of the joints and regular paroxysms of the disease. Dr. Althaus has great faith in the powers of Vichy for gout, if the dyspeptic symptoms are very prominent, but he is of opinion that *Carlsbad* and the muriated lithia waters of *Baden-Baden* give better promise of a cure. In cases where patients suffer from œdema of the feet, and have a cachectic complexion, Vichy will not help.

The "*Notice medicale sur l'usage des eaux minerales de Vichy,*" which certainly can be expected to put the most favorable interpretation upon the efficacy of the Spa, candidly admits that it very seldom happens that gout is radically cured by Vichy. It diminishes the frequency, the length and the intensity of the attacks, but it cannot cure the gouty affections of the joints, nor dissolve gouty deposits because they usually consist of urate of soda.\*

*Uric acid diathesis* is frequently checked by the use of Vichy, and in cases of *renal calculi and gravel*, Vichy water by its diuretic action, greatly facilitates the *elimination* of these formations. It may also serve as a preventative of calculus in the bladder by fluidifying and removing mucus which might become the nucleus of a stone. But its reputation as a solvent of *stone in the bladder* is without foundation. It simply relieves some of the unpleasant symptoms, and proves beneficial in certain cases of catarrh of the bladder dependent upon stricture of the urethra, or atony of the bladder often observed in old persons.

In *diabetes* connected with gout and disordered liver, Vichy proves often beneficial, and effects great amelioration, but scarcely ever a cure.

In chronic catarrh of the air-passages, after the inflammation has subsided, and the disease become chronic, the muriated alkaline Spas are usually preferred, and in abdominal plethora and congestion of the liver, brought on by good liv-

\* See Lithia Water and Vichy with Lithia.

ing and want of exercise, the alkaline saline Spas promise better results.

The so-called *Vichy salt* is obtained by concentrating the water, and collecting the formed deposit, and, of course, cannot represent the mineral ingredients of the Spa. The *pastilles of Vichy* are simply a mixture of bicarbonate of soda with sugar and gum, sometimes flavored.



### MURIATED ALKALINE SPRINGS.

Representative: SELTERS.

Allied Springs: *Ems and Obersalzbrunn.*

Selters is situated in the valley of the Ems, in Nassau, 800 feet above the level of the sea, and has been known since the ninth century. The wholesome and stimulating effects of this Spa have given it a fame which is not confined to the small Duchy, the name of Selters (Seltzer) having become a household word in all countries.

Immense quantities of this Spa are annually exported, and probably form the principal revenue of the petty sovereign of Nassau. Hundreds of thousands of Selters jugs have also found their way across the Atlantic, and are looked upon with a sort of reverence by our German compatriots. The water usually arrives here in a decomposed condition, and having lost its principal virtue—carbonic acid gas—has a flat and unpalatable taste; but anything that flows out of a Selters jug, is believingly swallowed by them as the genuine thing. The virtues that should be in the water are thus transferred to the jugs, and this circumstance has been diligently improved upon by home manufacturers, who buy them, and put water in, which they call Selters. They use the broad seal of the Duke, and are little deterred from their mischievous practice by his formidable navy; only the enlightening of the public can stop it.

In England, the Brighton Company, under the direction of Struve, has taken the bold step of manufacturing Selters

water under their own name, and encouraged and protected by such philosophers as Faraday, it has made the *Brighton Seltzer* an article indispensable to our English cousins. We are also greatly indebted to the advice and encouragement of our most eminent scientific men and physicians, in the introduction of our waters, and by their kindly efforts, the great advantage which our glass fountains possess over common bottles, is daily better appreciated. These fountains are the true representatives of natural springs in miniature. They are portable, and come into the sick-room; not requiring the patient to travel thousands of miles, or to wait for the cure of his ailments till the coming summer. They flow in sparkling purity at a gentle touch, and they need not be emptied for fear that the remaining portion may get stale, as the waters preserve their effervescence for months, and remain good to the last drop.

Our Selters is rigidly prepared according to the analysis of Struve, with an excess of carbonic acid; and spouts forth in open defiance of the jug water. In our bellicose, and in the beginning, critical attitude towards the Duke and his pseudo-supporters, we have always abidingly relied upon the physicians as a reserve corps, and they have liberally supplied us with canister and solid shot. We do not, like his friends, cunningly and slyly undermine his trade. We stand in open opposition to it, and are of the opinion, as far as this country is concerned, that he had better quit the mineral water business, which after all does not become such a high personage, and devote his attention to the proper government of his subjects, who otherwise might some day get a notion of popular and state sovereignty, and secede from him. His spring is good, very good indeed, and were we on the spot, and had none of our fountains handy, we might be tempted to drink from it ourselves. Perhaps we might not get permission to do so, for the Duke is said to guard it with parental zeal. According to Dr. A. B. Granville, "*he even maintains armed sentinels at the well, to prevent strangers and intruders approaching its much coveted beverage—that its sale, so universal and forming a goodly portion of his revenue, may not be injured.*" But his spring loses life with every mile it travels,

and arrives in New York as a dead and decomposed body, the jugs serving as hangmen and coffins.

According to Struve, *Selters* contains in 16 ounces :

Sulphate of Potash.....	0.3970	grains.
Phosphate of Soda.....	0.0042	“
Chloride of Potassium.....	0.3580	“
Chloride of Sodium.....	17.2920	“
Fluoride of Calcium.....	0.0018	“
Carbonate of Soda.....	6.1533	“
Carbonate of Lithia.....	traces.	
Carbonate of Lime.....	1.8386	“
Carbonate of Baryta.....	0.0019	“
Carbonate of Strontia.....	0.0190	“
Carbonate of Magnesia.....	2.0000	“
Alumina.....	0.0013	“
Silicic Acid.....	0.3020	“
		<hr/>
	28.3991	grains.

Carbonic acid gas, 30 cubic inches.

The springs of *Ems*, being situated in the small Duchy of Nassau, cannot be far from *Selters*. They issue from a gray-wacke formation in the valley of the river Lahn, 291 feet above the level of the sea, and are more strongly alkaline, and have less chloride of sodium than *Selters*. But their chief difference lies in their high temperature, which is 85° for the *Krähnenchen*, and 115° for the *Kesselbrunnen*, with a corresponding diminution of gaseous constituents, and on that account they are preferred in cases of acute catarrhs and pulmonary affections, where cold springs with an excess of carbonic acid might prove too stimulating and cause congestions. Patients using our muriated alkaline waters for such diseases should therefore be directed to warm the Spa, by immersing the tumbler (*not the fountain*) in warm water, or better, by adding to it hot milk.\* The mineral constituents of the springs of *Ems* are very constant, and nearly identical.

\* In order to be brief, we will call such mixtures simply “Warm Spas.”

The *Emser Krähnen*, according to Fresenius, contains in 16 ounces :

Bicarbonate of Soda.....	14.8376	grains.
(equal to 10.4846 of Carbonate of Soda.)		
Chloride of Sodium .....	7.0841	“
Sulphate of Soda.....	0.1377	“
Sulphate of Potash.....	0.3286	“
Bicarbonate of Lime .....	1.7246	“
Bicarbonate of Magnesia .....	1.5051	“
Bicarbonate of Protoxide of Iron..	(0.0166)	“
Bicarbonate of Manganese.....	(0.0072)	“
Bicarbonate of Baryta.....	} 0.0011	“
Bicarbonate of Strontia .....		
Phosphate of Alumina.....	0.0032	“
Silica .....	0.3797	“
	<hr/>	
	26.0255	grains.

Carbonic acid.....8.3249 cubic inches.

The physiological effects of muriated alkaline Spas are characterized by carbonic acid, carbonate of soda and chloride of sodium, modified by other mineral ingredients and by the temperature of the water.

Chloride of sodium\* is a normal constituent of the blood, and of all parts of the human body which contains from 1000 to 2000 grains of it. It is a very important element in the formation of cellular tissue and of exudation matter. It essentially promotes digestion and the secretion of gastric juice and bile, and also facilitates the absorption of chyle by the capillary vessels of the intestines. It increases the appetite, and stimulates the peristaltic motions of the bowels, and by augmenting the secretions of internal mucus fluidifies the fæces which are more easily voided. It is only a slight aperient, its action being mainly diuretic. It effectually prevents putrefaction and fermentation in the intestinal canal, and by rendering phosphates and sulphates of lime more soluble, facilitates their absorption. Most of it is eliminated by the

\* For carbonate of soda, see Vichy.

kidneys, but it is not found in the urine of persons abstaining from its use or suffering from pneumonia, it being probably used up for exudation matter. It is also excreted by the skin in persons who use considerable quantities of it. According to the experiments of Barral, F. W. Beneke and others, it augments the formation of urea from 100 to 300 per cent., and must be considered as the chief promoter of the retrogressive metamorphosis of matter.

Muriated alkaline Spas, especially Selters, have the most beneficial effect upon the human body. They lessen the acidity in the stomach, promote digestion and the elimination of used-up matter, and without acting as strong aperients or diuretics, soon regulate the functions of the different organs, and restore tone and vigor to the whole system.

In *bronchitis*, if caused by cold, and if cough in the morning and evening is the most prominent symptom, or if connected with hæmorrhoidal complaints—after measles and hooping cough in children, and in adults who suffer from inflammatory irritation—the warm Spa is eminently useful; but when the inflammatory irritation has subsided, the affection become chronic, and if there is relaxation of the mucous membrane, the cold Spa acts most powerfully.

In *catarrh of the larynx*, often found in public speakers, clergymen, teachers, singers, etc., and due to an over-exertion of the voice, and in catarrhs where the follicles of the mucous membranes have assumed a granular appearance, these Spas find great application, and are often used as a gargle. In Ems, elaborate provisions have been made that the gas should reach the suffering air passages, which can be far better accomplished by simply rinsing the mouth with carbonic acid or Selters water, when a large volume of gas will be set free, and try to find an outlet.

In *tuberculosis of the lungs*, the reputation of the warm Spa is *only* based upon the relief it affords in fluidifying the mucus, and facilitating a difficult and scanty expectoration; but if there are physical signs of tubercular infiltration, their use, as experience has fully shown, and as Dr. Althaus *distinctly* states, “*should under no circumstances be advised, as hæmoptoe, febrile symptoms, and an aggravation of the disease*

*altogether would be the consequence.*" Neither can *emphysema* of the lungs be cured by these or any other Spas; but the warm Spas of this class, by promoting expectoration, and improving abdominal circulation, greatly alleviate the most troublesome symptoms.

In *catarrh of the stomach* of a sub-acute nature, the warm Spa should be used at first, and with concomitant symptoms of ulcer, enough carbonic acid gas should be allowed to escape to prevent any ructus or flatus.

In *CHRONIC catarrh of the stomach*, the cold Spas of this class are a regular panacea, especially Selters, which is somewhat richer in chloride of sodium.

The warm Spas of this class are generally used in *chronic catarrh of the intestines*, caused by disturbed circulation, and in which diarrhœa alternates with constipation; in certain forms of *catarrh of the hepatic ducts* with impeded excretion of bile and icterus; in *chronic catarrh of the bladder*, and in *gravel and renal calculi*. In these latter diseases they are often preferred to Vichy, and their potency is explained by the theory that neither of them dissolve, but simply aid the elimination of solid concretions, and by curing the catarrh of those organs prevent new formations.

The cold Spas, especially Selters, are often prescribed in *hæmorrhoidal veins*, with inflammation of the mucus membrane and hæmorrhage, arising from pressure of stercoral matters and other causes of abdominal plethora, and with consequent affections of the nerves. But their use should be regularly continued, as the disease is apt to return. Carlsbad and Kissingen are sometimes preferred.

The Ems waters, especially the *Bubenquelle* which is used in the form of an *ascending douche*, have earned great fame as the chief remedy for *chronic parenchymatous metritis*, *hysterical convulsions* and *paralysis*, and other female complaints. We have constructed a little apparatus in order to reproduce the douche of any desired temperature.

The Spa passes through a fine coil in warm water before being converted into spray. The whole apparatus is very neat and simple, and has the appearance of a small tin pot with handle. We respectfully invite physicians to examine it, and see it operate.

In conclusion we should not forget to pay a just tribute to Selters water on account of its great importance in many social relations. It not only aids the solution of the mineral and albuminous ingredients of food which may have become insoluble by cooking, but contains itself in admirable proportion those mineral compounds necessary for the formation of blood and tissue, and for the structure of the human frame, not forgetting fluoride of calcium so essential for the formation of bones, and especially of teeth. And should the great harmony which the composition of Selters in many points presents with the normal mineral ingredients of the blood, not be the cause of its having become a luxury water, a Spa which always agrees with the system, and of which people never tire? The best authorities recommend its use to pregnant women, the fœtus, for a healthy development, requiring a large proportion of mineral and especially lime salts; and to women nursing infants, the milk being rendered by it more palatable and richer in mineral ingredients, and by greater alkalinity not so apt to coagulate in the stomach. Neither can it be doubted that many of the scrofulous symptoms in children are not only caused by insufficient assimilation and elimination of matter, but also by a want of those mineral constituents in the blood which are necessary for the building up of their frame.

Selters water is also extensively used with tart Rhine wines. It imparts to them a mild and pleasant champagne-like taste, and is very effectual in preventing the acidity in the stomach, and the fermentation in the intestines which generally follow their use. After the pleasures of the table, a glass of Selters water, taken before going to bed, will save to many persons those horrible, indescribable sufferings, with which, in the morning, they have to pay for their indulgence in the evening, and which in the German language are comprised by the generic term of "*Katzenjammer*."

As a general thing, the moderate use of Selters water will go far to keep persons in good health, and to prevent more serious disturbances which require the administration of more powerful remedies.

## ALKALINE SALINE SPRINGS.

Representative: CARLSBAD. (Sprudel).

Allied Springs: *Marienbad and Bertrich*.

The thermal springs of Carlsbad are situated in Bohemia, near the frontiers of Saxony and Bavaria, in a valley of the river Tepel, surrounded on three sides by granite mountains, and only open to the south and south-west. Their great renown dates as far back as 1358, when Charles IV. was emperor of Germany.

There are innumerable springs at Carlsbad, nine of which are used for drinking and bathing purposes. They have a very constant chemical composition, but their temperature varies between  $117\frac{1}{2}^{\circ}$  and  $162\frac{1}{2}^{\circ}$ . Becher ascribed their heat to the combustion of iron pyrites, and Klaproth endeavored to prove that it was caused by an immense bed of coal set on fire by iron pyrites; but later investigations have established the fact that their heat simply corresponds to the great depth from which they ascend. Here the boiling waters are under considerable hydrostatic pressure, and being impregnated with carbonic acid gas, they decompose the rocks which they meet in their subterranean course. When ascending to the surface part of the gas escapes, and the springs spout forth in regular intervals, and form heavy incrustations upon the earth.

The most famous of them is the Sprudel, which spouts 18 to 20 times in a minute, and rises from 4 to 8 feet. It is surrounded by large beds of *sprudel stone* capable of a high polish. Twenty million pounds of sulphate, and 13 million pounds of carbonate of soda are annually dissolved by it and brought to the surface; but according to the calculations of Vetter,\* the removal of such enormous quantities of salts cannot produce any serious excavations in the interior of the earth, as the royal castle of Berlin alone, if consisting entirely of sulphate and carbonate of soda, would supply the Carlsbad Sprudel for a hundred years.

The great antiquity of the springs at Carlsbad has been best elucidated by the researches of Berzelius. It was found that they had their origin in a common reservoir which is

\* Theoretisch-practisches Handbuch der Heilquellenlehre. Sec. Ed. Berlin, 1845.

roofed over by three layers of sprudel stone. These roofs are supported by numerous stalagmitic sprudel stone columns of from one to two feet in thickness, and there are in this subterranean three-story labyrinth, not only passages between the several apartments on the same floor, but also between the different stories. After the lowest story had been bored through, a large and violently agitated reservoir of boiling water was found, the bottom of which could not be sounded. How many years were required to build up such a structure?

The *Carlsbad Sprudel* according to Berzelius and Bauer, contains in 16 ounces :

Sulphate of Potash.....	0.7166	grains
Sulphate of Soda.....	19.2840	“
Phosphate of Soda.....	0.0037	“
Chloride of Sodium.....	7.9750	“
Bromide of Sodium.....	0.0091	“
Iodide of Sodium.....	0.0001	“
Fluoride of Calcium.....	0.0245	“
Carbonate of Soda.....	10.1320	“
Carbonate of Lithia.....	0.0200	“
Carbonate of Lime.....	2.3700	“
Carbonate of Strontia.....	0.0070	“
Carbonate of Magnesia.....	1.3690	“
Carbonate of Protoxide of Iron.....	(0.0270)	“
Carbonate of Manganese.....	(0.0060)	“
Alumina.....	0.0017	“
Silica.....	0.5770	“

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42.5227 grains.

Carbonic acid . . . . . 14 cubic inches.

Göttl, who analyzed the Sprudel in 1852, found more silica and phosphates, but we prefer to adhere to the numbers of the great chemist.

The physiological action of Carlsbad water is due to carbonic acid, sulphate of soda, carbonate of soda and chloride of sodium (see Vichy and Selters), greatly modified by carbonate of lime and silicic acid, and by the temperature of the water.

Sulphate of soda is contained in the human blood. Small quantities, administered internally, are excreted by the kid-

neys ; large quantities produce diarrhœa, and are said to abstract from the blood an amount of water equal to 12 times the quantity of the saline ingested, the greater portion of the salt being in such cases eliminated with the fæces. According to Liebig, the aperient action of sulphate of soda depends upon the concentration of its solution ; if heavier than the serum, he supposed an amount of water to rush from the blood into the intestinal canal in order to dilute the concentrated liquid. Later experiments, of Buchheim and others, have however disproved Liebig's theory by showing that the same amount of sulphate of soda, if administered in very dilute solution, has an increased aperient action which seems very natural, the purging power of the water itself being added to that of Glauber's salt. The continued use of sulphate of soda disturbs digestion, and causes catarrh of the intestines.

Carlsbad water has been often compared to Vichy, and is prescribed in similar diseases, but its amount of carbonate and sulphate of soda differs considerably from the celebrated French Spa. It is a very efficient remedy in *diseases of the liver and abdominal plethora*, rendering the fæcal matters very rich in biliary constituents, and increasing the amount of phosphoric acid in the urine. It is neither a diuretic, nor a strong purgative, and shares the property of all warm Spas of frequently producing constipation. There are cases on record where patients, during the whole time of their sojourn at Carlsbad, suffered from excessive costiveness ; and it was popularly believed that the Sprudel had petrified their intestines, in the manner observed in wood, plants and other objects over which it flows.

According to the researches of Professor Seegen, who experimented on nine persons, the quantity of fæces voided was considerably increased in two persons only ; in three it remained the same, and in two others costiveness was produced, which did not yield to large quantities of the Spa. Neither did the amount of urinary water correspond to the increased quantity of water taken, a large portion of it, on account of the high temperature of the Spa being probably lost by diaphoresis, while the weight of uric acid was gene-

rally diminished. We have not sufficient data to show how far the physiological action of the Sprudel may be modified by a lower temperature, and by an increase of carbonic acid gas.

In *habitual constipation* due to sedentary habits, and connected with disturbed abdominal circulation, the Carlsbad waters, *especially if allowed to cool*, have a mild but certain effect upon the bowels, which is more permanent than that produced by strong purgative waters.

In *hyperæmia of the liver*, arising from abdominal plethora, and not connected with diseases of the heart and lungs; in fatty degeneration of the liver, and granulated liver in its first stage; and in diseases of the liver arising from ague, in which case the spleen is also affected—the Carlsbad waters merit their high reputation, and seldom fail to effect a cure.

In *catarrh of the hepatic ducts and gall stones*, and also in renal calculi and gravel, they prove very efficacious by eliminating solid concretions.

In those forms of *gout* in which catarrh of the stomach, hyperæmia of the liver and abdominal plethora are prominent symptoms, great and lasting benefits may be expected from their use.

Carlsbad water has an unpalatable taste, which somewhat resembles salted mutton broth. This taste is hidden in our preparations by carbonic acid, but can be easily restored by warming the Spa, and allowing most of the gas to escape.

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## MURIATED WATERS.

Representative : KISSINGEN (Rakoczy).

Allied Springs : *Homburg*, the tepid waters of *Soden* and the thermals of *Wiessbaden* and *Baden-Baden*.

Kissingen is situated in the valley of the Saale, in Bavaria, 800 feet above the level of the sea. The springs issue at an average temperature of 50° from variegated sandstone and conchyliiferous lime stone, and are very rich in carbonic acid.

The waters come up with restless ebullition, owing to the constant evolution of gas, which imparts to them, when viewed in the shaft, an opalescent appearance. The discharge of gas varies with changes in the atmospheric pressure, being most violent at a low stand of the barometric column; and the inhabitants are able to foretell changes in the weather from the appearance of the springs.

The composition of the Kissingen waters is subject to great variations. Without attaching any great importance to analyses famous only on account of their great antiquity, and made in an age, when it was scientifically impossible to correctly determine the ingredients of Kissingen or any other Spa,—but nevertheless often adopted in the preparation of artificial waters even at the present time,—so much is certain, that the whole sum of anhydrous mineral ingredients was pretty correctly stated. By comparing them with more recent examinations, it appears that a most remarkable change must have taken place in the Kissingen waters. We cannot imagine that the public would be particularly benefited, if we should prepare the Kissingen Rakoczy according to the composition it was *supposed* to have *a hundred years ago*, and we therefore prefer to follow recent investigations, and to imitate the Spa, as near as may be, as it flows to-day from the bosom of nature.

According to Baron Liebig, who, by request of the King of Bavaria, made the analysis on the spot, *Kissingen* (Rakoczy) contains in 16 ounces :

Chloride of Potassium.....	2.2034	grains.
Chloride of Sodium .....	44.7133	“
Bromide of Sodium .....	0.0644	“
Nitrate of Soda.....	0.0715	“
Chloride of Lithium.....	0.1537	“
Chloride of Magnesium.....	2.3331	“
Sulphate of Magnesia .....	4.5088	“
Carbonate of Magnesia .....	0.1309	“
Sulphate of Lime.....	2.9904	“
Phosphate of Lime.....	0.0431	“
Carbonate of Lime.....	8.1482	“
Carbonate of Protoxide of Iron....	(0.2425)	“

Silica .....	0.0991 grains.
Ammonia .....	0.0070 “
Iodide of Sodium, Borate of Soda, Sulphate of Strontia, Fluoride of Calcium, Phosphate of Alumina, (Carbonate of Manganese).....	traces.
	<hr/>
	65.7094 grains.
Carbonic acid.....	41.77 cubic inches.

The physiological effects of Rakoczy are mainly due to carbonic acid gas, to the chlorides of sodium and lithium, and to lime and magnesia salts. It was *formerly* believed, that the small amount of carbonate of protoxide of iron was an important constituent, and the Rakoczy was classed among the chalybeate waters; but according to Dr. Althaus, such is not the case. Dr. A. B. Granville, a physician of the Spa for the last 27 years, in his “account of the Kissingen waters,” lays, indeed, great stress upon “the *quarter* of one grain of carbonate of protoxide of iron, held in almost ætherial solution in 16 ounces of water,” and he ascribes to it greater immediate effects than would be produced by 10 grains of *oxide* of iron or its carbonate, administered in the ordinary way. And he is no doubt right, and might just as well have said 10 *ounces* of oxide of iron, especially if calcined. But the same writer mentions that the strong chalybeate water of Bocklet, situated about 5 English miles from Kissingen, “is brought in bottles to the Kissingen wells every morning, to be drank occasionally either alone, in addition to, or in combination with the Rakoczy.” And it is also a fact that patients, after having completed their cure at Kissingen, are sent to Pyrmont, Homburg, etc., in order to drink the chalybeate waters of those Spas.\*

The action of chloride of sodium upon the human body, has been considered under muriated alkaline spas, and that of chloride of lithium we will postpone for lithia water. Lime and magnesia salts are converted by the alkaline juices of the small intestine into phosphates and carbonates (or yielding

\* See Iron Water.

carbonates by combustion), their acids combining with soda and potash; and are absorbed by the blood if enough carbonic acid be present to keep them in solution. If administered for a lengthened period, in too large quantity, or in the absence of carbonic acid, they have an emaciating effect, and deplete the system of carbonate\* and phosphate of soda, simply affecting the intestinal canal and passing off with other indigestible matter. By increasing the amount of lime and magnesia in the blood, they are probably more effective in the treatment of scrofula, especially in its erethic form, and of abscesses and similar diseases of the skin, caused by a faulty composition of the serum, than the minute proportion of iodides and bromides contained in muriated Spas. (Direct experiments with dilute acidulous solutions of chloride of calcium and magnesium, in the proportion in which these bases are found in the blood, could not prove but highly interesting and instructive.)

The *Kissingen Rakoczy* has a refreshing, slightly bitter, salty taste, and stimulates the mucous membranes of the stomach. Hunger and thirst are increased. Its action is mainly *diuretic*, and according to Dr. A. B. Granville, it is only aperient if large doses, two or three glasses, be taken. It at first not unfrequently produces costiveness, but its general tendency is to augment the secretion in the intestines, the action of which becomes at length perfectly quotidian and abundant. In *habitual constipation* and *chronic catarrh of the intestines*, the internal use of Kissingen is combined with *Kissingen bitterwater*. According to Dr. Althaus, the effect of Kissingen upon the bowels is more marked if the Spa is allowed to stand for some time, as a great part of the carbonic acid then escapes. But Dr. C. Enzmann † very sharply controverts the idea that carbonic acid impairs the aperient action of Spas. In his opinion *the aperient effects of any saline solution are considerably increased by the addition of any acid, and in mineral waters by carbonic acid*, which stimulates the peristaltic motions of, and the watery secretion in, the intestinal canal. This is fortunately not the first time, where

\* Vichy patients are sent to Kissingen.

† Die Mineralwasserkuren, etc., Dresden.

Doctors disagree. Dr. Enzmann's theory gains much strength by the experience with Spas poor in carbonic acid, which are generally constipating; many observations however have proved that the effects of Kissingen are quite different in different constitutions. With some, costiveness is produced, with others, a gentle aperient or even laxative action is the rule. Judging from the chemical composition of Kissingen water, it cannot be a strong purgative, and the excess of carbonic acid, besides effecting a better *absorption* of the mineral ingredients, and increasing diuresis, may also impart sufficient vigor and tone to the system to resist an action which is after all only abnormal.

The Kissingen waters are very effective in certain forms of *indigestion*, owing to *chronic catarrh of the stomach*, *deficient secretion of the gastric juice*, *liver disease* and *abuse of intoxicating liquors*; also in *abdominal plethora* in *weak, irritable and scrofulous patients* to whom the use of stronger waters, by causing relaxation of the mucous membrane of the intestines, might prove detrimental.

They have also been warmly recommended for *consumptive patients* if suffering from troublesome catarrh, indigestion and disturbed nutrition, but it is advisable to dilute the Spa with its own bulk of water. Their beneficial effect is probably due to chloride of sodium, which is largely used up in pulmonary diseases (see chloride of sodium).

In tumors of the *spleen*, due to *ague* or to *suppressed catamenia* and *hæmorrhoids*, the Kissingen treatment is often successful, but should be followed by the use of saline chalybeate waters.

The use of Kissingen in *chronic catarrhs* is based upon its excess of carbonic acid. As all our waters contain an excess of this important gas, there is no reason why Kissingen should be preferred to the muriated alkaline Spas.

The Kissingen waters have a great reputation for curing *gout and rheumatism*, and not without cause, as they contain some chloride of lithium. By exciting the secretions of the intestines, kidneys and the skin, they reduce habitual plethora, and promote a healthy metamorphosis of matter. The dose (at the springs) being from 3 to 8 tumblersfull, taken at

an interval of 15 minutes each, a sufficient amount of chloride of lithium is ingested to show its effect upon the uric acid in the blood. According to Dr. Althaus, "*Patients suffering from so-called irregular gout, where the joints are not much affected and no paroxysms take place, sometimes feel an increase in the severity of the symptoms during the first few weeks of the Kissingen treatment, when a paroxysm of gout occurs which lasts for a week or a fortnight, after which the health improves rapidly.*" This sounds hopeful enough for gouty persons, but we cannot advise them to undergo an additional pain of 4 or 6 weeks, and to swallow Kissingen water by the gallon, on account of a little chloride of lithium. Our lithia water acts more promptly though more painfully, but also more *effectively*; and should its merits be alone due to lithia salts (which is not probable), one gallon of it ought to produce the same result as 46 gallons of Kissingen Rakoczy.

We must also say a few words in condemnation of the habit of mixing Kissingen and Vichy, *half and half*, a habit which can have only originated in the bar room. It is intended to improve the taste, and get the benefits of both waters. Their character being diametrically opposite, their beneficial effects are about as well secured by a mixture as those of nitric acid and caustic potash would be if well mixed together.

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### BITTER WATERS.

Representative: KISSINGEN BITTERWATER and FRIEDRICHSHALL.

Allied Springs: *Saidschütz, Sedlitz, and Püllna.*

Bitterwaters derive their name from the taste of their chief ingredients, the sulphates of soda and magnesia. If they contain only sulphates, they are strong purgatives; but a prolonged use of them greatly disturbs digestion. The fluid in the intestinal canal is considerably augmented, only

small quantities being absorbed. Their bad effects are usually increased by a large percentage of sparingly soluble lime salts. The waters mentioned under the head of allied springs, and more especially Püllna, belong to that class. The Said-schütz water is favorably modified by a certain proportion of nitrate of magnesia, to which its cooling and diuretic effects must be ascribed.

But if bitterwaters consist of a mixture of sulphates and chlorides, the bad effects due to sulphates are entirely overcome, and their action is so favorably modified that according to Althaus, "*they should be used with preference, whenever the use of bitterwaters is required.*" They are gentle *purgatives and diuretics*. If large doses be taken before breakfast, they purge strongly with gentle diuresis; if small doses be administered, they purge gently and produce a strong diuretic action. The latter effect is more generally observed by taking the water after breakfast. Such are the Friedrichshall and Kissingen Bitterwaters. They nearly agree in chemical composition, and, as might be expected, produce identical effects. But the Bavarian Government would not consent to admit the latter in the class of safe and aperient medicaments, before a certain number of well-directed and well-observed trials with it had been made. The Kissingen bitterwater was accordingly tried *in extenso* in the hospitals of Bavaria, and in the hospital of Berlin of which Dr. Herzberg was Physician-in-Chief. The reports unanimously established the identical action of the two bitterwaters.

According to Baron Liebig, the *Kissingen Bitterwater* contains in 16 ounces:

Sulphate of Soda . . . . .	46.51 grains.
Sulphate of Magnesia . . . . .	39.55 "
Chloride of Sodium . . . . .	61.10 "
Chloride of Magnesium . . . . .	30.25 "
Chloride of Ammonium . . . . .	0.02 "
Chloride of Lithium . . . . .	0.09 "
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	177.52 grains.
Carbonic Acid . . . . .	5.9 cubic inches.

Dr. Mossler, of Giessen, made a series of investigations on the physiological effects of the Friedrichshall water, and as they are applicable to our preparation, we will give a short synopsis of them.

He experimented for a period of 36 days, on three persons who took the same amount of solid and liquid food. In the first period of nine days, the normal condition of the body was determined, and no bitterwater taken. In the second and third series of nine days each, doses of 5, 8, 16 and 32 ounces of bitterwater were taken *before* and *after* breakfast; and in the last period of nine days the after-effects were observed.

By 5 oz. of bitterwater, the *faeces* were increased slightly; 8 oz., taken before breakfast, increased them 2,010 grains, and after breakfast, 1,545 grains; 16 oz. increased them 6,750 grains in one person and only 1,155 in another; and with 32 oz. taken before breakfast, the increase was 17,250 grains, and after breakfast 12,240 grains.

The quantity of *urinary water*, if 5 oz. of bitterwater, were taken before breakfast, showed an increase of 690 grains; 8 oz. taken before breakfast increased it 7,380 grains, and after breakfast 8,175 grains; 16 oz. taken before breakfast increased the urinary water only 1,320 grains, but after breakfast, 8,760 grains; and 32 oz. taken before breakfast increased it 8,250 grains, after breakfast, 13,695 grains. The specific gravity of the urine remained essentially unaltered, and its reaction continued acid.—The quantity of urea rose with small doses of bitterwater, and decreased when large doses were taken. By the free action of the bowels, some of the urea formed may have been eliminated with *faecal matters*.—The quantity of uric acid was diminished.

The amount of chloride of sodium in the urine always corresponded to that of urea. After small doses of bitterwater, more chloride of "*sodium*" was discharged than had been ingested by the bitterwater;\* after large doses of bitterwater, a portion of the ingested chloride of sodium passed off

\*The excess of chloride of sodium is due to the decomposition of the chloride of magnesium of the bitterwater by the alkaline juices of the small intestine. Compare physiological action of *Kissingen*, p. 41-42

with the fæces.—The increase of sulphates in the urine was entirely due to sulphates contained in the bitterwater; but the larger portion of them passed off with fæcal matters. The rate of pulsation and respiration was somewhat increased by large doses of bitterwater; the animal temperature remained almost unaltered.

By the use of bitterwater for four consecutive days, the weight of the body decreased 195 grains for 5 oz. of bitterwater, 6,960 grains for 8 oz., and 12,255 grains for 16 oz. After 32 oz. of bitterwater taken for nine consecutive days, the body had lost 24,075 grains in weight. The waste of tissue was mainly confined to the fat.

The amount of urinary water remained increased, and the urea again rose for several days after the use of the waters had been discontinued; and the weight of the body, after nine days, was larger than before the commencement of the experiment.

Kissingen bitterwater can therefore be advantageously used as a *purgative* and *diuretic*. If a strong action upon the bowels is contemplated, as in *cases of considerable accumulation of fæces or congestion towards the head and lungs*, large doses are required at short intervals and before breakfast. In *abdominal plethora*, if due to indulgence in the pleasures of the table, to sedentary habits, diseases of the heart, or in pregnancy, a tumblerfull in the morning and another in the evening can be continued for some time without weakening the system. The action of the intestines is thereby regulated, and the water will, in many cases, be found preferable to Carlsbad. As a diuretic, the Kissingen bitterwater can be used in certain cases of dropsy, and pleuritic and other exudations. It is also eminently useful in scrofula, especially in swellings of the cervical glands, in tumors of the cellular tissue, chronic inflammation of the mucus membranes and eruptions of the skin.\*

**Citrate of Magnesia**, as prepared by us, does not exactly

\* The common bottles which we use for Kissingen bitterwater, Carlsbad, and Emser Krähnchen hold two-thirds of a pint.

agree with the prescribed formula. It is simply a strong, *slightly* acidulous solution of basic citrate of magnesia, with syrup and excess of carbonic acid, and deposits a small amount of the salt after several days. It contains no potash. We took the liberty to suppose that the use of crystallized bicarbonate of potash was simply intended for the convenience of druggists, as a ready mode to impart effervescence to the potion; and as we have better means of impregnating the solution with an excess of carbonic acid, the use of bicarbonate of potash has been dispensed with.

Although citrate of magnesia is a popular and highly-praised aperient, we, for our own part, would far prefer to take the corresponding soda salt, which is an agreeable and gentle cathartic, and, if absorbed, converted into carbonate of soda. The magnesia salts, according to the experiments of Lersch, are far more injurious to the system than the corresponding soda salts; and, if some observations published in the London *Lancet* have not been disproved, the same also applies to potash salts, if ingested in large quantity.



## IRON WATER.

The most powerful natural chalybeates are those which contain much carbonic acid gas, and with the exception of iron, only a small amount of saline ingredients. The iron is dissolved in them as a bicarbonate, and amounts to 0.25 à 0.80 grains of carbonate for 16 ounces of water. Chalybeates which are poor in carbonic acid or which contain the iron as a sulphate, are generally considered as unfit for medicinal use. They produce catarrh of the stomach and intestines, and impair digestion.

The great importance of iron to the system, has no doubt caused the habit of administering large doses of iron preparations, and as our iron water contains only *one grain of the carbonate, dissolved as a bicarbonate of the protoxide in somewhat less than 16 ounces of carbonic acid water*, it has been

often considered as entirely too weak. But that is not the case; our iron water is stronger and more effective than the best *natural* chalybeate, and far superior to any other artificial preparation. A short examination of the manner in which iron is absorbed and enters the general circulation, will, we hope, remove all doubt on the subject.

Iron salts when introduced into the stomach, may be decomposed or not; if combined with an acid stronger than lactic, they will remain unaltered; if given as carbonates of the protoxide, they will be converted into sparingly soluble lactates; in both cases a portion may remain unaltered or combine with phosphoric acid. Passing further on, they meet the decidedly alkaline juices of the small intestine, and are decomposed with the exception of the insoluble phosphates; these may be partially absorbed if carbonic acid be present, the phosphate of the protoxide of iron being soluble in about 1,000 parts of water containing carbonic acid. The other iron salts, if soluble, will be converted into alkaline salts corresponding to the acids they had been combined with, and into the protoxide of iron or its carbonate and phosphate, and the hydrated oxide. Not tartrate, lactate, sulphate or iodide of *iron* will be absorbed, but tartrate, lactate and sulphate of *soda* and iodide of *sodium*, and only a small fraction of protoxide of iron, if enough water and carbonic acid be present to keep the newly formed salts partially in solution. The remainder will be useless; the hydrated oxide will be partially reduced to a protoxide, and the whole mass, after entering combinations with tannic and gallic acids, and forming sulphurets, will constipate the intestinal canal, and be finally discharged with the faecal matters.

After the use of iodide of iron, iodine can be readily found in the urine, and sometimes, also, traces of iron, and it is generally supposed that the iodide of *iron* has been absorbed, but that the iron itself has been retained by the blood, because wanted. There is, however, a great fallacy in the conclusion. The blood of the human body in its normal condition contains only 60 to 70 grains of iron, and it is rational to suppose that only a small fraction of that amount can be absorbed at one time, and that the surplus will be

eliminated. And, indeed, doses of half a grain of iron dissolved as a bicarbonate by an excess of carbonic acid water can generally be traced in the urine, thus showing that they have yielded *more than a sufficiency* of iron for the formation of hæmatine *during a certain time*; and if large doses cannot be traced or only slightly traced in the urine, less than half a grain of iron must have been absorbed by the blood—the remaining portion simply affects the intestinal canal, of which proofs will not be wanting.\*

Iron water should be prescribed, except in cases of actual loss of blood, after a course of other mineral waters whose specific action does not depend upon iron, as Vichy, Selters, Carlsbad and Kissingen Rakoczy. The latter is no chalybeate. It deposits its iron, according to Liebig, as a *yellowish* sediment on the bottom of the tumbler, two or three minutes after it is taken from the well, the ebullition of the escaping gas having simply kept the hydrated oxide finely divided and suspended during that time. (The almost *ætherial* solution of Granville). A true chalybeate acts quite differently. If some of our iron water be poured in a tumbler, it will remain perfectly clear *for hours together*, and finally show a reddish film *on the surface*; heated in a test tube it will not give a yellowish deposit like Kissingen, but a heavy *green* precipitate of carbonate of protoxide of iron, and a large surface has to be exposed to the atmosphere in order to observe a brownish film after one hour. But if it be oxydized by a few drops of nitric acid, and ammonia water added, a heavy light brown precipitate will be produced. Ferridecyanide of potassium (red prussiate of potash) is the best test; a drop of it will produce a copious blue deposit.

Kissingen patients have therefore to use other chalybeate springs, and it is no wonder that they are even sent to Brückenau, which, according to Scherer, contains only 0.067 grains of carbonate of iron, or about *four times less* than Kissingen Rakoczy. But Brückenau is after all a true chalybeate—it

\* That iron is sometimes excreted by the kidneys, and *especially when it is taken in natural mineral waters*, is shown by the inky precipitate the urine gives in these cases on the addition of tincture of galls. "Stille's Therap. and Mat. Med." 1864. 387.

is rich in carbonic acid, poor in saline ingredients, and holds the iron dissolved as a bicarbonate of the protoxide.

Small quantities of iron promote digestion and the action of the heart, and their physiological effects are, in many respects, similar to those of carbonic acid gas, of which all our waters contain an excess. On that account, and because carbonic acid dissolves the iron salts of food, we felt justified in omitting the minute portions of iron stated in the analyses in parenthesis. The error cannot be important. In order to ingest 15 grains of carbonate of protoxide of iron, it would take 555 pounds of Carlsbad, 1,250 pounds of Emser Krähenchen, 1,666 pounds of Vichy, and an indefinite amount of Selters; and it cannot be assumed that the beneficial action of those Spas is, in any way, due to their chalybeate nature. We hope our patrons will prefer our iron water plain and simple; it will certainly do as much, and more, for the system, than a large dose of any martial preparation now in use.

The effects of iron are marked by two distinct features :

1. The number of blood globules and their hæmatine is augmented. This increase, in anæmic and chlorotic persons, may amount to one-third of the original number.

2. The *phosphoric acid* \* eliminated in the urinary water is diminished.

True chalybeates are most admirable remedies for "*anæmia and all morbid conditions consequent upon it; such as certain forms of indigestion, constipation and diarrhœa, amenorrhœa, dysmenorrhœa, blenorhœa of the uterus and the vagina, sterility, and tendency to abortion.*" "*In certain diseases of the nervous system, in headache, neuralgia in the back, chorea, tremor, paralysis, hysteria, and hypochondriasis, they also prove highly beneficial.*"

It should be observed that food containing tannic acid—as tea and many preserves—is not admissible during a course of iron water. A portion of the iron would be converted

\* This diminution must be partly ascribed to the formation of an insoluble phosphate of iron in the small intestine.

into an insoluble tannate, and fail to produce those beneficial results which otherwise may be confidently relied upon.



## LITHIA WATER AND VICHY WITH LITHIA.

Lithia was discovered by Arfvedson, a pupil of Berzelius, in 1818, and named, at the suggestion of the great chemist, from *λίθος*, a stone, because it was supposed to occur only in the mineral kingdom. It is the oxide of a metal closely resembling sodium and potassium, of 0.5986 sp. gr.; and was first obtained in the metallic state by Davy. Its equivalent is 7, as determined by Mallet (*American Journal of Science*, **18**, 349). In handbooks, it is usually stated at 6, or 6 and a fraction; but the methods used in its determination were not free from error.

Lithia is found in many minerals: Spodumene, (Mass., Maine, and Ct.); petalite, (Mass.); lepidolite, (Mass., Maine, and Ct.); amblygonite, triphylite, lithia-tourmaline, &c., and in many mineral springs, as Kreuznach, Dürkheim, Wiessbaden, Baden-Baden (Mur and Fettquelle), Kissingen, Bilin, Carlsbad, Franzensbad, Marienbad, and Wheal Clifford.

It imparts to flame a crimson color of exceeding beauty. Soda hides this color, and this accounts for small quantities of lithia having been often overlooked; but the spectrum analysis has furnished the means of separating the rays of each metal, and of detecting them, if present in the minutest quantity. Mixtures of the salts of calcium, magnesium, strontium, potassium, sodium, lithium, rubidium, and cæsium, if heated in a non-luminous flame, and viewed through the spectroscope, appear each with their characteristic rays; and 1-100,000 of a grain of lithia can now be readily discovered, while one-fourth of a grain will cause the crimson ray to continue for a whole hour.

Prof. Bunsen has, by this means, found lithia to be very widely diffused through nature. He not only discovered it in many rocks and minerals and in sea water, but also in the

vegetable and animal kingdoms. He found it in the ashes of sea weeds, of *grapes*, of vine leaves, of tobacco, of grain of every description, of the milk of animals fed upon grain, and in the ashes of *the human blood and muscles* (those of gouty people probably excepted).

Lipowitz first observed the great affinity of lithia for uric acid, which is sometimes called lithic acid—a coincidence of names rather interesting, but quite accidental. He found that acid-urate of lithia, when not too strongly dried, is readily soluble in sixty parts of water at  $122^{\circ}$ ; and that the salt did not separate out again when the solution cooled. By comparative experiments with potash, soda, and other bases, he proved the urates of lithia to be by far the most soluble of all urates.

Alexander Ure, of London, profiting by the researches of Lipowitz, found one grain of carbonate of lithia in an ounce of distilled water at  $90^{\circ}$  to dissolve from two to three grains of uric acid; a much larger quantity than is dissolved by carbonate of potash and soda. He exposed a human calculus which was composed of alternate layers of uric acid and oxalate of lime, to the action of four grains of carbonate of lithia, in one ounce of distilled water at  $98^{\circ}$ , for five consecutive hours, and found that the calculus had lost five grains in weight; and he proposed the injection of carbonate of lithia into the bladder for the purpose of dissolving and disintegrating urinary calculi.

Had he repeated the experiment with the same calculus, the loss would probably have been much smaller, as the action of carbonate of lithia would soon be arrested by oxalate of lime. The beneficial results expected from an injection of carbonate of lithia into the bladder would, in all probability, be greatly lessened by the soluble phosphates of the urine. (See phosphate of lithia).

Dr. Garrod proved the urate of lithia to be more soluble than the carbonate; a fact already established. His mode of procedure, however, is interesting. When boiling an *excess* of carbonate of lithia in water, the addition of uric acid caused it to dissolve with the formation of biurate of lithia.

“*The same observer experimented upon a metacarpal bone,*

*the phalangeal extremity of which was completely infiltrated with a gouty deposit of urate of soda. This was placed in a small glass, and a few grains of carbonate of lithia added, and, in the course of two or three days, the whole deposit was dissolved without having been heated. On making comparative experiments with the carbonates of lithia, potash and soda, on a cartilage infiltrated with urate deposit, he found that the cartilage, taken from the lithia solution forty-eight hours afterward, had been restored to its normal condition; that from the potash was much acted upon, while that which had been submitted to the influence of carbonate of soda, appeared unaltered."* He brought his observations to the notice of the medical profession, and recommended the use of carbonate of lithia in cases of *uric acid diathesis connected with gravel*, and in cases of *chronic gout*.

Doses of one to four grains dissolved in water, and repeated two or three times a day, produce, according to Garrod, no physiological symptoms, but exert a marked influence where the patients are voiding uric acid, causing gravel to diminish and even to cease. The supply of lithia at that time (1857) was so small as to preclude the possibility of an extended series of observations. And lithia seems to have grown in popular favor; although now produced in larger quantities, its supply is not nearly equal to the demand.

The muriated lithia waters of Baden-Baden (Murquelle) which contain 2-3694 grains of chloride of lithium in 16 ounces of water, have only recently been employed in cases of gout and lithiasis. Their physiological effects are considerably modified by lime and magnesia salts, and by the temperature of the water. They contain, like Kissingen, no alkalis, the lithium in both Spas being combined with chlorine.

I quote Dr. Ruef's report on the Baden-Baden waters as given by Althaus :

"At first they promote digestion, and a feeling of well-being is induced; but after they have been taken for some time, and especially when in large doses, sickness, disposition to vomiting, and diarrhoea ensue, which in most cases gradually disappear, but sometimes continue as long as the water is taken. A constant effect is an increased elimination of urine, the amount of which is often doubled or even trebled; after some time it

becomes turbid, and large quantities of a reddish sediment are deposited by it. In some patients profuse perspiration came on after from five to ten days, and continued so long as the water was taken. In the case of a lady who had not freely perspired for years, this perspiration even continued two months after the treatment was finished. It therefore appears that the water is a diuretic as well as a diaphoretic. In almost all patients the pain in the joints increased at first, but never spread to healthy parts. In joints which were perfectly contracted, crackling, dragging and pulling was felt as if the articulation was being torn asunder; but after such an attack of pain a sensation of easiness and decided improvement was perceived, and the mobility of the limb much increased. In one patient a regular fit of gout came on while drinking the water, under the continued use of which this patient so rapidly improved that he could walk about again after three days. Gouty affections of the joints, the sheaths of the nerves and muscles, if not of very long standing, were cured after three or four weeks. In periodically recurring headache on one side, which is often due to gout, the effects were likewise beneficial. The mode of administering the water was as follows: For patients with whom large quantities of water did not agree, five grains of carbonate of lithia were added to a bottle of Murquelle, which contains five grains of chloride of lithium, *and the water was then impregnated with carbonic acid.* Of this one tumblerful was taken three times a day, and if an increase of the dose appeared necessary, two or three grains of the carbonate were added to every glass. If patients are able to retain much water on the stomach, they may take six or eight tumblersful of Murquelle without any artificial addition of carbonate of lithia. Baths with water of the same spring are also given, and a mother lye is prepared from it, which may be added to them."

The observations of Dr. Ruef are encouraging enough, and seem to establish the direct effect of lithia salts upon urate deposits of the living body. Lithia, if administered internally, cannot, of course, act under the favorable conditions of Garrod's experiments with a gouty cartilage. Being taken in dilute solutions, and getting diffused through the blood, it can act upon affected joints only in the proportion they have to the general circulation, and its action will be further modified by the mineral ingredients of the blood and urine.

Investigations on that subject are by no means complete. The solubility of urates has been mostly determined for hot and cold solutions, while in a physiological point of view it is of the highest importance to have the determination made at the temperature of the blood. They throw, however, much light upon the probable formation of urate deposits, and as it may be agreeable to many of our readers to have them in a connected form, I will state the solubility of uric acid and urates, and other difficultly soluble mineral substances, as far as they concern the human body.

*Uric acid* is almost insoluble in cold, and sparingly soluble in warm water. It requires about 10,000 parts of cold water for solution.\* It is insoluble in alcohol and ether. It is readily dissolved by alkaline carbonates, lactates, acetates, borates and phosphates; also to some extent by chloride of lithium, and by a warm aqueous solution of cane sugar and glycerine. The solution—with the exception of lithia—cannot be effected by heating a mixture of uric acid and an alkaline carbonate, and especially carbonate of soda. Only a little of the urate would be dissolved, the greater portion of it remaining suspended in the liquor, an insoluble acid salt, and a soluble basic salt being apparently formed. The best method of obtaining a solution, is to dissolve the carbonate of soda in boiling water, and then to add uric acid in a suspended state.

In repeating Dr. Garrod's experiment, who added uric acid to an excess of carbonate of lithia in boiling water, and found it to dissolve as biurate of lithia, I observed somewhat different reactions. The uric acid is dissolved, and the excess of lithia gradually disappears, *but without effervescence*, a urate and a bicarbonate of lithia being evidently formed. The solution remains clear, as the bicarbonate of lithia is more soluble than the normal salt, and the addition of small portions of uric acid can be continued for some time, without producing any apparent change in the liquor. After the whole amount of lithia which remains uncombined with uric acid, has been thus brought to the state of a bicarbonate, a *further addition of uric acid causes a violent effervescence*, due to the escape of carbonic acid gas. By carefully adding uric acid, till further effervescence ceases, the liquor becomes opaque, but continues faintly *alkaline*, thus showing:

1. That the lithia is in the state of a urate, and,

\* The solubility of uric acid, etc., has been very differently stated by different observers. I give only those numbers which seem to be entitled to most credit. Compare: "*First Outlines of a Dictionary of Solubilities, etc.*," by FRANK H. STORER. Cambridge, 1863.

2. That the urate of lithia is more soluble than the carbonate, and less soluble than the bicarbonate of lithia.

By the addition of a little water the solution becomes again clear, and again dissolves uric acid. It assumes an acid reaction, the lithia being now converted into the acid salt.

In 90 parts of water, a mixture of one part of carbonate of lithia and one part of uric acid is easily dissolved at the ordinary temperature; at boiling heat, one part of carbonate of lithia dissolves almost 4 parts of uric acid, and one part of caustic lithia dissolves 6 parts of uric acid (Lipowitz.)

I found a mixture of uric acid and carbonate of lithia dissolved easily at the ordinary temperature, and very readily at 100°;—a very important difference between carbonate of lithia and other alkalis, and which may be sufficient to explain why carbonate of soda fails to dissolve urate deposits. Mixtures of *uric acid, carbonate of lithia and carbonate of soda*, or of *uric acid, chloride of lithium and carbonate of soda*, can be readily dissolved; the lithium in the latter case apparently acting as a carbonate with an equivalent amount of chloride of sodium. No precipitate is formed by adding to a concentrated solution of urate of lithia a concentrated solution of bicarbonate of soda.

*The acid-urate of lithia*, which, as stated above, is soluble in 60 parts of water, is also to some extent soluble in alcohol (v. Schilling).

*Urate of potash* is soluble in 44 parts of cold, and 30 to 40 parts of boiling water.

*Acid-urate of potash* is soluble in 780 to 800 parts of water at 68° and 80 parts of boiling water. *It is much less soluble in an aqueous solution of carbonate of potash than in pure water.*

*Urate of soda* is soluble in 77 parts of cold, and 75 parts of boiling water. *Carbonic acid precipitates the acid salt from its solution in alkalies* (see carbonic acid in the blood). It is also decomposed by the carbonic acid of the atmosphere.

*Acid-urate of soda*, according to Bensch, dissolves in 1,100 to 1,200 parts of water at 59° and in 125 parts of boiling water. It is like the corresponding potash salt, *much less soluble in an aqueous solution of carbonate of soda than in pure water.*

*Urate of ammonia* requires 480 parts of water for solution (Proust).

*Urate of Lime* is soluble in 1,500 parts of cold, and 1,440 parts of boiling water.

*Acid-urate of Lime* is soluble in 603 parts of cold, and 276 parts of boiling water (Drs. Allan and Bensch), and much more readily soluble in an aqueous solution of chloride of potassium. Lime salts, before the reactions of lithia were known, were recommended as best calculated to prevent the formation of uric acid calculi. (Ann. der Chemie und Pharm., LXV., p. 184.)

*Acid-urate of Magnesia*, according to Bensch, dissolves in 3,500 to 4,000 parts of cold, and in 150 to 170 parts of boiling water.

*Carbonate of Lithia* is soluble in 130 parts of water and in 20 parts of carbonic acid water.

*Carbonate of Lime* is soluble in 50,000 parts of water and, if recently precipitated, in 74 parts of carbonic acid water, (more readily soluble in chlorides).

*Carbonate of Magnesia*, if recently precipitated, is soluble in 5,071 parts of water and in 70 parts of carbonic acid water, (more readily soluble in chlorides).

*Carbonate of Protoxide of Iron*, if hydrated, is slightly soluble in water. It dissolves in carbonic acid water, also in aqueous solutions of chloride of ammonium, and cane sugar.

*Phosphate of Lithia* ( $3\text{LiO cPO}_5$ ),—the only phosphate the existence of which has been well proved (Storer),—is soluble in 2,539 parts of pure water at the ordinary temperature. *It is readily soluble in ammoniacal salts and in carbonic acid water.* (The other lithia salts are very soluble, some of them deliquescent.)

*Bone-phosphate of Lime* is insoluble in water, but dissolves, according to Berzelius, in no inconsiderable quantity, in liquids which contain various organic non-acid substances in solution. It is easily soluble in water which contains chloride of sodium or chloride of ammonium, and in carbonic acid water. One-fourth of the dissolved phosphate (in carbonic acid water) remains in solution after the water has been boiled.

*Phosphate of Protoxide of Iron* is insoluble in water, but dissolves in about 1,000 parts of carbonic acid water.

*Uric acid* is one of the final products of the disintegration of animal tissue. In the normal condition of the blood it is readily excreted by the kidneys in combination with bases. The action of the carbonic acid of the blood is here of the highest importance. We have already stated (see *carbonic acid gas and carbonic acid water*) that the *free* gases of *arterial* blood, according to the researches of J. Sachs, contain 70 per cent. of carbonic acid. This gas, which is the main solvent of the phosphates and carbonates of iron, lime and magnesia in the blood, decomposes urate of soda by forming acid-urate of soda and carbonate of soda, or uric acid, acid-urate of soda and carbonate of soda, thus explaining to some extent the acid reaction of urine.\*

The maximum quantity of acid-urate of soda which can be eliminated by the urinary water, depends upon the solubility of that salt at 98°. In the absence of a direct determination,

\* The tribasic phosphate of soda is converted by carbonic acid into the bibasic salt and carbonate of soda (Rose), while the bibasic salt has the property of yielding to "uric acid" one of the two atoms of fixed base, and of being converted into an acid-phosphate, (Lehmann).

we will assume its ratio of solubility to correspond to the temperature, which is not improbable. As one part of acid-urate of soda dissolves in 1,200 parts of water at 59°, and in 125 parts of water at 212°, it should, under that supposition, dissolve in 273 parts of water at 98°; and if the influence which other constituents of the urine may exercise upon the solubility of this salt, be not taken into account, 1,000 parts of urine at 98° could not hold quite four grains of the acid salt in solution.\*

By a disturbed excretory action of the kidneys, urate of soda may be retained in the blood, and being eliminated in other ways, become partly insoluble. This action hardly depends upon the solubility of the acid salt, as blood neither contains the salts of the alkalies in the proportion of their solubilities, nor presents the condition of a concentrated solution in respect to any of its mineral ingredients, and it seems more probable that the excretion begins when uric acid is present in the blood *in more than normal proportion*;† the crystallization of acid-urates, and their final formation into solid deposits being an after-process. These deposits are usually called urates, and are supposed to consist of urate of soda with very small quantities of urate of lime and ammonia, but a re-examination will probably prove them to be mainly *acid-urate* of soda.

The behavior of uric acid with carbonate of soda seems to agree well with the established action of alkaline Spas, such as Vichy. They produce a strong diuretic action, remove soluble urates from the blood, and prevent a further accumulation of gouty deposits. The blood is rendered more strongly alkaline and is fluidified by the solvent action of the alkali upon the albumen,—and the pain ceases. The sufferers are

\* The turbidness observed in fresh urine on cooling, affords to Lehmann a proof of the presence of urate of soda, because the urine becomes again clear and limpid when raised to the original temperature. This applies well for the acid salt, the great solubility of the normal salt not being essentially affected by changes of temperature.

† Dr. Garrod found in the blood of gouty patients 0.004 per cent., 0.005 per cent., and in one case even 0.0175 per cent. of uric acid.

usually satisfied with that result, and being relieved from pain, do not mind much the remaining knotty portions.

Lithia goes a step further. For a short time it troubles the gouty patient as little as it would a healthy man, and seems to be entirely occupied with the removal of soluble urates. But after a few days, or at once, if the patient has been in the habit of drinking Vichy, it attacks the affected joints, and the pain produced (for but a short period, however) by the solution and resorption of urate deposits seems to be the very essence of gouty reminiscences.

Our *Lithia Water* contains in 16 ounces of carbonic acid water :

Chloride of Lithium .....	7.203	grains.
Bicarbonate of Soda .....	32.717	"
Sulphate of Soda (anhydrous) .....	4	"
Chloride of Sodium .....	0.080	"
Chloride of Potassium .....	1	"
Chloride of Ammonium .....	1	"
	<hr/>	
	46	grains.

By *equivalent substitution* it will act as :

Bicarbonate of Lithia .....	10	grains.
Bicarbonate of Soda .....	20	"
Sulphate of Soda .....	4	"
Chloride of Sodium ... ..	10	"
Chloride of Potassium .....	1	"
Chloride of Ammonium .....	1	"
	<hr/>	
	46	grains.

Our *Vichy with Lithia* contains in 16 ounces of Vichy *two grains of bicarbonate of lithia* introduced as a *chloride*.\*

The question presents itself, why lithia, acting as a carbonate, is introduced as a chloride? It was done mainly, because the chances of having the whole amount of lithia absorbed, seem greatly increased by that combination, as alka-

\* Our portable glass fountains, holding about 24 ounces of water, would therefore contain 15 grains of bicarbonate of lithia in lithia water, and 3 grains of bicarbonate of lithia in Vichy with lithia.

line chlorides are very soluble and *entirely* absorbed by the blood, if not taken in too large quantity. Some respect was also paid to the combinations of nature. Our most important and effective lithia Spas contain the lithia combined with chlorine, its action upon the acid-urates being induced by the alkalies of the blood.

A closer examination of the composition of our lithia water will reveal several interesting features :

1. It approaches Vichy water in alkalinity, but is not sufficiently alkaline to disturb the normal acid reaction of the urine, whereby a precipitate of phosphate of lime might be caused in the bladder ; it will simply *reduce* the acidity of the urine.

2. After the formation of urate of lithia, the proportion of bicarbonate of soda and chloride of sodium will be almost identical with Ems water, which is eminently useful in that form of catarrh which is frequently observed in gouty persons, and sometimes alternates with true paroxysms of gout.\*

3. It has a strong diuretic action. (Compare the action of carbonate of soda, chloride of sodium, and small quantities of sulphate of soda.)

4. By the presence of alkaline chlorides the formation of urea, and the solubility of phosphates is promoted.

5. The excess of carbonic acid, with some chloride of ammonium,† is *essential*. Without them the formation of a highly insoluble phosphate of lithia in the small intestine could not be well prevented. The excess of carbonic acid also insures the absorption of all mineral ingredients, if not taken in too large quantity.

The introduction of lithia has inspired many men with enthusiasm, and filled others with distrust ; an occurrence not unusual, when old habits and theories have to give way to new ones. We should take a common sense view of the matter, and not expect impossibilities from a *few grains* of lithia, *because* it dissolves urate deposits. In the first place, it can-

\* J. ALTHAUS. "The Spas of Europe." London, 1862. p. 327.

† It amounts to only one-fifth of that of gastric juice.

not dissolve stone in the bladder if that should consist of phosphates and oxalates and not of urates. According to Dalton,\* stone is formed in certain diseases of the bladder by too long retention, and ensuing alkaline fermentation of the urine, whereby the phosphate of lime is rendered insoluble; but the experiments of Wöhler and Frerichs† seem to connect it indirectly with the urates in the blood. After administering urate of potash to a man and a dog, those philosophers found, in both cases, large quantities of oxalate of lime in the urine.

In the second place, it does not meet urate deposits in a favorable molecular condition. Being deposited very gradually, they must be of a crystalline nature, and present all the difficulties met with in the solution of crystallized salts.

In the third place, the weight of those deposits, in some cases, is not insignificant, and if expressed in grains, would be represented by a pretty high figure; and as one grain of carbonate of lithia, under the most favorable circumstances, could not be well expected to dissolve more than two grains of uric acid, it would take some time to reach a normal condition. The atony of organic action in old persons, and serious changes in the composition of the blood, need hardly be mentioned.

It should be remarked in this connection, that on one occasion the above formula was changed by substituting biborate for sulphate of soda; the inducement thereto being the comparative tenacity with which a *warm* solution of biborate of soda retains uric acid, even if supersaturated by a strong mineral acid, but the alkalinity of our preparation and the presence of chlorides renders its addition superfluous. Still, borax may possibly find some *external* application in diseases connected with uric acid. This acid is mainly excreted by the kidneys, but according to the investigations of Wiederhold‡ also by the lungs and by the skin. Is it unreasonable to suppose, if by a disturbed action of the kidneys an undue amount of uric acid is retained in the blood, that it may in

\* Dalton's Physiology 1864, p. 361. † Ann. der Chem. u. Pharm. LXV. 335.

‡ Deutsche Klinik von A. Goeschel, Nov. 18, 1858.

more than usual proportion find an outlet by the other channels? And may not the want of diaphoresis, often observed in gouty persons, have something to do with an accumulation of uric acid? A warm solution of borax readily dissolves uric acid, and a few trials might readily determine, how far it can be advantageously applied in rheumatic and gouty affections.

The property of lithia,—of forming easily soluble acid-urates, and of dissolving uric acid and urate deposits in the human body,—seems to assign to it an important rank *in all diseases in which the formation and proportion of uric acid is unduly increased*. According to Lehmann, an augmentation in the amount of uric acid in the urine always accompanies the groups of symptoms usually designated as *fevers*, the uric acid either separating or remaining dissolved. How far our lithia water, by increasing the solubility of acid-urates, and by its strong diuretic action, can be used for the amelioration of these diseases, we can only hope to learn from the observations of physicians.

There is also a large number of diseases from rheumatism upwards to chronic and inveterate gout, and uric acid diathesis connected with gravel, in all of which uric acid is present in abnormal proportion. It is not our province to inquire into their specific characters and differences, but we may be allowed to look upon them in the relation they have to uric acid. They may in that respect be divided into two groups: 1. Where the urates are formed rapidly, and are eliminated with the urinary water; or, 2. Where they are partially retained, accumulate more or less slowly, and being decomposed by carbonic acid, are finally deposited as acid-urates of soda or uric acid.

The theory has been presented that lithia water should be used in the second group of diseases only. Why not in the first, which often merges into the second? If urine is often so highly charged with acid-urates as to deposit them on a small reduction of temperature, it must be in the state of a concentrated solution, and must have removed from the blood a quantity of acid-urates corresponding to their solubility. It would seem natural that by the introduction of a better

solvent, as lithia, which forms an easily soluble acid-urate, the same amount of urinary water would remove from the blood, during the same time, a much larger quantity of uric acid without presenting the character of a concentrated liquid. But we will not discuss theories; we would simply mention that living proofs of the beneficial effects of our lithia water, in such cases, are walking about the streets.

The symptoms, as far as we are able to judge, closely agree with the observations of Dr. Ruef. The disease is at first aggravated, and an increased pain in the affected parts seems to mark the moment when urate deposits begin to be resorbed. After several days, according to the condition of the patient, an amelioration takes place. The increase of pain seems to be of such uniform occurrence that it will probably serve as a guide in the administration of lithia water. Still, it cannot be called a desirable property, and it may in aggravated cases be wise to first establish a strong diuretic action with less pain, by the use of Vichy with Lithia. The pain produced by lithia is not a constitutional distemper; it is simply due to the solution of urate deposits and to a temporary increase of uric acid in the blood, and its degree closely corresponds to the amount of urates that for the time being may be in solution. This is proved by the circumstance that the pain ceases in a brief time, if lithia be discontinued;—the dissolved urates are excreted, the solid deposits are no longer affected, and the patient believes himself almost restored. The pain reappears, however, if the use of lithia water be recommenced, thus affording an index of the progress of the cure. Lithia itself is a very harmless alkali; if taken in the same quantity by a healthy person, it produces no physiological effects, and it also troubles the patient less and less, as he nears a normal condition, the pain becoming *different* from the accustomed twinges, and finally ceasing altogether. Lithia, it seems, has to fulfil its mission, viz., remove all abnormal urates from the body, and the patient, in order to be restored, must get well *under its use*. The urinary water is discharged in great abundance and becomes perfectly clear and limpid, and a strong diaphoresis marks, in some cases, the approach of a perfect cure.

In *gravel*, the elimination of solid deposits is greatly increased in the beginning, and lithia water has been suspected of causing their formation—a charge rather too flat for disproof.\*

In order to insure the absorption of lithia water, small doses—a wine-glass full—should be taken at a time. Parrish states the maximum dose at 4 grains of the carbonate three times a day, while Dr. Ruef administered even more. Our portable glass fountains contain about  $\frac{3}{4}$  of the maximum dose of lithia, so that patients, according to those authorities, could use one per day without harm. But from the small experience that has been gathered, it is hardly advisable to do so before the paroxysm of the disease has been overcome; and it remains also to be seen, whether the composition of our lithia water, by rendering the whole amount of the alkali effective, necessitates the use of the prescribed quantities. Its use as a therapeutical agent is also of too recent a date to afford sufficient experience of its physiological action; we may, however, hope that the observations which may be made with it, will be brought to the notice of the medical profession through the proper channels.

In preparing our lithia water, we have tried to fulfill all conditions necessary for its complete absorption by the blood, and for the utmost solubility of the ingredients of a copiously discharged urine; and it is to be hoped that this new alkali, in the hands of the medical profession, will confer great and lasting benefits upon many a poor sufferer. As its physiological effects are watched with interest by the attending physician, new and important applications will probably be found for it in diseases not directly connected with uric acid.

We quote from an article of J. Begbie, in the *Edinburgh Med. Journ.*, May, 1858, p. 983:

“So intimate is the relation, and so frequent the concurrence of rheumatism with an unhealthy condition of the uterus, that Dr. Todd has seriously proposed the question: “Whether, under certain circumstances, the uterus may not be regarded as a source of rheumatic or arthritic matter?” and has devoted one of his interesting Croonian lectures to the illustration of the subject. I incline much more to the view, that the uterus is affected in its functions and structure through the rheumatic blood. We know that it suffers through gout, and that the affections thus engendered are relieved or overcome through colchicum and such other

\* See Vichy.

means as favor the elimination of the gouty matter. I cannot doubt that it is similarly affected through the rheumatic element, hence the relief obtained, in so many of its disorders, through arsenic and other remedies, which are known to influence that particular constitution. I have seen cases of peritonitis in intimate relation with rheumatism, and doubt not the accurate observation of those who have diagnosed rheumatic inflammation of the womb. The connection of rheumatism and dysmenorrhœa has long been recognized. Dr. Rigby writes to Dr. Todd: 'I have been for several years aware, that many common derangements of the uterine organs are frequently connected with a state of the system analogous to what, when it attacks the limbs, is known by the name of rheumatic gout, arthritis, etc. This is more especially the case with certain forms of dysmenorrhœa, inflammation of the os and cervix uteri, with albuminous discharge and the early stage of scirrhus uteri.'

The great therapeutical importance of lithia has already stimulated its production, and we may hope to have an abundance of this new alkali before the lapse of many years. Its sources are multiplying. Only quite recently, the hot springs of *Wheat Clifford*, which yield 150 gallons of water per minute, have been found to contain in 16 ounces, 2,85 grains of chloride of lithium; and the *American Journal of Science* (November number, 1864) in alluding to that important discovery, very appropriately remarks: "*Both chemists and medical men will hail this supply of lithium.*"

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### THE LESSER INGREDIENTS OF MINERAL WATERS.

In defining the character of mineral springs, according to their most prominent constituents, we have purposely omitted the consideration of other ingredients which are present in smaller quantities, and common to most. Although this mode of considering the physiological action of springs is very convenient for the elucidation of their characteristic differences, it conveys an erroneous idea of their therapeutical value; a spring being a remedy, not on account of one or two ingredients—as chloride of sodium, carbonate or sulphate of soda, from which it takes its character—but on account of the sum of its mineral ingredients. We have only to compare their quantities and mixture with the mineral portion of the human blood, in order to at once perceive a striking resemblance, and to divine the importance of the lesser ingredients.

The composition of mineral springs is governed by the rocks and strata which they permeate, the amount of water they discharge, with its temperature and hydrostatic pressure, and the volume of carbonic acid gas dissolved in it; also, by the time the springs have been in contact with the rocks. The saline substances are not usually removed from the latter by a simple process of solution, as mineral springs, although their nature depends upon that of the rocks, never represent their composition in a soluble form. Their action is a decomposing one, and mainly due to carbonic acid which has the power of withdrawing from all silicates their base, if that be soluble in carbonic acid water. And this decomposing action of carbonic acid water, together with its property of keeping a number of saline substances in solution which would be insoluble in common water, is the great foundation of modern geology and of all organic life.

Plants draw their nourishment from the earth in a manner which, in many respects, is similar to that of mineral springs. They have to a certain extent the power of assimilating or rejecting mineral substances as they may be either necessary or superfluous for their growth, while the action of springs is determined by fixed laws of affinities and solubilities of chemical substances; but both effect a solution by means of water and carbonic acid, and both depend upon the nature of the soil. The striking differences between mineral springs, as they may issue in a granite, limestone, or sandstone region, are reproduced on a grander and more varied scale, in the vegetable kingdom. We find species, genera and whole families of plants disappear and make room for others, according to changes of soil, of temperature and the amount of water; and if we deduct from them their organic portion in an anhydrous form, we have nothing left but a mineral water, or something that has been one, of a composition almost uniform in the same tribes.

We can look upon food as a combination of an anhydrous organic portion, and the ingredients of a mineral water which by the addition of water and gastric juice or *carbonic acid* are again made soluble. Fermented liquors, as beer, cider and wine, contain only a small portion of alcohol and organic

matter; their bulk consists of a mineral water rich in carbonic acid. And is it surprising that we should find a similar relation in the human body which is built up by the assimilation of vegetable food, or by the flesh of animals fed upon it? If we deduct from the blood its organic portion, we find a mineral water coursing in our veins which contains about 30 cubic inches of carbonic acid gas for every 16 ounces.

The mineral ingredients of the blood are, within small limits, present in a fixed proportion, which is of vital importance to a healthy condition of the system. *They are all necessary.* A man who can be starved to death by an abundance of food in which certain organic principles are wanting, can be equally starved by the abstraction of chloride of sodium; and a child fed on substances which are destitute of lime salts, would soon share the fate of the grasses on some guano islands which, with the exception of silicic acid, find everything in abundance for a luxurious life, but soon break down, wither and die for want of a material which is indispensable to the building up of their stems.

The great effectiveness of certain Spas should not, therefore, be ascribed to one or two of its prominent constituents, but to the very harmony which their composition presents with the mineral ingredients of the human blood. Let us take *Selters*, for example, and compare its composition with that of the ashes of blood serum, according to an analysis which is considered as the most reliable one (by Lehmann):

	<i>Blood serum.</i>	<i>Selters.</i>
Chloride of Sodium . . . . .	17.292 grains.	17.2920
Chloride of Potassium . . . . .	1.150	0.3580
Carbonate of Soda . . . . .	8.180	6.1533
Phosphate of Soda . . . . .	0.900	0.0042
Sulphate of Potash . . . . .	0.780	0.3970

The resemblance would be still more striking, should we compare all mineral ingredients of the *blood* with those of *Selters*; and that Spa has, on that account, always seemed to us, of all natural mineral waters, the most philosophically compounded. It is not a whim that has made of *Selters* a

luxury ; it is not an accident that it agrees with people, that it is always liked, and that they never get tired of its use. We explain it by the composition of the Spa ; it furnishes the normal mineral ingredients of the blood in a condition in which they are easily absorbed, independently of the state of digestion ; it must have a tendency to establish them in their normal fixed proportion, and to induce a healthy metamorphosis of matter by reflex action. It is also apparent why other Spas of more marked variations can be advantageously used for the restoration of a normal condition of the blood, in cases where its composition has undergone more serious changes ; and why carbonic acid water, by dissolving the mineral ingredients of food, will gradually produce the same result. The single consideration that blood contains its own volume of carbonic acid gas in solution, shows the importance of using water of the same condition. The production of carbonic acid is largest in a healthy state of the system, and is always diminished in chronic diseases, and in most conditions which interfere with perfect health ; and as that gas must form an important constituent of the gastric juice and intestinal liquids, we find such disorders usually accompanied by impaired digestion, and the use of carbonated waters signalized by improved nutrition.

Exception has been taken to mineral waters, that they are poor in phosphates, but if we take into consideration that a large proportion of the phosphates of food are eliminated with fæcal matters, an artificial introduction of them seems hardly advisable. The excess of carbonic acid will certainly dissolve as many as can be absorbed, and even if bicarbonate of lime should enter the blood, it would probably undergo a transformation by the presence of phosphate of soda. Or, may we not also supply phosphoric acid, and, emancipating ourselves entirely from the accidental productions of nature, prepare a *normal mineral water*, the composition of which should be in *perfect harmony* with the normal mineral ingredients of the human blood ? It might form the basis of all Spas, their differences to consist only in the increase of one or two substances, as carbonate or sulphate of soda, chloride of sodium, carbonate of protoxide of iron, etc., and if we should honor

the normal mineral water with the name of *Normal Selters*, the others might conveniently be called *Normal Vichy*, *Normal Carlsbad*, *Normal Kissingen* and *Normal Iron Water*.

But natural springs seem to provide abundant means for the treatment of various diseases. They annually restore thousands of patients who had been dismissed as bad cases and sent to them as a last refuge; and when the farewell bumper is emptied in praise of the bubbling waters, and blessings are showered upon them for the new lease of life, little is thought of the intimate relation which exists between our own nature and that of the springs. They are the living beings of inanimate nature, exhaling the same gas which escapes from our lungs, and often imitating the very pulsations of a living body; and they contain in admirable proportion those mineral substances which are necessary to us for perfect health and a rational enjoyment of life.

E R R A T A .

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- Page 5, 6th line from bottom, read "Callirhoë."  
Page 5, 3d line from bottom, read "into the."  
Page 14, 17th line from top, read "80 to 90 per cent."  
Page 15, 4th line from bottom, read "Reissig."  
Page 33, 1st line from bottom, read "hæmoptoë."  
Page 41, 4th line from bottom, read "Spas."  
Page 43, 1st line from bottom, read "tumblersful."  
Page 47, 11th line from bottom, read "tumblerful."





