

Practical directions for the preparation of aërated waters, and the various compounds of carbonic acid gas, by Bakewell's patent apparatus : with observations upon the pharmaceutical and therapeutical agencies ... / By Robert Venables.

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AËRATED WATERS

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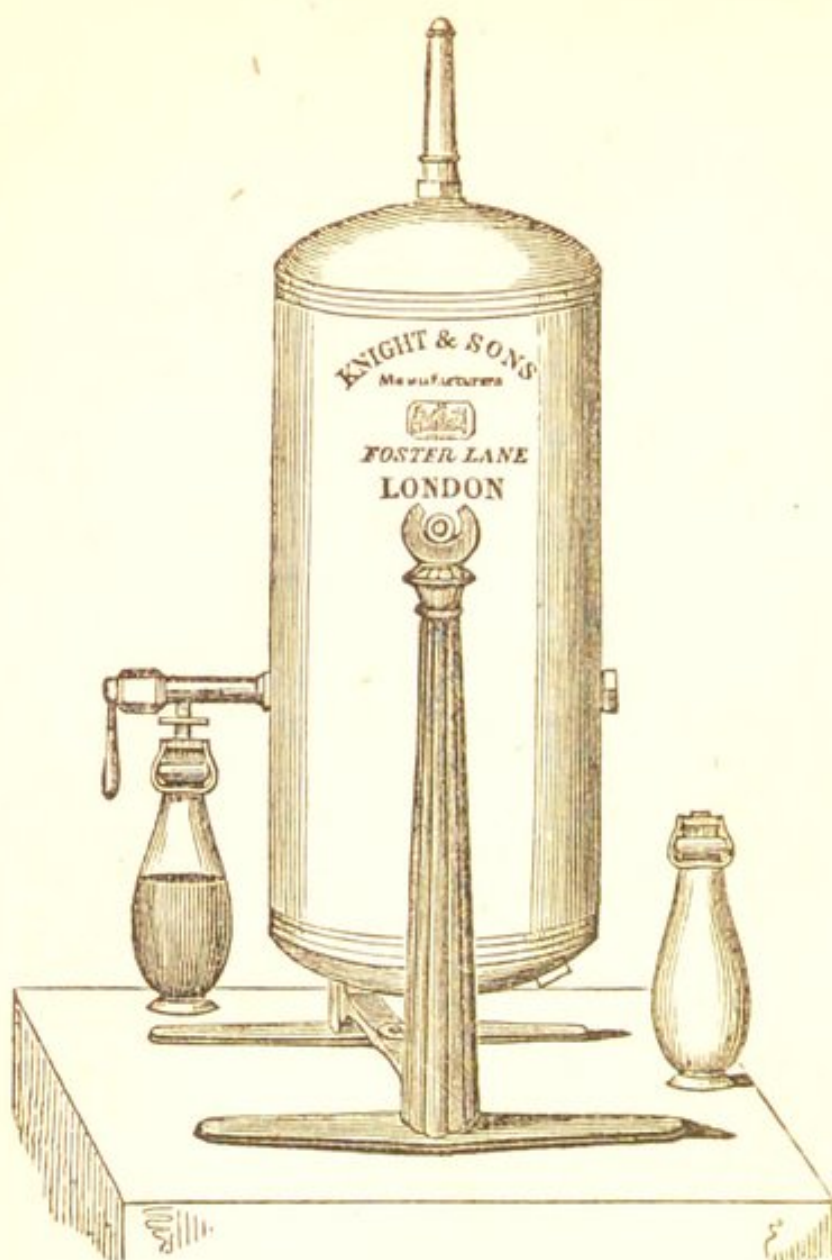
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BAKEWELL'S PATENT PORTABLE APPARATUS

FOR THE PRODUCTION OF

AËRATED WATERS.

PRACTICAL DIRECTIONS
FOR THE PREPARATION OF
AËRATED WATERS,
AND THE VARIOUS COMPOUNDS OF
CARBONIC ACID GAS,
BY
BAKEWELL'S PATENT APPARATUS:

WITH OBSERVATIONS UPON
THE PHARMACEUTICAL AND THERAPEUTICAL AGENCIES,
AND THEIR
EFFICACY IN THE CURE OF SOME OF THE MOST IMPORTANT
DISEASES OF THE HUMAN BODY, viz.
INDIGESTION, PHTHISIS, NERVOUS ATONY OR MENTAL
DEPRESSION,
DISEASES OF THE GENITO-URINARY ORGANS, &c.;
WITH CASES IN ILLUSTRATION.

BY ROBERT VENABLES, A.M., M.B.,
INCEP. CANDIDATE, ROYAL COLLEGE OF PHYSICIANS, LONDON.

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"Asclepiades officium esse medici dicit, ut tuto, ut celeriter, ut jucunde  
curet."—CELS. lib. iii. cap. iv.  
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PREFACE.

LAST year, when engaged with Mr. Knight upon the construction of a chemical chest, he directed my attention to the Patent Aërating Apparatus, for the more easy and effectual preparation of the purest soda water, and free from every possible impurity or contamination. On explaining to me the construction and use of the Apparatus, I was no less surprised than gratified at its extreme simplicity. On reflection, it occurred to me that it might be rendered subservient to pharmaceutical purposes; but my views at first were limited to the preparation of proto-carbonate of iron, for the fulfilment of therapeutical indications. The administration of iron in its most efficient form, that of proto-salt, has long been an object of anxious speculation. Not that the preparation of protoxide proves a difficulty in chemistry, but the preservation of it in this state has hitherto proved an insurmountable obstacle. The proto-salts of iron pass so rapidly into persalts that they cannot be conveniently preserved at the *minimum* of

oxidation by any means hitherto devised. The Patent Apparatus, however, relieves us from this inconvenience, and insures to us,—what has been long felt as a desideratum,—a means not only of preparing and preserving iron in its most energetic mode, or active condition, but of still further enhancing its virtues, by holding it in solution by an excess of carbonic acid gas.

Upon mentioning this subject to Mr. Knight, he very liberally offered me the use of an Apparatus, for the purpose of instituting any experiments, pharmaceutical or therapeutical, that I might feel disposed to make ; and it was the ease and facility of investigation thus placed at my command, that induced me to undertake the extended series of inquiries, which have given rise to the present production. The result of these inquiries, therefore, and which are here given to the public, is not mere speculation, nor even legitimate inferences from known phenomena, but positive facts ; the certainty of which has been fully established by repeated observations and experiments.

The arrangement I have endeavoured to render as simple as possible, at the same time consulting clearness and perspicuity. In the first place, some general history of carbonic acid is submitted, and the different sources and methods of obtaining it. The preference is here given to the sesquicarbonate of soda for the evolution of the gas, rather to annihilate all suspicion, than from any conviction of the possibility of impurity.

The construction of the Apparatus is such, as to obviate any possible contamination from the ordinary sources of carbonic acid.

I have considered the agencies of carbonic acid, both as a chemical solvent and precipitant, and as a pharmaceutical and therapeutical agent. Upon these subjects I have advanced scarcely anything that I have not verified by actual experiment ; and the only matter upon which I entertain the slightest doubt, is the extent of the solvent action of carbonic acid upon oxalate of lime. But in this diathesis it is not of much importance, because the indication often is to change the oxalate of lime diathesis to the lithic acid one ; and, therefore, though chemically inert, it will offer a grateful adjunct to the other means. In the pharmaceutical and therapeutical divisions, I have entered as fully into the capabilities and applications of this gas as the circumstances seemed to me to require ; and I think the present will be found to present a concise summary of all that is useful or necessary to be known upon these subjects.

The observations under the head of “ Special Therapeutics,” or the applications of carbonic acid gas to the relief or cure of individual diseases, may at first sight appear to savour somewhat of a *universal remedy*. But it must be remembered, that carbonic is acid but one member or element of a greater variety of agents or compounds, suited to the cure, or at least, to the treat-

ment of a great number of diseases, very different in their characters, and opposite even in their nature ; and the carbonic acid is in such cases to be regarded as a means of enhancing their virtues, or of rendering them more capable and energetic in fulfilling special indications.

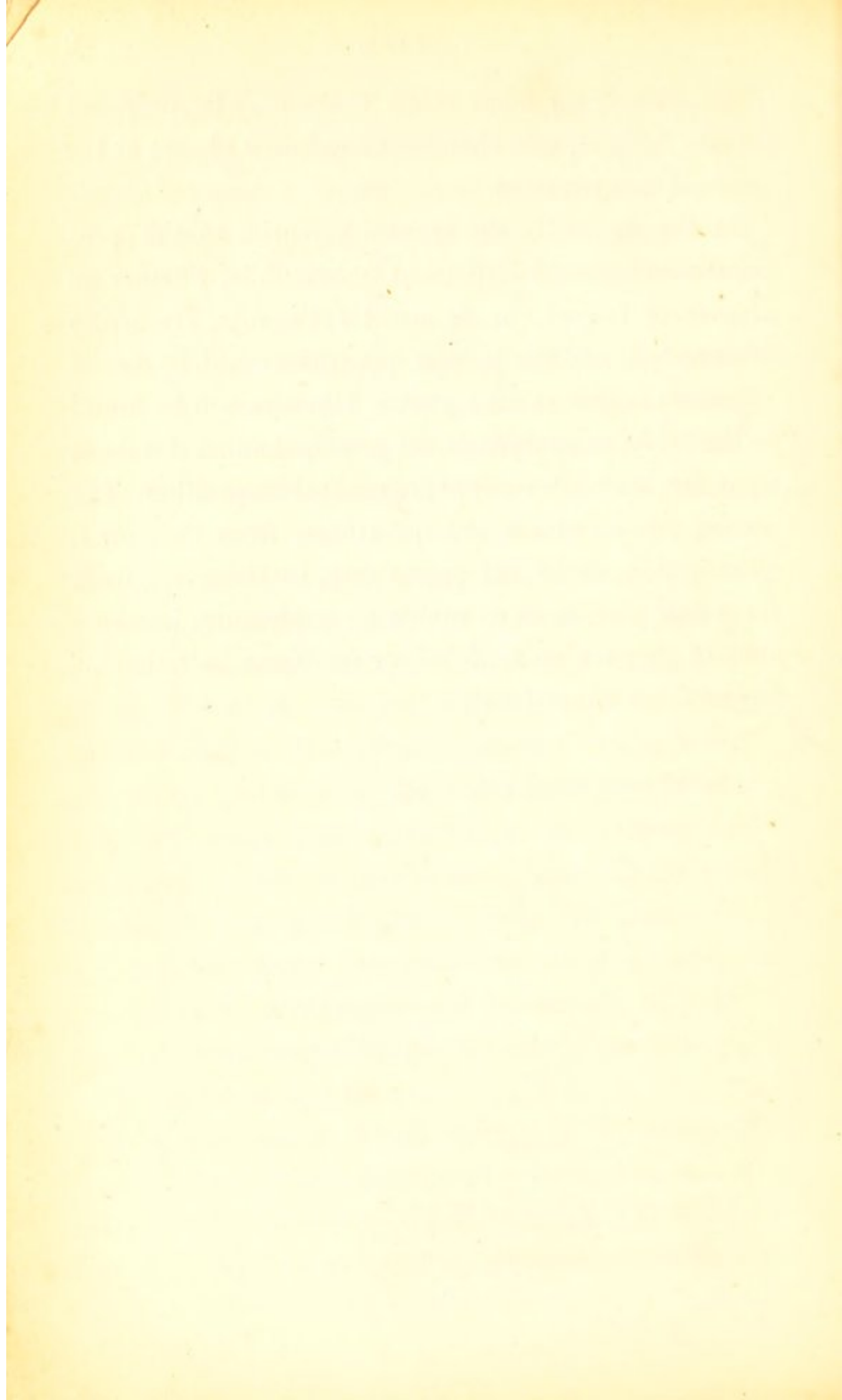
In considering special therapeutics, or the treatment of individual diseases, I have generally omitted those parts of the treatment not connected with carbonic acid and its factitious compounds. This seemed necessary, in order, first, to confine this summary to the prescribed limits : secondly, to prevent it assuming that exclusively professional character inconsistent with its nature and objects ; and yet it is hoped that the professional reader, who has not zealously and practically applied himself to the subject, will find much in this little treatise to instruct him, and to enable him to render his means more agreeable to his patient, and more active in their curative powers ; and this too with a degree of ease and facility hitherto unknown. Indeed, I myself have little doubt that ere long the PATENT AERATING APPARATUS will become as indispensable to the laboratory of the practitioner, or pharmacien, as either a mortar or a pestle.

The general reader it will initiate in the means of ministering to his own health and gratification, and of indulging his friends with all the elegance and luxury of some of the most grateful and agreeable beverages.

Thus *effervescing* home-made wines may be prepared on the instant, and champagne imitated almost at the moment it is required.

In the Appendix the articles essential to the preparation of several important compounds, whether as articles of luxury, or as medicinal agents, are briefly enumerated, and the precise quantities required for the necessary reactions are stated. Likewise will be found in the tables an analysis of the principal mineral waters, upon Dr. Murray's views of proximate composition. The second table reduces the quantities, from those of a wine gallon, or 58,327 grains troy, to those required for a half pint, so as to enable us at pleasure, immediately to prepare an artificial, or factitious imitation of any of these mineral waters.

5, St. Vincent Place, City Road.



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EXPLANATION OF THE SYMBOLS.

Every simple principle is designated by letters generally selected from the Latin initials. Thus—

O	represents	Oxygen.
Cl	„	Chlorine.
H	„	Hydrogen.
C	„	Carbon.
S	„	Sulphur.
K	„	Potassium.
Na	„	Sodium.
Ca	„	Calcium.
Mg	„	Magnesium.

To apply these symbols to chemical purposes :—

Water is a compound of hydrogen and oxygen, atom to atom, and is expressed— H O .

Lime is a compound of one eq. of calcium to one of oxygen, and is expressed— Ca O .

When a compound consists of one equivalent, to two or three of another, as, for instance, carbonic acid, which consists of one of carbon and two of oxygen, a number expressive of the number of atoms is placed after it, thus— Ca O_2

Sulphuric acid, S O_3 , shews its composition to be one of sulphur and three of oxygen. But a number placed on the left hand multiplies the whole :— 2 S O_3 expresses two of sulphuric acid, and so on.

INTRODUCTION.

SODA-WATER, aërated waters, aërated lemonade, &c., have lately come so much into use, that they may be regarded in the present day as luxuries, rather than pharmaceutical or therapeutical agents. To minister, therefore, to the gratification or to the health of the public, is now an object of paramount importance. Many who indulge in such beverages frequently complain that they are not pure, but impregnated with extraneous compounds, which, in many cases, seriously affect the health. In the case of soda powders, the effervescence is excited by the action of an acid stronger than the carbonic, the tartaric for instance, upon the sesquicarbonate of soda. In the decomposition, the carbonic acid is replaced by the tartaric, and the resulting salt, tartrate, or bitartrate of soda, according to the quantity of acid used, is swallowed and taken into the stomach. This not unfrequently proves injurious; and in cases where even any alkaline preparation would be deleterious, there is no alternative. For instance, in certain diatheses, more especially where the urinary system may be concerned, soda-powders would prove most pernicious; and acids alone are indicated. In such cases the individual must be contented with the appropriate acid, administered in the ordinary mode.

These inconveniences are now easily remedied by BAKEWELL'S PATENT PORTABLE AERATING APPARATUS, manufactured by Knight and Sons, Foster Lane, Cheapside, London. I will endeavour to give a concise de-

scription of its construction and use for the preparation of aërated waters, lemonade, and the factitious compounds, &c., of carbonic acid.

It consists of a strong iron cylinder, within which are cemented two distinct earthenware vessels. In the

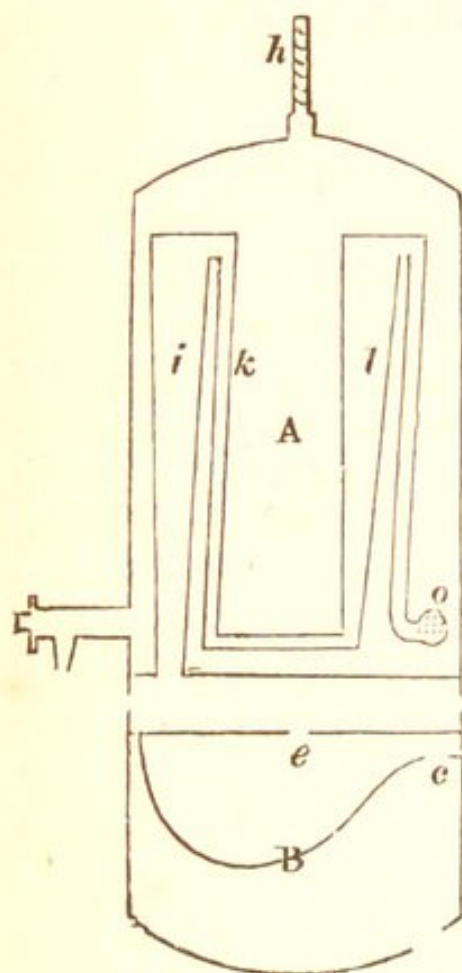


diagram they are marked A and B. The lower one B, may be named the *liberator*, because it is in this compartment that the aërating gas (carbonic acid) is liberated. The liberator consists of two compartments: the lower one receives the sesquicarbonate of soda, which is introduced by the aperture in the bottom. The upper one is for the diluted sulphuric acid, and which is introduced by a glass funnel, through a hole in the side. While the machine rests in the vertical position, the acid and soda are kept quite distinct. The upper part A, may be called the *condensing aëerator*, because it is in

this compartment that the impregnation of the fluid to be aërated takes place. Although connected with the lower portion, yet no communication of the contents can take place except through the aperture *e*, and the conical funnel *i, k, l, o*. At *h*, in the top of the apparatus, there is an aperture, through which the fluid to be aërated is poured into the aëerator A, and this is also furnished with a tap for drawing off the fluid when sufficiently aërated. The apertures in the lower portion or liberator are closed by air-tight plugs, which screw over them. The aperture in the top of the aëerator is closed by a pressure gauge, which screws on air-tight, and is constructed to indicate a pressure equal

to that of five atmospheres. The machine being charged by the introduction of the respective materials, if it be made to vibrate upon its supports or trunnions, the acid in the upper compartment of the liberator passes through the little aperture *e* to the soda in the lower part, and disengages a quantity of carbonic acid. The gas thus liberated, and assuming its natural elasticity passes through *c*, and then through *e*, making its way up through *i*, then down through *k*, from whence it passes up through *l*, and finally makes its exit through the minute apertures in *o*, where it is mixed under a considerable degree of pressure, and condensed in the fluid in the aëerator. When the pressure gauge indicates by the rise of the mercury, that a sufficient quantity of gas has been condensed, the vibrations may be stopped, and the aërated liquid can be drawn off through the tap, as required.

The charge of sesquicarbonate of soda for the impregnation of a gallon of water, under a pressure of five atmospheres, is about six ounces, and which for complete decomposition would require, omitting fractions, about three ounces five drachms and a half, by weight of the common sulphuric acid. But if a highly impregnated fluid be constantly required, it is advisable to use rather more soda, say from half an ounce to an ounce. As the fluid is drawn off, the carbonic acid relieved from the pressure, resumes a part of its elasticity, and rises above the water. This will be manifested by the fall of the pressure gauge. But if an excess of soda be used, a vibration or two will cause the gauge to rise again to its original number, "five." The proportion of sulphuric acid for six ounces, is three ounces five drachms and a half; but it is better to have an excess of acid, by which the more perfect and complete decomposition of the sesquicarbonate of soda will be effected, and the resulting sulphate kept in solution, an advantage when cleaning out the apparatus. Seven ounces of sesquicarbonate of soda require about four

ounces and one drachm by weight, consequently about six ounces would suffice.

If supercarbonated soda or magnesian water be the only beverage required, the requisite quantity of soda or magnesia may be mixed with the water to be aërated, and introduced into the aëerator. If lemonade be the object, this may be made in the usual way and introduced into the aëerator, and subjected to the pressure of the gas. Lemonade may also be made with the crystallised citric acid ; half an ounce of which dissolved in a gallon of water, in which some dried lemon peel has been macerated, or to which the requisite flavour has been communicated, by the addition of a little of the essential oil of lemons, and sweetened with sugar, will form a most agreeable and grateful lemonade, which may be aërated with or without soda, as already explained.

When, however, it is the intention to use aërated water for several distinct and different purposes, it will be better to use simple water for the impregnation in the aëerator, and expose the different matters to be carbonated to the action of the aërated water drawn off from the apparatus, in the flask, which being fitted with a valve stopple, may be detached, and the matters previously introduced into the flask, may be left exposed to the water surcharged with carbonic acid under the original pressure, for any length of time, as, from the peculiar construction, no gas can escape. These and a variety of similar applications of the apparatus, both for ordinary and pharmaceutical purposes, will be found fully detailed in another part of this summary. A box of apparatus accompanies the aërating machine, with full directions for their use, both in charging the machine, and for drawing off the liquids impregnated with the carbonic acid gas ; and which it would be quite superfluous to repeat here. I shall therefore refer to the original source for more complete information upon those points.

GUIDE.

CARBONIC acid, in its isolated state, is a gas, or air, of great elasticity; so that, when freed from some of its combinations, it expands with great force, occupying many times the volume or bulk of the matters from which it may have been evolved. It is the principle evolved from certain wines and malt-liquors, as Champagne, porter, ale, &c., after being bottled, and which gives them their sparkling and brisk qualities, and palatable taste. It is given off by the lungs during expiration; and it is the noxious product, that has occasionally proved fatal, evolved during the burning of charcoal in bed-rooms; yet though so noxious in respiration, it acts quite differently when absorbed by water, and taken into the stomach.

Carbonic acid is, as has been already stated, naturally a gaseous principle; not, however, strictly simple, but a compound, consisting of a combination, in certain proportions, of two simple elements: carbon, or common charcoal, and oxygen. It may be formed by the direct union of its elements, and a synthetical proof of its composition be thus obtained. If a piece of carbon be introduced into a glass retort, fitted with a brass cap and stop-cock, and the retort be now exhausted; by connecting with a jar filled with oxygen gas confined over water, a communication may be established between the jar and the retort, and the latter be filled with oxygen. By applying the flame of a spirit-lamp or a red-hot iron to the spot of the retort upon which the charcoal rests, it speedily ignites, burns

with great brilliancy and intensity, throwing off vivid scintillations, and ultimately disappears. When the apparatus has been allowed to cool, it will be found by mere inspection, that although the charcoal has entirely disappeared, the residual gas has undergone no alteration whatever in volume. Consequently, the oxygen and the carbon must have combined without any change of volume. The gas thus produced will be found possessed of very different properties from those originally possessed by the oxygen:—it is much heavier than atmospheric air; it extinguishes burning bodies when immersed in it; animals cannot breathe it without being suffocated or stupefied; it may be poured from one vessel to another like water; it is colourless and invisible, like common air; and, mixed with air in the ratio of one to ten, it renders it irrespirable, or rather unfit for respiration, producing stupor and death as a narcotic poison. On analysis, it is found to consist of one volume of oxygen and half a volume of the vapour of carbon, consequently its specific gravity will equal the specific gravity of oxygen and half that of carbon, thus—

Two volumes of oxygen, sp. gr.	$1102.6 \times 2 =$	2205.2
One volume vapour of carbon,	843.0	843.0

Form two volumes of carbonic acid	2	3048.2
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One volume consequently = . . .		1524.1
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By weight carbonic acid consists of two equivalents of oxygen $8 \times 2 = 16$, and one of carbon $6 + 16 = 22$, gives the weight of one equivalent of carbonic acid.

EVOLUTION.

Carbonic acid exists plentifully in nature, and is an abundant product of several operations. It exists in

very small proportion in our atmosphere as a product probably of combustion and of animal respiration. It is also generated during the slow decomposition of most vegetable substances, and is evolved in very large quantities from the ground in volcanic countries. It is also produced in large quantity during most fermentations. It exists in combination with many of the bases ; and it is from such compounds that it is generally evolved for purposes such as we are about to consider.

The most important and extensive of its natural compounds are those formed with the earths and alkalies. Thus common marble, or calc-spar, and common soda, afford it in great abundance. If calc-spar, which consists principally of carbonate of lime, be submitted in fragments to the action of almost any dilute acid, a brisk effervescence immediately ensues, the carbonic acid is disengaged, and replaced by the other more powerful acid. The same phenomena ensue, if we substitute the common soda of commerce, which is a carbonate, and act upon it by any of the more powerful acids. The acids usually selected are, from their cheapness, the hydrochloric (muriatic), for decomposing the carbonate of lime, and the sulphuric (oil of vitriol), for that of the soda. The carbonate of lime, broken in fragments, is put into the apparatus, and hydrochloric acid (muriatic), diluted with seven or eight parts of water, poured upon the lime, will immediately evolve carbonic acid in great plenty. The carbonic acid evolved, by a peculiar construction or modification of the generating or recipient apparatus, may be conducted and applied to any intended purpose. It is evident that precisely the same methods apply to soda and sulphuric acid. Sulphuric acid has been employed by some for evolving the carbonic acid from calc-spar or chalk ;* but the inconvenience is, that the

* In the manufacture of soda-water on a large scale, the gas is obtained from chalk and sulphuric acid.

resulting sulphate of lime, being but very sparingly soluble, is not so easily removed.

The dilution of the acid is to be regulated according to the required rapidity of evolution. The more diluted the acids, and the larger the fragments of calc and soda, the more slow the disengagement of the acid gas; on the contrary, the more concentrated the acids, and the smaller and more comminuted the calc and soda, the more violent the effervescence, and the more rapid the evolution of the acid gas. But care, however, must be taken to use water enough to dissolve, or rather prevent the complete solidification of the newly-formed salts, otherwise the action would cease, or at least be greatly obstructed, and the quantity of acid evolved be reduced to scarcely any.

The reaction by which the carbonic acid is evolved is very simple: $\text{Ca O}, \text{C O}_2$ and $\text{H}, \text{C L} = \text{Ca C L} + \text{H O}$ which remain in the liberator, and C O_2 being liberated, escapes. The case of soda and sulphuric acid, may be illustrated thus:— $\text{Na O}, \text{C O}_2 + \text{S O}_3 = \text{Na O S O}_3$, and C O_2^* set free, escapes, and rises into the aëerator.†

CHEMICAL PROPERTIES AND AGENCIES.

Carbonic acid is absorbed by water, which dissolves its own volume of the gas, forming a very grateful acidulous solution, which sparkles on agitation. This solution reddens litmus; not, however, permanently, the red colour disappearing on exposure to air, but still more effectually on the application of a very moderate heat. It exists in most spring waters, and is the cause of their sparkling appearance when poured from one vessel into another, and also of their agreeable taste; and it is the expulsion of this acid, by boiling or

* In the case of sesquicarbonate, *half* as much more carbonic acid is evolved.

† These symbols of composition and proportion are explained in another part.

distilling, that renders these waters "vapid," flat, and disagreeable to the taste, however cold they may be.

Water then, under ordinary circumstances, may hold in solution its own bulk, but by pressure may be made to absorb an almost indefinite quantity. When the pressure is removed, a brisk effervescence commences, the violence of which is proportional to the volumes of gas condensed in a given volume of water.

Carbonic acid, though ordinarily a gas, may be reduced to the solid state, and hence has been the medium of exhibiting many curious and interesting phenomena. Evolved under a pressure of thirty-six atmospheres, it condenses into a liquid, which is colourless, transparent, and exceedingly mobile, and has a specific gravity of 0.83 at 32° Fahr. It is remarkable for its excessive expansibility by heat, which is at least four times that of air, or nearly one per cent. for each degree of Fahrenheit. When the pressure of fluidity is suddenly removed from the liquid acid, it vaporises with such rapidity, that the gaseous portion carries off with it all the caloric of fluidity of the remaining portion, which consequently solidifies.* Shilourier has contrived an ingenious apparatus for the solidification of carbonic acid, by which it can be obtained in this state in very large quantity. It is white, in filamentous masses, somewhat like asbestos; it evaporates spontaneously, but still very slowly; it is very soluble, both in ether and alcohol. The solution in ether, by its evaporation, produces the most intense cold known, and which has been estimated at between 180 and 190 degrees below 0 of Fahrenheit.

* It is a well-established fact in physics, that the varieties of form, gaseous, liquid, and solid, under which bodies present, depend upon the quantity of *latent* caloric with which they are chemically combined. Hence, whenever a body changes its mode, it must either combine with or evolve caloric, according as the change is attended with a diminution or increase of density. In the present case, the gaseified portion, passing from the liquid state to that of a gas, absorbs and renders latent so large a quantity of caloric, as to render the remainder solid.

CHEMICAL COMBINATIONS.

Carbonic acid combines with the bases, alkaline, earthy and metallic. These compounds are found native, and some of them most abundantly. The alkalies, and the earths especially, are mostly met with in nature in the state of carbonates, and the carbonate of lime is the grand source of the evolution of carbonic acid. These salts may be either basic, neutral, or acidulous; that is, the base may be in excess; or the base and the acid may be in equivalent, or as it is termed *neutral* proportions; or lastly, the acid may be in excess relatively to the base. These last, however, are double salts, containing really *carbonate of water*, which still, however, exists only in combination, carbonic acid not combining directly with water in definite proportions. As a general principle, it may be laid down that the carbonated salts, consisting of carbonic acid as a constituent, may be readily recognised by their yielding, when acted on by hydrochloric or any of the strong acids, in the cold, the peculiar gas possessing the properties which have been already described.

ALKALINE CARBONATES.

Carbonate of Potass. — $\text{K O}, \text{C O}_2$ or $\dot{\text{K}} \ddot{\text{C}} + 48 + 22 = 70$. This saline compound, which is the great source of all the other preparations of this alkali, is principally obtained from the ashes resulting from the incineration of inland vegetables, especially an American ash. The potass exists in the juices combined with various acids, as the oxalic, malic, acetic, nitric, &c. During the combustion of the wood these salts are converted into carbonate; the carbon of the wood being oxygenated during the combustion, is converted into carbonic acid, and the constituents of the *organic* acids,

by re-arrangement, &c., form more carbonic acid. The constitution of the nitric acid is destroyed by the joint action of the high temperature and carbon, and being by the latter deprived of oxygen, more carbonic acid is formed; and combining with the potass, carbonate of this alkali is generated. Any excess of carbonic acid is driven off by the heat and escapes.

The ashes, however, thus obtained, are far from being pure, as they contain with the carbonate a great quantity of insoluble matters; such are silex, earthy salts, and carbonaceous matter. From these it is partly freed by repeated solution in water, and subsequent crystallization. But even so prepared it is found to contain a quantity of silica, sulphate of potass, and chloride of potassium, in the proportion of from fifteen to forty per cent.

If the carbonate be required of very superior purity, it is best prepared by calcining bitartrate of potass, (cream of tartar). The tartaric acid is decomposed, and a re-arrangement of its elements effected, so as to produce carbonic acid, which unites with the potass, forming carbonate of potass. The mass is then to be digested with water, filtered, to separate the charcoal, and then evaporated in a clean iron vessel. A white granular mass is thus obtained, formerly named *salt of tartar*. It is very deliquescent, dissolves in half its weight of water, and crystallises in oblique rhombic octohedres, retaining two equivalents of water of crystallization. It is therefore, $\text{K O}, \text{C O}_2 + 2 \text{H O}$. It has a strong alkaline reaction, is almost completely insoluble in alcohol, from which, when recently ignited, it abstracts the water, combines with it, and forms a dense heavy solution, upon which the alcohol thus rendered more highly concentrated, swims.

In this state (a neutral carbonate) it has a disagreeable urinary taste, and is also too caustic either to be taken in large doses, or to be long continued. Its causticity, however, may be reduced by combining it

with an additional equivalent of carbonic acid. It is seldom, therefore, given in the neutral state in large doses, or even in small ones, long continued; the milder carbonate being usually selected. It is used, however, for making effervescing draughts, which is done by mixing a solution of it with the requisite proportion of lemon juice or citric acid. But even for this purpose the following is often preferred.

Bicarbonate of Potass.— $\text{K O}, 2 \text{ C O}_2 + \text{H O}$ or $\ddot{\text{K}}, 2 \ddot{\text{C}}$; but according to some it is a carbonate of potass, with carbonate of water, and therefore ought to be expressed thus:— $\text{K O}, \text{C O}_2 + \text{H O}, \text{C O}_2$. It is formed by passing a current of carbonic acid gas through a saturated solution of the former or neutral carbonate; the temperature of which should not exceed 100° . The London College direct the carbonic acid to be passed through to saturation, and then a gentle heat to be applied, that whatever crystals may have been formed may be again dissolved. The solution is then set aside that the crystals may separate, which takes place on the cooling of the liquid. These are afterwards to be dried. The crystals are right rhombic prisms with eight sides. They dissolve in four parts of cold water, but in a much less proportion of hot. On heating its solution to the boiling point, the extra equivalent of acid is expelled, and it is reduced to the neutral carbonate. Its reaction upon vegetable colours is very feebly alkaline.

If a greater portion of carbonic be forced into a solution of the bicarbonate, and be confined there by pressure, an effervescing solution of bicarbonate of potass is formed, which the moment the pressure has been removed effervesces briskly, and presents one of the most agreeable formulæ for the medicinal administration of potass.* I have been thus diffuse upon potass, because

* The method of preparing all the varieties of combination of carbonic acid, with the bases, for medicinal exhibition, will be explained in another place.

the general facts of preparation, &c., are equally applicable to soda; the preparations of which consequently will not require such minuteness of detail.

Carbonate of Soda.— $\text{Na O}, \text{C O}_2$ or $\text{Na C} + 10 \text{ H O}$,
Eq. $32 + 22 + 10 \text{ H O} = 144$. This salt was formerly obtained from the incineration of marine vegetables, especially the salsola soda, and several varieties of fuci, as the potash from land ones. Its manufacture from common salt, however, has now become a special object of commerce. The salt must first be converted into sulphate of soda, as in the preparation of hydrochloric acid. The sulphate of soda, dried, is mixed with its own weight of limestone, or common chalk, and about half its weight of small coal. This mixture levigated into a fine powder, is put into a reverberatory furnace in charges of about two cwt. each. Here it is exposed to a full red heat, on the floor of the furnace, for about an hour. The mass fuses, and being well stirred about for a few minutes, is raked off through an opening in the side, and received in metal boxes. It forms a black mass, named *black-ash* or *British barilla*. The theory is as follows:—the sulphate being heated with the coals, both the sulphuric acid and the soda are de-oxidized by the carbon of the coals, and a simple binary compound of sulphur and sodium—sulphuret of sodium—result. The carbonate of lime and this sulphuret immediately react on each other, and exchanging principles, form into sulphuret of calcium and carbonate of soda. The whole of the soda, however, is not carbonated in this process, and consequently some additional manipulation, unnecessary to detail, is required. The result of the process when completed, is named *white* or *soda-ash*, and contains from about 40 to 50 per cent. of real alkali.

To obtain the crystallized carbonate, the soda ash is dissolved in water, then boiled, strained and evaporated to a pellicle, and left to crystallize. Pure carbonate of soda crystallizes in flat, oblique, rhomboidal

prisms containing ten equivalents of water of crystallization. It is soluble in five parts of cold, and in one of boiling water. Unlike the carbonate of potass it *effloresces* in the air and falls into a powder; whereas the carbonate of potass in the same circumstances *deliquesces* and becomes fluid. In the former case the water of crystallization is given off; in the latter, water is abstracted from the atmosphere and retained in sufficient quantity to dissolve the salt.

By a gentle heat it first fuses, and then becomes a white powder, the "Soda exsiccata" of the London Pharmacopœia. In a strong heat the soda exsiccata fuses, but undergoes no other change.

Carbonate of soda is used in medicine precisely in the same manner as potass; and, as being more agreeable and less caustic, is often preferred. It is the alkali invariably selected for the preparation of the different "soda waters." In the general principles what has been said of potass will, *mutatis mutandis*, apply to soda.

Bicarbonate of Soda.— $\text{Na O, C O}_2 + \text{H O, C O}_2$. The same combination of the water with the excess of carbonic acid, as in bicarbonate of potass, is said to occur here, and its equivalent may be readily determined from the sum of those of its constituents. It is formed by passing carbonic acid into a cold saturated solution of carbonate of soda till saturated with the acid. The bicarbonate precipitates in small opakish crystals, having the appearance of starch. It requires fifteen parts of cold water for solution, has a very slight alkaline reaction, and is far from being disagreeable to the taste.

EARTHY CARBONATES.

Carbonic acid unites with all the alkaline earths, but it will be unnecessary to consider more than two. The neutral earthy carbonates are *insoluble* in water; are infusible, but at a red heat part with their carbonic acid

and become caustic. These properties distinguish them from the alkalies.

Carbonate of Lime.— Ca O , C O_2 or $\text{Ca } \ddot{\text{C}}$, Eq. 50. This compound presents itself in the different characters of marble, chalk, &c. The principal use is for the evolution of carbonic acid, but as this has been already noticed, no additional remarks are required here.

Carbonate of lime is insoluble in pure water, but dissolves in water impregnated with carbonic acid. This solubility does not seem to be owing to the formation of a bicarbonate, but depends upon a specific solvent power of the acid upon several bodies insoluble in water,—silica, for instance, phosphate of lime, and some other earthy salts. In many spring waters carbonate of lime is held in solution by free carbonic acid, and such waters become turbid on boiling. In such cases the excess of carbonic acid is driven off by the heat, and the carbonate is precipitated, forming thick incrustations, named tufa, upon the sides of the recesses, for instance, of tea kettles, coppers, boilers, &c. Prepared chalk is constantly used in medicine to check diarrhœa, and sometimes, though less frequently, to correct acidity.

Carbonate of Magnesia.— Mg. O , C O_2 or $\text{Mg } \ddot{\text{C}}$. This compound is found anhydrous in nature in rhomboidal crystals, like calc-spar. If a current of carbonic acid gas be passed through magnesia in water, the magnesia is dissolved, and is then gradually deposited in rhomboidal prisms of six or eight sides. These crystals contain about three equivalents of water, and they are the bases of the soluble magnesian waters. The salt is decomposed by heat, and rendered basic, and is the *magnesia alba* of the shops. It may be prepared by mixing together boiling solutions of sulphate of magnesia, and carbonate of soda, the former slightly in excess. It is a light, bulky precipitate nearly insoluble in water. During the reaction, about one-fourth of the carbonic acid is driven off, and replaced by water,

forming an hydrate : the residue, therefore, consists of carbonate and hydrate of magnesia, in the proportion of three of the former to one of the latter, thus :—
 $\text{Mg O. H O} + (3 \text{ Mg O. C O}_2 \text{ H O.})$ or it may be stated $4 \text{ Mg O} + 3 \text{ C O}_2 + 4 \text{ H O.}$

The foregoing are the principal alkaline compounds used in medicine—at least, as therapeutical agents. Alkalies have been found difficult of exhibition, as well as injurious, not only to digestion, but also to several other functions, as well from their disagreeable taste, as from their chemical action upon the tissues, and their effects upon the organic integration. These effects are nearly in a direct proportion with their alkaline powers and causticity. Hence practitioners have been compelled either to forego the benefits to be derived from the more powerful and active, or to devise means of depriving the latter in part at least, of their noxious properties. The first object is attained by substituting the alkaline earths, more especially *magnesia*, for the more caustic alkalies—potass, or soda. The latter purpose may be effected by combining them with carbonic acid to complete saturation. But we may proceed still further, and surcharge the solution of the saturated carbonate with carbonic acid, as is illustrated in the instance of factitious soda water. The dose of the carbonated alkali dissolved in the requisite proportion of water, is then surcharged with carbonic acid under a sufficient pressure, and is thus preserved for use in proper bottles, and the excess of gas confined by air-tight stopples, or corks. But in these cases, the bottles must be kept in such a position that the fluid instead of the gas be in contact with the cork, otherwise the gas would escape through its pores; hence the peculiar shape of soda-water bottles, which do not permit rest in any other than the position most suitable to the preservation and confinement of the acid gas. In another part of this essay, I shall endeavour to show that all these, and a great many other thera-

peutical and pharmaceutical objects may be more conveniently attained, or perhaps, more correctly speaking, effected on the moment, by "Bakewell's Patent Apparatus for the Preparation of Aërated" (more correctly carbonated?) "Waters."

I have not in this summary noticed the volatile alkali or ammonia, because it is hardly administered, with the view of a remote alkaline re-agency. Its organic composition unfits it for any ulterior agencies, and therefore it seems quite unnecessary to enter upon the question of its compounds with carbonic acid. We next come to the metallic carbonates.

METALLIC CARBONATES.

Although the term *metallic*, in its *distinctive* application in this place, is in the stricter philosophy incorrect, yet as it will be found to a certain extent both distinctive and characteristic, for the sake of perspicuity, I shall adopt it. The caustic alkalies and the alkaline earths are truly *metallic* compounds, in fact, compounds of oxygen with a metallic base. Thus, potass and soda consist of oxygen united to the *metallic* bases, *potassium* and *sodium*, while lime and magnesia consist of the same principle, combined with the metals *calcium* and *magnesium*. No metal combines directly with an acid, and therefore oxidation is an essential and indispensable preliminary. Thus, iron and sulphuric acid will not unite unless the iron have been previously oxidized; and when we speak of sulphate of iron, we are not understood (chemically), as expressing a compound of pure iron and sulphuric acid, but rather of this latter with the iron previously oxidized, or as it is named oxide of iron. Therefore the proper expression would be sulphate *of oxide* of iron. The same holds good with respect to the alkaline bases. But the *alkaline* is distinguished from what may be termed the *pure metallic* by certain properties highly charac-

teristic and distinctive. The solubility of the alkalies in water is distinctive in relation to the metallic oxides, which, as a class, may be said to be almost completely insoluble. But the most characteristic property of the alkalies is their action upon the several vegetable colours; thus they turn all the vegetable blue colours (one only excepted) green. Litmus, however, is an exception which has its colour merely *deepened*, but without change, by an alkali. When the vegetable blues have been reddened by an acid, alkalies in neutralising proportions discharge the red, restoring the original blue, and if added in excess after this proportion, they change the restored blue to green. Their action also upon the vegetable yellows is peculiar. These, more especially turmeric, they change to a reddish brown. The carbonates of the caustic alkalies also are soluble, whereas the same neutral compounds of the alkaline earths and metallic oxides are insoluble in pure water.

It may also be observed farther, in relation to the ordinary metals, that in their pure or uncombined state they exert no agency whatever in a physiological sense, curative or morbid, upon the animal body. It is only when combined with other principles that they form active agents, whether sanatory or deleterious. Many of the metals combine in various proportions with the other principles, each subsequent proportion bearing a definite ratio to the original, of which all the others are either multiples or submultiples by a whole number. These definite ratios in some cases amount to several. Thus manganese forms five very distinct compounds with oxygen, in which the relative proportions are very different. Thus we have them of:—

<i>Base</i>	<i>oxygen</i>
one	one
two	three
one	two
one	three
one	seven.

And if to these we add the two complex oxides, red oxide and varvicite, we may enumerate seven different compounds, in five of which at least the oxygen and the metal manganese are directly united in different, but fixed and relatively definite proportions. Now the properties and physiological agencies are often not only completely changed, but also differ essentially from each other according to the relative proportions of the combining principles which constitute the compound. In a great proportion of instances, the base as it were being fixed, every additional dose of the oxygen increases the activity, and frequently the virulence, (physiologically) of the compound. For example, mercury (quicksilver), has no physiological action. It may, if introduced, act mechanically, but in its perfectly pure and uncombined state it may be regarded as wholly inert; combined with oxygen in primary proportions, an active and powerful therapeutical agent is formed, named the *protoxide*. When the ratio is one prime or equivalent of mercury to two of oxygen, we obtain the *binoxide*, or *peroxide*, an agent of such physiological virulence, that it may be considered in large doses, and indeed should be guarded against, as a rank poison.

The above may be considered as the general rule, but there are some few exceptions; for instance, *antimony* and *iron*, in which the rule is the direct reverse. The lower the degree of oxidation in these instances, the more active and efficient the remedies. Hence it will be seen that in therapeutics we have not only to discover remedies for disease, but carefully to examine their properties when discovered, and to apply the knowledge thus gained to render them not only more palatable and mild in their action, but also to take care that we are not led away by analogies, so as to reduce or destroy the efficiency of active principles, and render them nearly if not wholly inert.

Proto-carbonate of Iron.— Fe O , C O_2 or Fe C .

—Iron is one of the most valuable tonics we possess, and admirably adapted to certain peculiar forms of atony and general debility. But, as has been already stated, to derive all the benefits it is capable of producing, it must be given in its most active and energetic forms. It is well known that the celebrated Griffiths' Mixture, which obtained so great a notoriety from the control which it exerted over those colliquative and exhausting sweats which aggravate the last stages of phthisis, or consumption, was a preparation of iron upon this principle, the energy of which depended upon the formation of *carbonate* of iron.

Proto-carbonate of iron is beyond all question the very best preparation, whether we look to its curative, its tonic, or its general prophylactic powers. It is readily prepared by decomposing a solution of the green or *proto-sulphate* of iron by means of one of carbonate of soda or of potass. A white precipitate forms, which, however, soon becomes red; this is owing to the rapidity with which iron attracts oxygen, passing from protoxide to *peroxide*, or more correctly, sesqui-oxide. This tendency to pass into peroxide is so great that if we use water, holding common atmospheric air condensed, for the solution of the proto-sulphate, the solution very soon begins to assume a reddish colour, owing to the iron combining with the oxygen of the air contained in the water. In this state, being insoluble, it separates and gradually subsides, so that the liquid poured off will be found deprived in a great degree of the chalybeate. The carbonate formed by precipitating sulphate of iron by an alkaline carbonate forms one of the preparations of the former pharmacopœias; but during the drying of the salt it absorbed oxygen, and gave out carbonic acid, resembling in every particular common rust of iron. Now in this state of higher oxidation, it is not only less active as a curative agent, but exerts a special irritative influence upon the tissue, and a re-action upon the system at large, which

proves highly deleterious and disagreeable. The London College have now given a formula for the sesqui-oxide, but the therapeutical action of this is far inferior to that of the proto-carbonate; in all cases therefore where we wish to preserve the iron in the lower state of oxidation, we should use distilled water, or at least water from which the air has been expelled by previous boiling. But even thus, although we may precipitate carbonate of *protoxide*, as observed already, it will become peroxide before it can be dried. In order, however, to obtain the proto-carbonate as pure as possible, and to preserve it as far as possible in this state, it is proposed to mix the fresh precipitate with sugar, and to evaporate to dryness, constantly agitating the mass. By this means a quantity escapes alteration, being protected from the air by a coating of sugar varnish which attaches itself to, and envelopes the particles. Still, however, as a portion gets peroxidized, the carbonate here will be a mixture of both, and the peroxide will, to a certain extent, impair the efficacy of the carbonate.

Carbonate of iron, though insoluble in water, yet was found singularly efficacious as a remedial agent. It is however a principle in pharmacology, that in general the power of remedies is not only exerted more quickly, but rendered much more active by solution. Therefore, to effect the solubility of the carbonate of iron forms an object of special moment. The salt, though insoluble in mere water, readily dissolves in water strongly impregnated with carbonic acid gas. This property consequently enables us to give steel under the much more grateful form of an *effervescing chalybeate*. This is effected by mixing together the equivalent proportions of sulphate of iron and carbonate of potass, or of soda for decomposition and the generation of carbonate of iron. If carbonated water be drawn upon this mixture, decomposition will ensue, and the generated carbonate of iron be held

in solution by the excess of carbonic acid. In this state it is fit for use.

In the above process it is evident that with carbonate of iron we will have also sulphate of potass or of soda, as the case may be, owing to the mutual transfer of acids and bases. Notwithstanding that the quantity of alkaline salts, generally speaking, will be small, yet even so their presence is often a great inconvenience—sometimes even wholly inadmissible; yet under these circumstances they cannot be separated. It becomes therefore a question of some importance whether we can easily prepare an effervescing chalybeate, free from all other saline contamination. *By the aid of the carbonating apparatus, this is practicable, and both easily and quickly.*

Carbonic acid condensed in water speedily attacks iron, forms it into carbonate and dissolves it. If then a small coil of iron wire, harpsichord wire for instance, be introduced into the pressure flask before its connexion with the apparatus; and the flask be now filled with distilled water, impregnated with carbonic acid under strong pressure, and allowed to remain so for some little time, a perfectly pure effervescing chalybeate draught will be obtained. Or if some iron filings or wire be placed in the water in the condenser, as the water becomes impregnated with the acid, the iron will be converted into carbonate, and held in solution, which will be ready for use the moment it is drawn off from the apparatus.

In consequence of the difficulty of preserving or indeed of obtaining the salts of protoxide of iron, the College of Physicians have directed a tincture of the sesquichloride for internal use. But it is probable that the chlorides, in efficacy, are analogous to the oxides, and that the proto-chloride is by far the more efficient medicinal agent. Proto-chloride of iron may be formed by dissolving metallic iron in hydrochloric acid, hydrogen escapes, and proto-chloride of iron remains in solu-

tion. It is of a pale bluish green colour, and yields on evaporation rhombic crystals of a pale bluish green colour, which are hydrated chloride of iron : $\text{Fe Cl} + 4 \text{ HO}$. They are slightly deliquescent, and their solution absorbs oxygen rapidly from the air and becomes dark green coloured, owing to the iron passing to the state of a per-salt. When the crystals are heated they lose water, and if the air be excluded a dry white protochloride of iron is obtained ; but if the air be admitted per- or sesquichloride is formed. Anhydrous protochloride may be very elegantly prepared by passing a stream of dry hydrochloric acid gas over fine iron wire, coiled up in a tube of hard Bohemian potass glass, and heated to bright redness. Hydrogen is given off, while the chlorine uniting with the iron, a protochloride of iron is formed, which volatilizes and passes into the cold part of the tube, where it condenses in the form of brilliant white spangles, which by the action of the air are rapidly decomposed and peroxidized. Protochloride of iron may be readily prepared in the wet way by mixing adjusted solutions, that is, of the corresponding equivalents of proto-sulphate of iron and chloride of sodium (common salt) together. A transfer of all the principles takes place, and we have a solution of protochloride of iron and sulphate of soda. It is evident that this cannot be conveniently kept without decomposition, and that the formula is inadmissible in circumstances where any portion of an *alkaline sulphate* would be objectionable. From experience I think I may assert that the proto-carbonate of iron is inferior to none in efficacy ; and from the facility with which it can now be prepared, and administered in its pure, perfect, and efficient state, that as a pharmaceutical agent it will supersede all other preparations of iron, except in some rare cases, where the chloride or sesquichloride may be desirable for combination, or that special circumstances may indicate some other of the chalybeate formulæ.

I have been thus diffuse upon the subject of iron, because, notwithstanding its great value in medicine, yet its preservation as an active therapeutical agent has always proved an insurmountable pharmaceutical difficulty. Hence the various preparations of citrate, acetate, potassio-tartrate, all which are more difficult of preparation and far inferior in power and efficacy to the protocarbonate of iron in solution.

PHARMACEUTICAL AGENCIES.

Having considered carbonic acid both in its free and combined state, the next subject for consideration is the pharmaceutical purposes which it is calculated to effect. It is a general principle in chemistry that bodies do not act upon each other unless one or both be in solution, or at least, that water in some form be present. Although there are some exceptions to this rule; for example, some of the metals with chlorine, iodine, bromine, &c., where mere contact is sufficient to the development of chemical action and combination: yet in a great proportion of instances it will be found, that compound bodies do not react upon each other, unless one at least be in solution or that water in some form be present. For example: dry carbonate of soda, and the citric or tartaric acid do not act upon each though mixed together; but if water, especially hot, be poured upon the mixture, a most energetic action is excited, and violent effervescence assures us that the stronger acid is rapidly disengaging the carbonic. In like manner if dry sulphate of iron and carbonate of soda be mixed, their principles remain quiescent; but if water be added, reaction immediately commences, and there is a complete interchange of principles, to such an extent that one of the salts at least shall be completely changed.

The above principles in fact may be said to extend to

therapeutical pharmacy; which may be defined the art of preparing medicinal agents so as to exalt their virtues and increase their powers. With but very few exceptions, remedies are found to be more energetic, and much more in proportion as they are rendered more soluble. Hence we combine morphia, the active principle of opium, with hydrochloric acid, or with the acetic, and in the latter case we prefer the acetic acid in excess; because pure morphia is very insoluble, and therefore would prove neither so instantaneous, nor energetic in its effects. But by combining with hydrochloric acid, hydrochlorate of morphia is formed, a salt of considerable solubility, and which therefore acts speedily and powerfully. The compound with acetic acid still more clearly illustrates these principles. The acetate of morphia by keeping, parts with a proportion of its acid, becoming di-acetate, a salt comparatively very insoluble, and in proportion slow and inert in its action, but when acetic acid is added, an acetate dissolved still more effectually by an excess of acid, and proportionally rapid and energetic in its action, is formed.

From the principles above established, we may collect that the chemical agencies of carbonic acid may be rendered extensively subservient to therapeutical pharmacy, from its capabilities of rendering some of our most powerful and active medicines soluble, and thus placing them in the circumstances most calculated to increase their energies, and insure their therapeutical agencies to the fullest extent and in the highest degree. It has been shewn that although some of the neutral compounds of carbonic acid, the carbonated alkaline earths for instance, are wholly insoluble in water, yet water impregnated with carbonic acid will now prove a solvent. However, in reference to the earthy carbonates, we seldom, if ever, have occasion to avail ourselves (pharmaceutically) of the solvent powers of this gas; chalk being a general remedy for diarrhœa is

probably more effectual in its natural state of insolubility, than when held in solution by an excess of the gas. As an antacid also, most practitioners prefer the chalk as an insoluble compound to the same held in solution by an excess of carbonic acid.

The facts, however, in respect to the alkalies are widely different; as antacids, the more caustic the alkalies, the greater their saturating powers; but in this caustic state the more energetic their chemical action on the tissue, and consequently the more active they prove in impairing the digestive functions. A given quantity of carbonated alkali, no matter how great the quantity of carbonic acid, will always exert the same saturating or neutralising power as the corresponding quantity of caustic or uncombined alkali; but in the former case the development of the antacid reagents, will not exert any chemically injurious reagents upon the gastric tissues; but in the caustic condition, although the ultimate effect will be the same, the local action upon the tissue will be much more destructive, and by the reaction upon the economy will to a proportionate extent, prove generally injurious. Hence the carbonated alkalies are preferred for internal administration. But the bicarbonates, the mildest forms, are much less soluble; this inconvenience however may be remedied by using, as the solvent, water highly charged with carbonic acid. The bicarbonates insoluble in a proportion of pure water are speedily dissolved by the same water strongly impregnated with carbonic acid gas. Hence we can readily comprehend how carbonic acid may be made a valuable pharmaceutical agent, in respect to the caustic alkalies.

With respect to the earths, magnesia is the only one requiring any observation. This earth, owing to its very inferior causticity, while at the same time it neutralizes acidity, has been occasionally preferred to the alkalies. Magnesia, however, is very bulky; or in other words, a given degree of saturating power cannot be

attained without an excessively bulky dose. Magnesia too, both in its caustic and carbonated state, acts very slowly, and a considerable time elapses before the combination takes place. Another, and a very great inconvenience, arises from the habitual use of ordinary magnesia, namely, that it is apt to concrete, or aggregate with the mucus of the intestinal tube, into masses of considerable size. Hence frequently obstinate costiveness, and even inflammation of the bowels from the prolonged and inconsiderate use of magnesia. By dissolving the magnesia by means of carbonic acid, these effects may be entirely prevented; and as the saturating powers of magnesia nearly equal those of ammonia, this mode of administration will prove a valuable means of securing its effects. The dose of carbonate of magnesia placed in the receiving flask, and the aërated water drawn upon it, will be dissolved, and is most advantageously administered in this way.

In the administration of iron as a chalybeate, tonic, astringent, emmenagogue, or indeed for any other purpose, we shall find carbonic acid presenting us with the means of not only exalting the virtues, but of greatly increasing the powers of the remedy. It must be kept in view that the proto-salts of iron are the most *powerful* therapeutical agents, while they are comparatively wholly devoid of all *irritating* agencies, but the very reverse holds good with respect to the per- or sesqui-salts of the same mineral. The *proto-carbonate* of iron is unquestionably the very best chalybeate; hence the reputation of "Griffiths' mixture," which owes its virtues to the extemporaneous formation of protocarbonate of iron. To prove of use it should be administered the moment it has been prepared. Its virtues seem to depend upon, 1st, the iron being in the form of *protoxide*; 2nd, the protoxide being united or salified by the *carbonic* acid; 3rd, according to Dr. Paris, the *protocarbonate* of iron is held partly in solution, by an excess of alkali. All these

advantages may be obtained by dissolving iron in water by means of excess of carbonic acid, and we shall have this farther advantage, that we can in this way give the chalybeate pure and uncontaminated when this is desirable; or in conjunction with other principles when such is the object.

THERAPEUTICAL AGENCIES.

Having considered the pharmaceutical uses of carbonic acid, we now inquire what are the therapeutical indications which it is calculated to fulfil. This is an inquiry, the subject of which presents many difficulties in its arrangement. Carbonic acid perhaps may be considered, as having in itself little or no medicinal effects; but however weakly, it is certainly capable of fulfilling some important therapeutical indications.

Medicines have been usually classed according to the effects which they are capable of producing in the animal body, and hence, as many are capable of several varieties, we often have the same remedy occupying a place in several of the classes. The effects which medicines are capable of producing, have been arranged into general stimulants, local stimulants, chemical and mechanical. These actions have been again subdivided into narcotics, antispasmodics, tonics, astringents, &c. It will therefore be most convenient to arrange the therapeutical history of carbonic acid under the special heads, omitting altogether those heads to which it has no known or referable relation.

Narcotic Agencies.—Carbonic is a very powerful narcotic. Taken into the lungs, its powers are in proportion to its concentration, or the nature of its contamination. One volume of carbonic renders four volumes of atmospheric air incapable of supporting

combustion,* and a lighted taper immersed in such an atmosphere is immediately extinguished. Hence carbonic acid cannot be safely breathed; and diluted with even ten parts of atmospheric air its effects are very pernicious.

Applied to the surface, it is capable of producing its narcotic effects. The same may be said of the application to the mucous membrane of the stomach. It is well known that carbonated water has caused giddiness and intoxication when drank too freely at first. The sparkling wines, champagne for instance, and bottled malt liquors, owe their more rapidly intoxicating powers to their greater impregnation with this gas.

But in moderation, carbonic acid has a pleasurable and exhilarating stimulant action, and in consequence is often a very valuable remedy. Its gratefulness, too, to the stomach, will often permit its administration, when more powerful but less agreeable narcotics would not be tolerated. However, carbonic acid will not often be selected for its narcotic influence, although it may be made use of to render more active remedies agreeable and indeed tolerable to the stomach.

Anti-spasmodic.—It is difficult to assign any anti-spasmodic powers to carbonic acid. Many of its compounds, however, have most decidedly anti-spasmodic virtues. Vomiting, for instance, is a morbid perversion, over which it seems more capable of exerting a controlling influence than any other remedy, not even excepting the more direct anti-spasmodics and narcotics. The efficacy of effervescing draughts has long been known as a means of checking vomiting; and every gourmand is practically acquainted with the

* The author, many years since, proposed the application of *carbonic acid gas* to the purpose of more instantaneously extinguishing fires. It has a great advantage over water; its action is more energetic, and what the fire spares, the gas does not destroy, as is mostly the case with water.

value of a bottle or two of soda-water the morning after his debauch.

But although the powers of carbonic acid in its insulated state may not take a prominent position in the class of narcotics and anti-spasmodics, yet as an auxiliary it will be found greatly to enhance the value of the positive agents of these two classes. For instance, opium, alcohol, ether, musk, camphor, assa-fœtida, are in many cases greatly improved in their virtues, and their nauseous properties often corrected by intermixture with carbonated water, which may be made the vehicle of their administration. Hence the professional reader will perceive that he will find in carbonated, or as it is more frequently designated, aërated water, a very suitable vehicle for the exhibition of both narcotics and anti-spasmodics.

Tonic Agencies.—The stimulant action considered under the two preceding heads, has been termed diffusible, that is, the action of which is *general*, but *hasty* and *transient* in its operation. The present head and the succeeding will comprehend general excitants, but which are far more gradual, but at the same time much more permanent in their effects. Tonics are defined, medicines, the primary action of which is to give tone and vigour to the muscular fibre and system in general. The mode in which they act, or the special tissues upon which they operate in effecting the necessary tension, would be foreign to the objects of this summary. There is no doubt that a considerable portion of their energy is exerted upon the nervous system, which in general debility appears to suffer to a greater or less extent from atony.

A question of more importance, however, is, has carbonic acid any tonic power? or can it restore tonicity to the nervous system, and, through it, vigour and energy to the other systems? In reply, it may be observed that the mineral acids are ranked as tonics, and are looked upon as possessed of considerable

power. Carbonic acid, however, has not been classed as one of these, and this probably has originated in the fact, that the means of exhibiting it in an insulated state have not hitherto been very practicable. I have lately tried it in this way, and though much less energetic than some others of this class, it certainly in my opinion ought to rank before many articles enumerated as belonging to this class. Those who use or who will try carbonic acid as a tonic, will find that it is not wholly devoid of power.

But whatever its own immediate virtues in this way, there can be no doubt of its utility as an adjunct. Upon some it confers all the efficacy they possess—for example, steel, and which would exert no action whatever, unless combined with this or some other acid; and I think I can from experience assert that there is no preparation of iron so mild, so active, and so decidedly suitable as a chalybeate, or congenial to the animal economy, as the protocarbonate of iron, held in solution by an excess of carbonic acid gas. If the digestion be impaired, provided there be no inflammatory action, the above preparation will be found to exert considerable influence. Should the blood be impoverished, and deficient in the red particles, this preparation will restore it to its healthy condition more effectually than any other. If we observe its action upon the pale and anæmious leucophlegmatic habit, we are often astonished at the rapid improvement, and the return of health and spirits.

The vegetable tonics and bitters are objected to by many persons on account of their disagreeable taste. If such be the case, all these disagreeables may be readily corrected by making aërated water, in some one of its modes, the vehicle for their administration. Sometimes bitter infusions, decoctions, &c. may be given in this way even to children, and there can be no more elegant and agreeable mode of administering di-sulphate of quina, whether with or without the additional sulphuric acid, than in a glass of aërated water.

Astringent Agencies.—The observations just now made upon the tonic capabilities of carbonic acid will, *mutatis mutandis*, apply to its astringent ones. There is little doubt that, although these may be comparatively weak, yet that they do exist. I have seen one or two instances of sweating completely checked by water strongly impregnated with carbonic acid gas. In diabetes I believe it will be found to afford great relief. In that form of diuresis, attended with excess of urea, and which seems often to be the primitive step to diabetes, it proves a very valuable agent, either alone or in conjunction with opium. I have likewise found it very useful in some cases of chylous, and albuminous urine, especially those forms which frequently appear as the sequel of measles and scarlet fever, &c.; but in such cases it appears to me that the combination with protoxide of iron is best adapted. It need hardly be stated here, that carbonic acid may be used as an efficient and agreeable vehicle for the administration of those astringents which present no chemical incompatibilities.

Cathartic Agencies.—Cathartics are defined, medicines which excite the peristaltic motions of the intestines, or which excite the exhalant and other vessels to pour out a superabundance of their fluids, and thus excite to their evacuation. Some are supposed to exert a direct stimulus upon the muscular fibres, and thus excite to unusual contraction. The expulsion of the contents of the intestinal tube must be the consequence. Some, however, seem to exert a mere mechanical action; and perhaps any cathartic effect from carbonic acid is wholly referable to this principle. It is a law in physiology well established, that the stretching of the fibres of a muscle excites that muscle to a vigorous and active contraction. Hence it is that the hollow muscles,—the heart and bladder, for instance, when their cavities are distended by fluids, however bland and incapable of any specific irritation, are excited to active contraction in consequence of the distension of their muscular fibres, and thus the distend-

ing fluid is expelled. Thus mere water injected into the rectum, causes an evacuation, the effects of the mechanical excitement of the fibres of the rectum being propagated, by what is named "*the sympathy of continuity*," to the entire extent of the intestinal tube. Carbonic acid, then, although incapable by itself of any direct excitement, and which, if it really existed, would in all probability be counteracted and neutralized by its narcotic influence, may by its mechanical agency be rendered subservient to hastening and rendering more efficient the agency of other cathartics. It is well known that a drachm or two of Epsom or Rochelle salts taken in a glass of carbonated or aërated water will produce a more instantaneous effect, and cause a more satisfactory evacuation than could be obtained from two ounces of the salts administered in the usual way. This is owing to the mechanical agency of the gas relieved from artificial pressure, expanding still more from the heat of the intestines, and consequently distending the muscular coat of the intestines, and thus exciting to vigorous contraction.

It is a fact too familiar to require any elucidation, that a violent stimulus, or one more moderate and gentle, but too long continued or too often applied, not only ceases to excite, but superinduces a positive torpor. Now this is exactly what results from the habitual use, or more correctly, perhaps, abuse of purgatives. From daily repetition the intestines become insensible, and torpor is the result. To overcome the inactivity, larger doses are resorted to, which soon fail, and then recourse is had to more violent and drastic purgatives, which in time lose their power, and obstinate constipation is the unhappy (and often most depressing) result. Such consequences may be, as I have repeatedly observed, subdued by small doses of saline aperients in a tumbler of water highly charged with carbonic acid, in some instances a bitter infusion, or tincture, or a vegetable or mineral tonic—bark, or steel for instance, forms a useful as well as active adjunct. These are the

principles of activity in many of the *mineral waters*, which can be very conveniently and effectually imitated by art. The utility and value, therefore, of carbonic acid as an auxiliary to aperient medicines, is a fact beyond the possibility of doubt, and as an auxiliary the action of which may be considered almost identical with that adopted by nature; the great advantage from such an imitation admits of no question. The mode of preparation for this purpose will be explained in another part.

Emmenagogue Agencies.—Carbonic acid cannot be looked upon as possessing any direct power of this sort. As a febrifuge, or anti-febrile agent when condensed in water, it may, through such agency, that is the lowering excitement and an inflammatory tendency, have indirectly some emmenagogue influence. But many cases of amenorrhœa occur in very different states of system;—sometimes there is a pale sallow cast of countenance, a leucophlegmatic and anæmious state of system; impoverished condition of the blood, deficient in the red particles, and abounding in watery, and perhaps some saline principles, attended with nervous atony and general debility; in such cases chalybeates are our sheet-anchor, and the reader will readily recollect that carbonic acid enables us to administer iron under the most favourable circumstances, and best suited to insure its full and most beneficial effects. Whatever the emmenagogue, where practicable, carbonated water presents us with one of the very best vehicles or adjuncts.

Diuretic Agencies.—Diuretics are medicines which promote and increase the flow of urine: some act directly by stimulating the kidneys; others have a more indirect mode of action, but which it would be quite foreign to our purpose to examine. The only action that could possibly be exerted by carbonic acid, would be by direct transmission and action upon the secreting vessels of the kidneys. All acids seem to have some influence of this sort; the mineral acids

certainly pass through the system to the kidneys, and exert a diuretic agency, however slight this may be. The vegetable acids undergo decomposition, carbonic acid being formed from a new arrangement of their elements, but part passes unaltered through the kidneys and excites them to increased action, and is voided with the urine. But carbonic acid itself in part is decomposed. Of this any person may satisfy himself, by drinking water surcharged with carbonic acid, and distilling, at a moderate heat, the urine from a retort, fitted so as to convey the volatile principles through lime water, carbonate of lime will be immediately formed; or the gaseous products of the distillation may be received over water and subsequently examined. Of these facts I have repeatedly assured myself.

It must be admitted, however, that the diuretic powers of carbonic acid are comparatively but feeble; but united to potass or soda, an active diuretic salt is obtained. The alkaline salts formed with the vegetable or destructible acids, such as the acetate, the bitartrate, citrate, &c., of potass or soda, are diuretic; but when the urine is examined, the original acid is found to have been converted into the carbonic, and a carbonate of the alkali may be detected in the urine. But let the diuretic be what it may, carbonic acid certainly seems very often to increase the effect. Thus I have seen the power and activity of nitre, ether, squill, digitalis, colchicum, &c., very much increased, by administering them in water impregnated with carbonic acid. The mode of doing this requires no explanation.

Antacid Agencies.—These, of course, can be none, as the acid can exert no neutralising power. But it may have an indirect influence by improving the tone of the digestive system, and which it certainly seems to do. However, it is more frequently given combined with the alkalis, or magnesia and lime, for this purpose, and as it corrects their causticity, and is itself again evolved and set free in the stomach, it can exert its tonic influence while the alkali neutralizes the morbid acid.

Lithontriptic Agencies.—Certain medicines were at one time supposed to pass from the digestive system to the kidneys and bladder, and by a chemical action to dissolve calculi. Such operations, however, are scarcely admitted at the present day, or at least their sphere has been greatly circumscribed.

There appear to be many objections and great difficulties to admitting the direct influence of lithontriptics; for it is a well known fact, that the urine holds in solution many principles of an opposite nature, and that the solvent for some is a direct precipitant of some of the others. For example, the lithic acid is dissolved by the caustic alkalies; but *they* precipitate the earthy phosphates. Hence, these remedies are considered, or are rather prescribed with the view of correcting the morbid contents of the stomach, and *primæ viæ*, upon which the calculous deposit is supposed to depend. Indeed, it is only upon this principle that we could reconcile the fact, that the separation of lithic acid from the urine, can be frequently controlled by the carbonates of the alkalies, and by magnesia. Lithic acid is wholly insoluble in the *carbonated* alkalies, and is displaced and separated from its solvent bases by carbonic acid. But if we admit the action of the alkalies to be exerted, in correcting those morbid actions in the digestive functions, upon which the lithic acid diathesis, as it is termed, depends; the fact then becomes intelligible.

That the class, however, of lithontriptic agents may be pushed so far as to produce a *chemically* morbid condition of the urine, and precipitate some of its constituents in calculous masses, admits of no doubt whatever. Acids may be pushed so far as to neutralize the solvent ammonia of the lithic acid, and cause this to precipitate in the crystalline form. Again, by an immoderate use of the alkalies, the excess of acid, the phosphoric, which retains the earthy bases in solution, may be neutralized, and the precipitation of the neutral or basic earthy phosphates, &c., will be the necessary consequence.

The principal calculi are the lithic acid, and the earthy phosphates.* Where the lithic acid diathesis prevails, we resort principally to potass, soda, or magnesia. But we cannot persevere with these agents in their caustic state, at least, the two first. When we require their assistance we prefer them carbonated, and even a large excess of carbonic acid is not found to prejudice their action, while it renders them milder or more tolerable, and at the same time less injurious to the digestive apparatus. The effect of carbonic acid in rendering magnesia soluble, has been already noticed.

In the *phosphatic* diathesis, either the ammonio-magnesian phosphate, or a mixture of this with the phosphate of lime—the mixed or fusible phosphates—separate from the urine. As this must depend upon the neutralization of the *excess* of *phosphoric acid*, which keeps the phosphates in solution, by some alkali, and which is almost invariably ammonia, unless by some artificial impregnation with some of the other neutralizing bases it be determined otherwise; in order to prevent this, and the continued deposition of the phosphates, we exhibit acids. The mineral acids, at least the hydrochloric, nitric, and phosphoric, not only neutralize the precipitating agent, and prevent its operation, but are also capable of *re-dissolving* the precipitated phosphates. These, however, even when diluted, act injuriously upon the intestino-mucous tissues, and thus it is often impossible to persevere in their use to the requisite extent. The sulphuric acid is objectionable, as it forms with lime an insoluble sulphate. These objections suggested the use of the vegetable acids, and hence, the citric and tartaric acids have been frequently administered. The citric and tartaric acids both form with lime salts insoluble in

* For further information, see Practical Guide to the Urinary Cabinet, Knight and Sons, Foster Lane.

water. But independently of this, these acids undergo decomposition *in transitu*, and thus their action is often prevented, add to which, that even these acids, by continued use, disagree with the stomach.

It has been already observed that hydrochlorate of ammonia, as well as carbonic acid, exerts a solvent power upon certain of the earthy salts, as the phosphates, &c. Now, carbonic acid taken into the stomach, will find its way in abundance into the urine, and being in excess will exert a solvent power, or perhaps an antiprecipitating agency upon the phosphatic precipitants existing in the urine. There can be no question of its chemical powers, and water strongly impregnated with this gas prevents the deposition of the earthy phosphates, at least in the bladder. The solvent action of the acid can be very satisfactorily demonstrated by boiling such urine; for the carbonic acid being expelled at this high temperature, the phosphates deprived of the solvent begin to separate, and the urine becomes turbid. As this acid can be taken for almost an indefinite length of time, without injurious action, and is capable of exerting so great an influence upon such morbid conditions of the urine, it evidently presents the practitioner with a most valuable resource, whether he trusts to its powers alone, or occasionally interposes those of the more powerful acids, as the phosphoric, hydrochloric, &c., of which and the vegetable ones, water, impregnated with carbonic acid gas, may be made not only an agreeable but very active and efficient vehicle.

In cases of the oxalate of lime, cystic oxide, &c., carbonic acid can at all events be of service when an alkali is contra-indicated. I find that the carbonic acid (though perhaps very sparingly), dissolves the oxalate of lime, and, therefore, it appears to me that this acid may prove beneficial where this diathesis prevails.

Refrigerant Agencies.—Refrigerants are remedies

which reduce the circulating forces, and diminish morbid heat without affecting the sensibility or nervous energy. They are in fact antiphlogistics without inducing asthenia, or any degree of nervous atony. The theory, or "modus operandi" of refrigerants is not so well understood as is that of the classes previously considered. It would be foreign to our purpose here to enter upon a subject so purely speculative, and therefore it will be sufficient to state that there are remedies capable by internal administration of exerting a *cooling* influence upon the morbidly heated surface, and of reducing the force and velocity of the circulation, without producing nervous atony or any general debility.

This class comprehends the acids both mineral and vegetable, and several of the alkaline salts. The vegetable acids, both in their free state, and combined with the alkalies in neutralising proportions, are considered as highly refrigerating, and they are frequently given with the alkaline carbonates, either during the effervescence consequent upon the mixture, or in such a way that the effervescence shall take place in the stomach. In this latter case the carbonic acid gas disengaged in the stomach seems to exert a very wholesome agency.

I have very often given carbonated water alone, as a refrigerant; and in many cases where the phlogistic diathesis is strongly manifested it will be found of very great service. In many instances too, where febrile heat seems to arise from a degree of nervous irritation, I have seen a few grains of nitre in a tumbler of aërated water produce very wonderful effects. It is surprising what a tranquillity is produced; and persons who had long suffered from a low degree of morbid heat and constant agitation have been astonished at the calm and tranquillity superinduced by such a draught. Of course when indicated, and not incompatible, aërated water may be made the vehicle

for the administration of other refrigerants, the virtues and powers of which it will very frequently exalt, independently of being itself a most grateful and agreeable adjunct.

Diluent Agencies.—These hardly require comment; they act by diluting the blood, and thus reducing its stimulating qualities. Consequently, in strict logical precision, water is the only diluent. In many cases, however, the ordinary waters, holding a number of saline principles in solution are so far objectionable. The solvent in these cases is often the carbonic acid, and such waters require to be boiled to expel the solvent, and precipitate the saline matters. In some instances even distillation is a necessary preliminary to get rid of all the salines. In either instance the water becomes mawkish and disagreeable, and intolerable to the stomach. In such cases the water should be previously distilled and then charged with carbonic acid condensed under a pressure exactly suited to the special circumstances of the case. Distilled or boiled water treated in this way, which otherwise it could not endure, will be rendered both agreeable and grateful to the stomach. It is evident that gruel, and some others of the farinaceous decoctions may, if judged suitable, be treated in a similar way.

Demulcent Agencies.—What has been stated with respect to diluents, *mutatis mutandis*, will apply to demulcents. These are remedies that obviate the action of acrimonious substances: they principally consist of mucilaginous matter, and where carbonic acid is not incompatible, they may be associated; and it is more than probable that the sedative action of the acid may prove beneficial, at least as an auxiliary. This will be found often the case in certain irritable states of the bladder, in which circumstances the uva ursi, alchemilla arvensis, and other urinary astringents, may be most agreeably administered in a glass of the aërated water.

SPECIAL THERAPEUTICS.

Having examined the pharmaceutical and general therapeutical agencies of carbonic acid and its compounds, we next come to what may be, not inaptly named its *special therapeutics*, that is, the special application and adaptation of the former agencies to the alleviation or cure of particular diseases.

As it is not my intention to enter upon this subject at much greater length than that for which my own immediate observations have furnished the materials, the leading facts to be detailed under this head may be regarded as the result of actual trials and experience. Much, of course, referable to this head has been already noticed under the general therapeutical agencies. I have availed myself of every opportunity that presented itself to investigate the compounds, the mode of preparing them, and the special indications which they are adapted to fulfil, and I am now about to present the reader with the result.

In stating the result of my inquiries into the department now under consideration, I shall endeavour to adhere as closely as possible to the nosological arrangements of diseases, without adopting any particular system to the exclusion of others. I shall begin with the first and most extensive class, namely, *Pyrexiaë*. This class comprehends a number of diseases, the principal character of which is fever, whether idiopathic or symptomatic.

Class I. Pyrexiaë.

Ord. 1. Idiopathic fevers. — It would perhaps be difficult to decide what influence carbonic acid can exert upon the diseases comprised in this order; yet some have asserted that carbonic acid is an antidote to fever; in a word, a complete and most effectual febrifuge. There is very little doubt, however, but that it may be rendered subservient to many useful and important purposes in the treatment. Dilution is an object of paramount importance at the beginning of most febrile

diseases, and the intense and almost insatiable thirst from which such patients constantly suffer point out the necessity of allaying it; hence, cooling subacid drinks are invariably recommended and administered. In the fever hospitals in Ireland, many varieties were prepared by various methods, in most of which the preparation of an acidulous drink with the evolution of carbonic acid, formed a principal feature. BAKEWELL'S APPARATUS presents us with the means of preparing a most grateful and agreeable drink of this sort. If lemonade of the requisite degree of acidity be placed in the condensing portion, on evolving the carbonic acid gas a most agreeable *effervescing* lemonade may be drawn off. Such drink will be palatable to every taste, and may be rendered still more agreeable and effectual by the addition of some of the factitious ices, as the raspberry, lemon, &c.—“à fluido, nempe, et crudo fœtu, ad rigidum et exsuccum senem, cui vita . . . fere deficit.”

It is evident still farther that this carbonated water, or even lemonade, when not incompatible, may be conjoined with or made the vehicle for the administration of the various saline compounds which have been recommended as *corrigents* of the *morbid* conditions of the blood in fever. Thus nitre, chloride of sodium or common salt, may be given to the requisite extent in the effervescing lemonade; and the carbonate of soda or potass may be similarly administered, only omitting the lemonade if we object to the formation of any *citrate* of soda, a chemical rather than a therapeutical objection. I have not had any opportunity at present of practically verifying the above, but from some analogous instances I have no doubt of its efficacy.

2. *Exanthemata*.—In some of the diseases of this order, especially measles and scarlatina, I have had one or two opportunities of trying the various forms of carbonated water. It is well known that these diseases prove more pernicious, generally speaking, from the virulence of their sequelæ, than from their own immediate violence. Anasarca of the lower extremities is a

very frequent consecutive of scarlatina, and is sometimes accompanied with ascites. In the latter case, the dropsical symptoms, I have observed, prove more obstinate and severe. These forms are, perhaps, more frequently than otherwise attended with albuminous urine. Such instances will be found to give way much more immediately to the protocarbonate of iron than to any other remedy. If there appear to be any great degree of inflammatory action, this should be previously reduced by a small bleeding or by antimony, and then the chalybeate may be given with great advantage and effect. The diuretic action is very effectually increased by combining the bitartrate of potass, or nitre, and a little ether or spirit of juniper. The ingredients for this purpose should be previously introduced into the receiving flask and then corked up, and adapted by its screw to the aëerator. On filling the bottle with the aërated water or lemonade, the chemical changes take place, and a most efficient tonic and diuretic draught, and withal most grateful, is instantly generated. I have treated six cases of dropsy with albuminous urine after scarlatina in this manner, and with the most decided success. Although such dropsies cannot be considered dangerous, they sometimes prove very troublesome and obstinate, inducing ulcerations about the feet and ancles, and sometimes even permanent cachexy; therefore a safe and effectual method of relieving these affections and invigorating the system seems to me a desideratum, and justifies the concise notice in this place.

The remaining three orders of this class, namely, the phlegmasiæ, hemorrhagiæ and profluvia, will hardly require special consideration. They are mostly associated with a phlogistic diathesis and an accelerated inflammatory state of the circulation. Nitre is found to present us with a very powerful refrigerant in such cases. Taken in small doses, it produces a sense of coolness in the mouth, and when frequently repeated

it reduces the tone of the circulation, the *hardness* of the pulse, and the morbid heat of surface which prevails in these cases, and often prove very harassing and distressing. It is thus found to be of essential service in those febrile states which not only accompany, but often greatly aggravate acute rheumatism and hæmoptysis, or spitting of blood. From three to ten grains should be given for a dose, and repeated every four or five hours.

Nitre, however, is very disagreeable, nauseous, and sometimes irritating to the mucous surface; but I have found that all these difficulties are readily surmounted by giving the salt dissolved in the aërated water or effervescing lemonade. I lately met with two cases of hæmoptysis, the one apparently depending upon tubercular cachexy, and the other upon active sanguineous congestion of the lungs. Nitre was tried to moderate the fever, and to reduce the temperature, which was very harassing to the patients, but in both cases could not be persevered in from the irritation which it seemed to occasion in the mucous membrane of the stomach and bowels. At this moment it occurred to me to try aërated lemonade as the vehicle. The dose of nitre then being placed in the bottle, and this connected with the condenser, the aërated lemonade was allowed to flow in, and thus administered. In this mode it produced no sensible irritation—on the contrary, it seemed to agree well, and was carried to the full extent, that is, till the symptoms which it was intended to control had been completely subdued.

There are some instances of bronchial hæmorrhage, which appears to depend upon general debility and a peculiar atony of the mucous lining of the pulmonary air tubes, in which I have found the protocarbonate of iron given as already proposed, of signal benefit; but to enlarge much more upon the particular diseases and their modifications, belonging to this class, in which the administration of the appropriate remedies

might be rendered more efficient or more tolerable, upon the plan just noted, would lead to details far too extensive, and would greatly exceed the limits necessarily assigned to this essay.

Perhaps the only objectionable cases are those in which there is gastro-enteritic inflammation, or a very irritable state of the intestinal organs, or of their mucous lining, in which probably the rapid expansion of a large proportion of carbonic acid gas would prove very distressing. These difficulties, however, may be got over by using a proportionally less quantity of the aërated fluid as a vehicle, and still farther by allowing it to stand for a short time before administration, so that some of the gas may escape; nor will this impair in any very sensible degree the value or virtues, for even still the water will retain a large quantity of carbonic acid condensed, or in solution, quite sufficient at all events to produce the sharp, pungent, and agreeable taste which this gas causes, as well as to produce all the chemical agencies of solution, &c. which under most circumstances it can exert.

Hæmatemesis.—This consists in the evacuation of blood from the stomach (generally dark) by vomiting, in contradistinction to hæmoptysis, in which the blood (frothy and of a florid red) is brought up by coughing. Alum is the most effectual styptic in such cases, but it so frequently disagrees, producing nausea, that it is difficult to manage its administration. The least objectionable mode hitherto devised, is that of alum-whey, made by curdling a pint of boiling milk by two drachms of pounded alum. But even so, I have often found it difficult to continue the use of the astringent to the requisite extent. Having had a short time since a case of acute hæmatemesis, in which even alum-whey could not be continued for more than a single day at a time, the disease in the intervals attaining its original severity, it occurred to me that the aërated lemonade might be advantageously made the vehicle of administration. The

dose, therefore, being introduced into the bottle, the aërated vehicle was received upon it; and in this particular instance, although the stomach was highly sensitive to every other mode of administration, yet it bore this form extremely well, and the medicine frequently could be continued for ten or twelve days at a time.

In *Menorrhagia*, the aërated fluid will often present to us a vehicle which will reconcile the stomach to our remedies, and enable it to tolerate what otherwise it could not endure.

SPORADIC FORMS.

Some of these are diseases depending, in different instances, upon different causes, and therefore are variable in their seat. In these the effect, although the same, may result from affections of different systems.

Chlorosis.—This may be divided into two kinds:—the one in which the menstrual discharge, having made its appearance at the regular time, afterwards ceases to appear at the proper period; the other in which the flux has never appeared at all, although the regular period for the first flow may have long since passed by. The first is named *suppressio*, the second *retentio menses*. Both these forms may originate in what is termed the *phlogistic diathesis*, or an inflammatory state of the system. It would be quite foreign to the purport of this summary to enter upon such specifications. It will, no doubt, occur to the practitioner, that the operating causes of disease, of whatever nature, must be first removed or controlled. When the disease originally results from debility, and an *anæmious* state of system, as is often the case; or that, during the progress of the disease, general debility, with an impoverished state of blood, supervenes, it is quite out of the question to expect the reinvigoration of the system, or the establishment of the uterine health, till this atony of the system has been corrected.

For this purpose, iron presents, as it were, our "sheet anchor;" and hence it is evident that the most *active* and at the same time the least *irritating* form, should be selected for its administration. Many encomiums have been passed upon the citrate, upon the principle, too, that the iron is more easily retained in the state of *protoxide* in this formula. But in this respect it has little or no advantage over any of the other preparations, as it soon becomes peroxidated, at least to a certain extent. Upon the albuminate of iron, I cannot offer much, as I have not used it to any extent. The *protocarbonate* is so easily prepared, and preserved in the most active condition, that I give it the preference over every other form. A small piece of iron wire, introduced into the receiving bottle before admitting the aërated water, will be acted upon and dissolved by the carbonic acid when admitted, and in the course of a few hours a very active chalybeate formed. A solution of both protocarbonate and proto-citrate of iron, may be formed by the same method, by using aërated lemonade, or aërated solution of citric acid.* This is a very powerful and efficient preparation, and I have given it lately in four cases of *retention*, and in two of suppression, attended with several phenomena indicative, indeed almost demonstrative, of a tubercular diathesis at least, if not of actual pulmonary tuberculation; and I rejoice to say, that the four cases of retention are perfectly well; the two of suppression are convalescent, the tubercular symptoms having greatly abated, indeed almost entirely disappeared.

When we do not object to the presence of a small quantity of an alkaline sulphate, pure *protosulphate* of iron with the equivalent of either carbonate of soda or

* The reaction is, that protocarbonate of iron, being first formed, is immediately decomposed by the citric acid, citrate in this instance of protoxide of iron being formed, and the carbonic acid displaced dissolves a new portion of iron, and the same reactions as before succeed, till the whole of the citric acid is neutralized; and lastly, protocarbonate in solution is also formed.

of potass, may be introduced into the bottle, and the aërated water admitted. Double decomposition ensues, a *protocarbonate* of iron and a sulphate of the alkali resulting.*

Dropsy.—In certain forms of dropsy, attended with great debility, and an albuminous state of urine, these preparations of iron are very advantageously conjoined with the diuretics. In the case of a man aged sixty-eight, afflicted with general dropsy, and which had invaded the *scrotum* and *prepuce*, the *ferro-citrated protocarbonate of iron*,† with nitric ether, compound spirit of juniper, and a little nitre, completely emptied the cellular tissue in the course of ten days, and in less than three weeks this patient was perfectly cured, and now remains well after an interval of nearly four months. The supertartrate of potass was given at the same time, but no pre-eminent virtues can be assigned to this diuretic, as it had been administered previously for a long time in vain. In the other forms of dropsy, I have had no opportunity of proving the efficacy of this remedy.

Scrofula is a disease of a very general character, as it shews itself in a great many varieties of form. The only instances in which it has fallen to my lot to prove the power of this mode of administering iron, was in a case of *tabes mesenterica*, and one of rickets. The first that of a child about eighteen months old, a twin, which presented all the characters of *mesenteric marasmus*. Alterative doses of mercury were given, with some improvement of the health, and then recourse was had to sesquichloride of iron, but without any marked advantage. At this particular period, I was investigating the matters of the present inquiry, and I determined to try the remedy in the present case. The success exceeded my most sanguine expectations, and I had the gratification to see this child's health com-

* The proportions will be seen in the Pharmacological Appendix.

† Some such terms, though perhaps not *chemically* correct, yet as distinctive and highly expressive, are retained.

pletely restored in comparatively a very short period of time. In the case of rickets, little was effected; but I attribute this to circumstances wholly unconnected with the therapeutical agencies of the remedy. I may observe that the phosphate of lime, which has been so much extolled in some forms of this disease, may be thus easily given dissolved in the aërated water or lemonade, as may be considered most advantageous.

Atrophy and general emaciation, as often dependent on general debility and depraved digestion, may be advantageously treated by these means; but I have nothing very interesting to offer upon this subject.

DISEASES OF THE NERVOUS SYSTEM.

Chorea, or St. Vitus's Dance.—This consists in an irregular action of the muscles, and totally independent of the will. It attacks younger subjects, and more particularly females. It often proves very obstinate, and the severer forms highly distressing. Active purging in most cases, ought to constitute the preliminary treatment; and as a special therapeutic, the sesquioxide of iron has attained an unusual degree of celebrity. This preparation, however, seems the most *irritating*, and at the same time the most *inert*, of all the chalybeate preparations; and it unfortunately happens, that (hitherto) no convenient and effectual method of obviating the inconvenience has been suggested. The mode, however, suggested in these observations presents an efficient corrective. The proto-carbonate of iron, prepared by the aërating apparatus, furnishes us with one of the most powerful agents for controlling that state of nervous irritation upon which chorea depends. Since I commenced these investigations, two opportunities have occurred of putting these powers to the test of clinical experiment. One was the case of a girl about thirteen years of age, and who had several attacks during the preceding twelve months. During the

last six months, the symptoms continually prevailed, with occasional aggravations of severity; but the disease obstinately resisted the usual treatment, and also the curative influence of the sesquioxide of iron, administered in very large doses. Indeed, the mother of this young girl informed me that she often seemed to suffer much more intensely after a large dose of the sesquioxide.* I therefore gave this patient a strongly impregnated solution of the ferro-citrated protocarbonate of iron, which she took three times a-day; and in two days the severity of the symptoms had so much abated that she could be trusted to walk by herself, which had not been the case before. In a month this patient had completely recovered, and has remained well ever since. The other case was that of a lad about fifteen years of age, of rather a less degree of severity; but the same treatment restored the health in a very short space of time.

Hysteria.—Purging where there appears to be intestinal torpor, the fetid gums to correct flatulence, fulfil the primary indications; then the iron given as a tonic will, except in some special cases, complete the cure, or will at least keep the disease so far in check, that time will of itself eradicate all vestige of the complaint.

Tic Doloureux.—I have not met with a case of such extreme severity as would enable me to speak positively of the controlling powers in such circumstances. But the oxides and carbonates of iron as ordinarily met with, have been extolled in most of the diseases comprehended under the term neuralgia. I have tried the proto-carbonate in solution in several very severe, pain-

* There is a mechanical inconvenience which results from the sesquioxide, which cannot by any possibility apply to the protocarbonate in solution. The former is given mixed into a sort of pulsataceous mass with viscid glutinous matters, as treacle, syrup, mucilage, &c., and aggregating in solid masses, somewhat like magnesia, in the intestines, produces very great irritation and distress. These effects can never result from the aerated solution of the protocarbonate.

ful affections, especially of the face, and with the most decided advantage. I also gave it in a case of severe hemicrania, and with the most complete success.

Nervous atony, or mental depression.—There are many instances of depression of spirits, and which it is often difficult to connect with any special cause. I have met with many such, especially among females, the character of which is very peculiar. The health does not seem generally to be much out of order; but they feel desponding, indulge in the most melancholy thoughts and forebodings, and when you have obtained their confidence, they will tell you that they have no cause for such depressing anticipations. On first applying, on your putting any question, they burst out into an ungovernable fit of weeping, which varies in duration in all probability according to the peculiar idiosyncrasy of the individual. Women after parturition are most commonly the subjects of such, yet it is not confined to the female sex, as I have seen several instances of such attacks in men. It is quite of a different character from either hysteria or hypochondriasis. Persons subject to this most distressing affection, express its nature by the trite and concise expression “lowness of spirits.”

As this affection depends upon various disturbances in the economy, these should be examined into, and as far as possible corrected. It would be quite foreign to my purpose to enter upon a minute detail of the means, which no doubt are sufficiently understood by practitioners. These being attended to, I found a combination of quina, protocarbonate of iron, with occasionally a dose of the liquor opii sedativus, a most effectual remedy. The liquor opii sedativus should be given at first as regularly as the other medicines, but when the symptoms begin to abate, the narcotic may be then given occasionally. The aërated water appears to me greatly to enhance the value of the other agents, as in one or two cases which have occurred to me

lately, I found this mode of administration much superior; as an instance I may state the following case.

A lady, about six weeks after her accouchement, complained to me that she felt in a very low and distressed state. Everything seemed to prey upon her mind, and existence became almost a misery, so depressed were her spirits, so horrible her reflections. Her confinement had been favourable; the offspring, such as was gratifying to the feelings of both parents, was healthy, and the mother had an abundance of nutriment of her own formation for the infant, and at the end of a month found herself perfectly well after a happy delivery. About six weeks, however, after the confinement, she lost her cheerfulness; her spirits became dull; she indulged in melancholy reflections, always anticipating the worst, yet when pressed could not explain the points upon which she entertained such evil forebodings.

I recommended her the sulphate of quina and liquor opii sedativus, upon which she improved at first, and then relapsed into nearly her former state. I now had an opportunity of giving the quina, protocarbonate of iron and liquor opii sedativus in the aërated lemonade as a vehicle, which had a most happy effect. The urgent symptoms, at the end of a week, began to abate, and in a fortnight had entirely disappeared; and at the end of a month she felt as well as ever she did in her life, and continues now at the end of two months to enjoy a perfect state of health. I have since had one or two opportunities of adopting the same means, though in cases of rather less severity, but still with the most complete success.

DISEASES OF THE CIRCULATING ORGANS.

Angina Pectoris.—This seems frequently to be a *neuralgic affection* of the heart. It is attended often with most intolerable pain in the breast, and a most dis-

tressing feeling as of impending suffocation. These symptoms frequently depend upon organic conditions of the organ, but in other instances it seems to exist independently of any thing *organically* wrong. In a case which I lately saw, and in which the phenomena seemed complicated with some obscure affection of the uterus, and attributed to a more than ordinary bad labour, the disease gave way to the ferro-citrated proto-carbonate of iron and morphia, and the patient left apparently with the health completely and permanently restored. It has occurred to me to try the sedative effects of *oxalic acid*, in small doses, in some cases of nervous irritation; and from these trials I feel justified in recommending it to notice. I have given it in doses of from three to ten grains three times a-day. It may be conjoined with liquor opii sedativus, or not, according to circumstances.*

Syncope.—Fainting very frequently depends on a sort of general debility and a degree of what may be named nervous atony. Patients of this description seldom or never suffer any degree of febrile excitement or irritation. On the contrary, there is mostly a sense of chilliness, and a general feeling of coldness. The temperature of the hands and feet are almost always much below the natural standard. The urine is pale, watery, of low specific gravity, hardly at all animalised, but seems to abound in an absolute or positive excess of alkaline salts, more especially potass. The blood seems to be completely deficient in the red particles, and to abound in watery serum; hence a bruise or even any pressure, leaves a state of skin similar to that from a bruise in its nearest advance to complete obliteration. The application of a dry cupping glass even leaves immediately on its being detached, a pale tawny looking patch equaling in extent the circumference of the glass. This now becomes black, and often remains so

* Some professional friends have tried it, at my suggestion, and with great advantage.

for an unusually long time. It appears to arise from the extravasation of a very watery serum, wholly devoid of red particles. I have at this moment a case of the above description under my care. The patient, a girl about twenty-four years of age, had enjoyed excellent health till a few years back, when she had charge of some children on board a steam vessel. In consequence of bad weather she became greatly alarmed and very anxious, her mental agitation having risen to a most intense degree. Since the above period, her health has seriously failed, and she faints upon the slightest exertion or agitation. The application even of a dry cupping glass, however small, induces syncope various in duration, but occurring several times in succession during the first hour. This patient has used the iron with decided advantage.

In cases of syncope in general, if the cause be obvious, the operation should be immediately arrested; or if this be impossible, it should be controlled and limited as much as possible, and all errors in the different systems and their functions corrected, when I am convinced the preparations of iron, administered as suggested above, will be found of the greatest utility.

DISEASES OF THE RESPIRATORY ORGANS.

Phthisis.—The essential morbid condition in this disease, is a tubercular state of the lungs. There are many diseases of the respiratory system so closely resembling phthisis, that they cannot be distinguished by the constitutional symptoms alone. Such perhaps might be designated (as a group) by the term *pseudophthisis*; but the vague and inaccurate application of the term *phthisis* should be abandoned, and be used only to express a tubercular state of the lungs, or that peculiar tubercular diathesis, which will be most assuredly attended with pulmonary localization of the disease, unless means be adopted to prevent this unfortunate result.

During the last ten or twelve years I have most anxiously devoted myself to researches into the *curability* and *cure* of tubercular phthisis; and unless I am greatly deceived, I have obtained some most important therapeutical results. As it is my intention, as soon as the materials shall have been properly arranged, to submit the results of these investigations to both the profession and the public, it would be premature here perhaps to do more than offer a general outline of my views, and the principles of practice founded upon them.

Consumption it appears to be almost clearly demonstrated, originates in what has been termed a tubercular condition of the blood. It is true that tubercles already formed cannot, or at least have not yet been detected in the *circulating* blood, that is, in the blood while in its appropriate vessels. Tubercles, however, are easily discovered in the blood in certain cellular tissues. Thus Dr. Carswell observes;—"It very rarely occurs that tuberculous matter can be detected in the blood contained within its proper vessels, but it is frequently met with in this fluid in the *cells of the spleen*. This organ is particularly favourable for ascertaining the presence of the tuberculous matter in the blood. Its spongy structure admits of the accumulation of the blood in such quantity, that the tuberculous matter can be seen forming in this fluid at some distance from the walls of the cells in which it is contained. Thus we can see the blood *coagulated* in *one* cell; coagulated and *deprived* of its *red colouring matter* in *another*; and in a *third*, converted into a mass of *solid fibrine*, containing in its centre a small *nodule of tuberculous matter*. It also sometimes happens that blood is effused in consequence of the rupture of some of the cells of the spleen, and an opportunity afforded of witnessing its successive or simultaneous conversion into fibrine and *tuberculous matter*."*

* Cyclopædia of Practical Medicine, Art. Tubercle.

From the above it must be evident that in phthisis a peculiar constitution of the blood prevails, which disposes it—for tubercle has not yet been discovered *integrated* in this fluid—to tubercular *integration*. Unless this be allowed, it would be almost impossible to account for tubercles. When we examine the chemical constitution of tubercle, we find it consisting of the elementary constituents of the blood itself. The analyses of MM. Hecht and Thenard, present us with the following results. Six grammes of firm tuberculous matter were found by M. Hecht to afford the following principles, and in the following proportions:—

	Grammes & Decigr.
Albumen	1.4
Gelatine	1.2
Fibrine	1.8
Water (or loss) . .	1.6

6

Thenard found one hundred parts of crude pulmonary tubercle to consist of—

Animal matter	98.15
Chloride of sodium . .	} 1.185
Phosphate of lime . .	
Carbonate of lime . .	
Oxide of Iron, a trace	

From the above it would seem that tubercle consists principally of albumen and fibrine, constituents of healthy blood; but it is probable that these, with a small proportion of gelatine, (if we admit such a natural principle,*) are integrated and probably aggregated in some peculiar manner, to admit of their being separated and deposited upon certain tissues,—the serous and mucous for instance, as tubercular matter. We

* According to some, gelatine is not a *natural* proximate principle, but an artificial product, resulting from the action of boiling water upon certain animal tissues. Prout, however, does not seem to acquiesce in this view of the matter.

cannot admit tubercle to originate in a *morbid* action of the secerning vessels of the tuberculated organs, because the tubercles have been observed gradually separating from the blood, and forming into masses. "As a morbid constituent of the blood," Carswell observes, "we can take no cognizance of tuberculous matter, otherwise than through the medium of the secretions, or until the fluid has ceased to circulate. Then it is seen to separate from the other constituents, the serum, fibrine, and colouring matter of the blood, and is distinguished from them by the peculiarity of its physical characters."*

Admitting the correctness of these views, evidently the first indication in the cure of phthisis, is to correct the morbid condition of the blood, by which the separation and localization of tubercular deposit will be arrested, and ultimately wholly prevented. The morbid conditions of the fluids, and more particularly of the blood, are best corrected by medicines, which, from the peculiarity of their action, were at one time named "*alteratives*." Mercury presents us with one of the most powerful and the most efficient of the class. There are some good grounds for believing that mercury has in some few instances effected the cure of phthisis; but the objection to it is, that the ordinary preparations are apt to excite in a frame already highly irritable, and greatly debilitated, mercurial irritation and debility, an effect which would prove most pernicious in its results. The success which attended Sir Astley Cooper's combination of oxymuriate of mercury with tincture of bark in the treatment of scrofulous diseases, induced me many years since to try this mercurial in some cases, apparently of phthisis, and the success greatly exceeded my expectations. I shall reserve all lengthened detail or discussion for a future occasion, and merely state at once the plan which I adopt.

I usually give from the twelfth to the twentieth of a

* Op. citat. *ibid.*

grain of the oxymuriate, with from an eighth to a quarter of a grain of the hydrochlorate of morphia, three or four times in the day. It is best given in distilled water, but the addition of a little diluted hydrochloric acid, will in most cases prevent any decomposition of the oxymuriate, even when combined with some vegetable astringents and certain other decomposing agents. The above is rendered more palatable and agreeable by the addition of a sufficient proportion of syrup of lemons, or of simple oxymel. Tincture, infusion or decoction of bark, sulphate of quinine, &c., may be added to this formula, where a tonic influence is required to develop more fully the alternative agency of the mercurial.

I have, during the last twelve or fourteen years, used the above formula in a very extended public practice; I perhaps may venture to assert, in upwards of five or six thousand pulmonary affections so closely resembling phthisis in all the constitutional symptoms, that the spurious could not be distinguished from the genuine disease, except by calling to our aid the *physical signs* derived from *auscultation*, *percussion*, &c. Many cases of well marked consumption ascertained by the physical signs, and some in the advanced stages of the disease, have yielded to the powers of this treatment, and the patients are at this moment in the enjoyment of excellent health. I therefore have no more hesitation in asserting the curability of consumption, than I should in asserting that of typhus, and if detected at the earliest period of tubercular localization, I should say that phthisis at this stage is more curable than the more exquisite forms of typhus when once fully developed. But perhaps enough has been advanced upon this subject, at least for the present.

With respect to the "modus operandi," I would offer the following, but whether the solution be correct or not, can in no way affect the therapeutical facts.

It is well known that albumen and oxymuriate of mercury act upon each other, a solution of the latter coagulating the former, producing a compound insoluble in water. According to some, the result is an albuminated bichloride of mercury. This compound, though insoluble in water, is soluble in various other reagents; for instance, hydrochlorate of ammonia, diluted hydrochloric acid, the chlorides and iodides of sodium, of potassium, &c., and also in an excess of either constituent — the oxymuriate, or the albumen. Hence then we can easily suppose a disintegrating agency exerted by the oxymuriate of mercury upon tubercles in the blood, the compound being kept in solution by the excess of albumen in the serum, and hence perhaps the alterative effect. If the elementary integration of tubercle take place in the organs of digestion, and that this morbid formation exist in the chyle, the same explanation will, *mutatis mutandis*, equally apply. If, on the other hand, tubercular integration depend upon a morbid action, reduction or disintegration of the effete tissues, and their being poured by the absorbents into the mass of blood in this state, and thus producing a tubercular condition of the vital fluid, it is evident still that the corrective agency of the oxymuriate, allowing such an agency, would still equally extend its influence to this effect, and thus arrest the tubercular deposit.

It is evident, from what has been advanced, that a tubercular condition of the blood seems to be a preliminary to tubercular localization; but in what consists the *efficient* source of this morbid condition, we are still unable to determine; whether it be in the chymifying process performed in the stomach, or in the chylickation in the duodenum, or in the glandular action subsequent to chylickation, or, lastly, whether it results from an imperfect or morbid reduction of the effete tissues, yet the oxymuriate of mercury can equally reach the effect wherever the cause may exist, or whichever it may be.

Two questions next present—Can oxymuriate of mercury remove the operating or efficient cause of the tubercular diathesis? Can it remove the effect, that is, promote the removal of the localized tubercles? Upon these matters, it is difficult to offer even a substantial conjecture;—all that I can say is, that I could adduce several instances in which the complete cure of well marked phthisis could be attributed to no other means, as in fact none others of any known or acknowledged influence were applied. At the same time, I think it will always be adviseable to adopt every other means capable either of alleviating or removing the existing condition, or of correcting the habit. Thus when we have succeeded in altering the state of the blood, we should endeavour to restore all the functions to a state of health, with a view to destroy every possible source of *sanguineous* tuberculation.

Colliquative sweats.—There is no symptom perhaps so harassing, so distressing to the patient, or so debilitating to the whole frame, as those profuse night sweats which prevail in the more advanced stages of phthisis. They are ushered in mostly by an intense febrile exacerbation, which equally harasses and disturbs the patient, and in the remission succeeds a still more harassing and distressing sweating stage. The whole constitutes the “*hectic paroxysm*,” which is universally allowed to prove far more pernicious than even the condition of the lungs upon which it depends. Thus we often find that the secondary effects are frequently more injurious and distressing to the system than the primary diseases upon which they depend. By their reaction too, in the system, they often aggravate and render the primary disease more virulent. I am satisfied that I have seen cases of phthisis in which pulmonary tuberculation had been at a stand still; as it were, dormant, till some nervous excitation, inducing intense hectic, re-excited tubercular action, and hurried on the disease to its final stages. Many of the instances of

what are vulgarly called "galloping consumption," are of this description. Thus I have known, and indeed have at this moment before me, the notes of the case of a female who had all the symptoms of phthisis, confirmed by all the physical signs of tolerably extensive tuberculation of the summit of each lung. Yet the disease remained stationary for a considerable period, not seeming to advance in the slightest degree, and the patient suffering little other inconvenience than dyspnœa, upon any unusual degree of exertion. This patient, however, was dreadfully frightened by a dog being seized with some sort of fit, which rendered its destruction necessary. This unfortunate occurrence threw the whole nervous system into the most intense agitation. Thus she became tremulous, excited and alarmed upon the most trifling occasions;—rapidity of pulse, thirst, and a degree of febrile heat of skin succeeded, with restlessness, anxiety, and loss of appetite. The fever now assumed the character of the most fully formed exquisite hectic, in which the night sweats became profuse, and the debility proportionate. But a remarkable change now began to develope itself in the lungs, the dyspnœa increased, the cough became more severe, the signs of tuberculation extended themselves downwards towards the base, where the respiration became altered, and in a very short time cavernulous respiration became quite distinct in the summit of the right lung, as also in the left, but less distinct;—in fine, this patient died in less than a month. Now I watched this case very attentively, and my observations led to the following conclusions; first,—while the patient enjoyed an undisturbed tranquillity of the nervous system, the tuberculating process seemed completely at a stand still. Secondly—the violent shock to the nervous system, and the permanent agitation which resulted, induced a degree of febrile excitement which speedily terminated in exquisitely formed hectic. An extreme of debility and general

depression succeeded as consequences to the exhausting influences of the profuse sweats which always terminated the paroxysm. The reaction upon the lungs became manifest in the superinduced activity of pulmonary tuberculation, and the speedy excavation of the portions of lung already tuberculated.*

Sir J. Clark, among the varieties of consumption, notices the acute, and the acute febrile consumption. The former he divides into two varieties. In the first he states, "the violence of the disease requires that the remedies should be applied with corresponding activity. These are purely antiphlogistic." "In the second variety of acute phthisis the patient appears to sink rather from feebleness of constitution, than the extent of disease; although in this," continues Sir James, "there is a deception, as the tuberculous disease of the lungs often makes very considerable progress, without being indicated by the usual symptoms; and the patient is far gone in consumption when she is thought to be merely troubled with it"†

Of the acute febrile consumption, the same author observes,—"The nature of the symptoms, and the rapid progress of the disease, scarcely leave a hope of benefit from any mode of treatment. The disease bursts out at once with violence, and its progress is generally such as to bid defiance to all the resources of our art."

Now if well considered, these varieties might be, if not always, at least very often, referred to ordinary phthisis, aggravated by a highly excitable nervous system, and a degree of febrile excitement converted

* The structure of calculi, frequently presenting layers formed unquestionably at distinct and distant periods, unequivocally proves the temporary cessation of the calculous separation, or in other words the operation of the diathesis. I am satisfied that a similar interruption or suspension of the tubercular infiltration, ("le travail de tuberculisation qui s'est emparé des poumons,") takes place occasionally in phthisis; and probably in this way the *intermitting character* assigned to the disease by some may be accounted for.

† On Consumption, &c., p. 391.

into exquisite hectic by the prevailing diathesis, and this reacting upon both the tubercular diathesis and the existing morbid condition of the lungs. Hence we may infer the necessity of checking the hectic symptoms, and especially the profuse and exhausting night sweats. Indeed Sir James Clark himself advocates similar principles. "In this case,"* he says, speaking of the second variety of acute consumption, "a regimen calculated to support the powers of the constitution, and tonic medicines are more strongly indicated, and are attended with more beneficial effects than in the usual forms of the disease. Change of air and a short voyage often produces a good effect in such passive forms of consumption where the patient has sufficient strength to bear the exertion and fatigue necessarily attending such measures."†

The night sweats are the most serious as well as the most influential and pernicious of the hectic category. They therefore claim the first and the most immediate attention of the practitioner. Nothing has been found to exert so powerful an influence in this description of hectic, as Griffith's Mixture; and from this influence it was usually designated "The celebrated Anti-hectic Mixture of Griffith." It is formed essentially by the mutual reaction of sulphate of iron and carbonate of potass upon each other, the result of the decomposition being protocarbonate of iron and sulphate of potass. Dr. Paris attributes its superior efficacy to the iron being first in the state of protoxide, and the carbonate of the protoxide being held partly in solution by an excess of the alkaline carbonate. This mixture has been highly extolled in hectic, in phthisis, in chronic catarrh, &c., and several other diseases resembling phthisis.

But the objections already mentioned, namely—the iron speedily passing to its maximum of oxidation, equally applies to this as to the other formulæ for the preparation of carbonate of iron. Hence this mixture

* Ibid, p. 392.

† Op. citat. p. 392.

soon becomes inert, if not irritating. It would appear that there is no small advantage in the iron being held in solution. Now this can be readily effected by forming a protocarbonate by means of BAKEWELL'S AERATING APPARATUS. A portion of iron put into the receiver, and the aërated water drawn off upon it will convert it into protocarbonate, which will be held in solution by an excess of the carbonic acid. In this case a few hours is necessary to act fully upon the iron ; but when time is an object, and that the small quantity of resulting alkaline sulphate is not objectionable, it may be prepared immediately ; or it may be more quickly formed from the carbonate of potass and sulphate of iron, as in Griffith's Mixture. If the proper proportions of the salts be placed in the receiving flask, and the aërated water admitted, double decomposition equally ensues, and the resulting protocarbonate of iron is held in solution by the large proportion of carbonic acid. The ferro-citrated protocarbonate of iron may be made by substituting aërated lemonade or solution of citric acid for mere aërated water.

I have tried iron prepared by the various processes above described, in several cases of hectic and night sweats originating from other causes as well as phthisis, and I have found it a most effectual remedy, checking both the fever and the sweating, increasing the appetite, restoring the strength, and in fact relieving the patient from his most distressing and harassing sensations. This is not the place for entering more fully upon the subject of phthisis, and I shall therefore defer further detail till another opportunity, when I hope to bring the subject more fully before the profession and the public.

OF TRACTION.

Before quitting the subject of consumption, I feel that I owe it to myself as well as to truth, to offer a few

explanatory observations upon *traction*, a new practice lately proposed by Mr. Cronin for the relief, and even for the cure of some of the degrees of consumption. I understand that some *ultra punctilious* individuals have taken great offence; and have equally misunderstood and censured me. But although some persons do not seem to comprehend the distinction between the support of an individual and the investigation of facts, whether real or imaginary, still it would be quite foreign to my present purpose, to attempt either to enlighten or to convince their understandings. Such I must leave to calmer contemplation and more ripened judgment. The nature of the operation called Traction, would be wholly out of place here, and as the originator himself has given as good a description as it will admit, I shall refer those who seek information to the fountain head itself.

Perhaps some may here ask do I pretend, or do I maintain that traction will cure consumption? I have never asserted, or even professed any such doctrine; but a remedy may greatly assist, though quite inadequate, "*per se*," in effecting the cure of disease. From what I have seen of traction, and I avow I have watched it closely, and indeed investigated it, and that not wholly free from some little scepticism, I think whatever may be the opinion of others, I owe it to justice, and to the public, to avow the truth, and to state the result of my experience. I have performed this operation myself in between two and three hundred instances; I have witnessed its performance in about five times as many more; and I have not seen above half a dozen instances in which it did not afford some relief. I know that there is a marked difference between mere relief and cure; but are we to withhold the means of even temporary relief, and of freeing, though but for a time, from the utmost agony and intensity of suffering, merely because the means in themselves may be incapable of effecting a perfect cure?

Would any considerations justify such doctrines; or are they even the therapeutical principles of the present day? Who hesitates to administer opium to relieve, though only for a time, the pain which it cannot cure?

I am also satisfied there are a number of cases of deranged health,—indeed so trifling, that the health can scarcely be said to be out of order,—that such cases would get well without any treatment whatever, and perhaps more rapidly if left to themselves, than when over-officiously interfered with. Such is not the description of cases upon which my conclusions have been based. I have seen dyspnœa of the most distressing kind relieved almost instantaneously, and this too without being able to form the slightest rational conjecture as to its mode of action. In many cases the *modus operandi* is perfectly obvious. In cases of enlarged abdominal viscera for instance, the mechanical effect of traction will be to draw the viscera down from the diaphragm, and by thus removing the opposition to its free descent, will allow a more complete inflation of the lungs. But in certain forms of dyspnœa, asthma for instance, this solution will not apply, and, therefore, we must of necessity be contented with the mere facts, and await patiently the solution. It is also surprising what relief it affords even in the most extreme cases of phthisis. I could call upon others who have equally with myself witnessed these facts; but perhaps the detail of one out of many instances, may be more satisfactory.

A respectable female, named Clarke, a married woman, with a family, and residing in Aylesbury-street, St. John-street, presented herself, in the utmost state of exhaustion. Although she had come in an omnibus, yet the fatigue of walking only a few yards, so completely exhausted her, that she could scarcely breathe, and was unable to support herself. In this condition she was obliged, immediately on her arrival, to throw herself

breathless into a chair, to prevent her falling. The emaciation was extreme, and the debility excessive. Her cough harassing, expectoration of the phthisical character, febrile heat of skin, with evening exacerbations, and night-sweats. She had suffered from hæmoptoe. Such were the rational signs in this case. A rather hurried physical examination, in consequence of the exhaustion from the slightest exertion, did not fully satisfy me of the exact nature of the case; but left the matter in some doubt. She was subjected to traction, and the result was very surprising. In about a week afterwards I again saw this patient; she could now walk out and back home, a distance altogether exceeding three miles, without either distress or inconvenience. A careful examination upon this occasion, and which she could now endure without inconvenience, discovered cavernulous respiration in the right supra-spinal region, between the clavicle and scapula; in fact, in the summit of the right lung. This patient has been seen by one or two other gentlemen, and was examined by one well versed in the practice of auscultation; yet, upon a cursory examination, the signs of phthisis proved of rather too equivocal a description to justify a decisive conclusion, till I directed his attention to the particular spot just noticed, when he immediately recognized the unequivocal signs of a small cavity. Now, this patient invariably experienced the most decided relief, at least, so far as regards the constitutional symptoms, from traction. For instance, the cough is much less distressing, the expectoration much reduced, no hectic, no night-sweats, no exhaustion upon moderate exertion, and the patient firmly believes in the complete restoration of her health.

Perhaps it may here be enquired, is there any alteration in the anatomical condition of the lung? A day or two since I saw this patient, and found the physical signs much as at first, and yet the patient was cheerful, and expressed to me her conviction, from her own feel-

ings, that she was rapidly approaching to perfect recovery ; a consummation, though devoutly to be wished, still to be left to time for the developement of the result.

I have adduced this case, out of several others equally interesting, because the physical signs are of so decided a character, and so conclusive ; because I have had opportunities of closely watching the case ; because I can refer to the testimony of others as to the facts ; and lastly, because the patient is still accessible to any one interested in such enquiries. I do not assert that this patient has been or will be cured ; but I can assert this, that an existence of misery and suffering has been exchanged for one of comparative ease and comfort, even admitting that its duration may not be in the slightest degree prolonged. And yet, if we consider the effects which misery and suffering by their reaction upon the system, must have in shortening life, it is a legitimate conclusion, that in proportion as the system shall be relieved from such reaction, so in a corresponding ratio will existence even be prolonged.

I trust the facts which I have now detailed will fully exonerate me from the imputation of improper or unworthy motives, in the part which I have taken in these investigations. The more perfect developement of professional resources, and consequently the public advantage, has been my principal object. This I look upon as the chief and the most imperative of professional duties ; and it is always gratifying to me when in the pursuit of this object, I can at the same time secure the esteem and respect of the profession. But if these cannot be preserved, without neglecting,—which may be regarded as equivalent to actually sacrificing—the public good, however I may regret the loss, my sense of the real nature of professional duty and responsibility obliges me to consult the public benefit, whatever sacrifice it may cost myself.

DIGESTIVE ORGANS.

The organs principally engaged are the stomach, duodenum and liver, and not unfrequently in children the mesenteric glands, giving rise to marasmus. One of the most frequent and indeed common occurrences from the diseases of these organs, is dyspepsia or indigestion. This has been divided into three stages by Dr. Philip, namely, the *merely functional* derangement of the organs concerned; inflammatory state of the same parts, and lastly, structural changes induced by the continued advance of disease.

The functional stages often depend upon atony or debility of the organs engaged, and the restoring their due tone is of primary importance in the treatment. A due regulation of the bowels is one of the most essential parts of the treatment; and I know of no means that will effect this with so much ease and comfort to the patient, as the saline aperients dissolved in aërated water or lemonade. I have very lately met with two cases in which *habitual* constipation was completely subdued by these means, what indeed we naturally infer from the known and acknowledged benefit derived in such cases by the use of aperient saline mineral waters. When the liver appears out of order as indicated by the appearance of the evacuations and other appropriate symptoms, an occasional mercurial sometimes becomes necessary. Frequently, however, mercury disagrees. In such cases I can strongly recommend the *oxymuriate*, and I have found it agree, and produce the alterative effects, when no other preparation could be attempted with impunity.

In some cases the mildest aperients induce extreme exhaustion, and leave, after their operation, a most distressing sense of languor and weariness. This is best corrected by tonics, and I believe that the combination of the saline aperient with protocarbonate of iron in solution will often succeed in preventing all these inconveniences.

Even in the inflammatory stages of indigestion, I find that the combination of protocarbonate of iron with the saline aperients, does not irritate nor increase the inflammatory symptoms. Iron is very beneficial in many of the forms of indigestion, and is a very valuable adjunct to several of the tonics and bitters. Thus aërated protocarbonate of iron may be given with sulphate of quina, calumba, and other vegetable tonics with which the salts of iron are not *chemically* incompatible. When quina is indicated, the aërated water presents us with the most efficacious means of administration, for not only is the medicine thus rendered less disagreeable, but from recent observations we have every reason to believe that its powers and virtues are greatly enhanced.

In the inflammatory stage after the application of leeches to the epigastrium, salines with protocarbonate of iron in solution prove highly energetic, and nothing that I know of proves so effectual in relieving that sense of burning in the palms of the hands and soles of the feet, so distressing to the patient, as nitre,* and which may be given with aërated lemonade, with or without protocarbonate of iron in solution, as the circumstances of the case may require.

The observations, with respect to indigestion, when the stomach is the principal seat of the disorder, will equally apply when the duodenum is the part principally involved. The remedies which act more immediately upon the duodenum may be administered with much greater effect in either aërated water or lemonade, as the practitioner may prefer.

Liver.—The liver is subject to inflammatory action or congestion, and consequently to a great number of derangements derived from the above morbid states. It would be quite out of place here, to notice these individually; but it is well known that many persons

* I have been informed that oxalic acid, as already stated, exerts wonderful powers in such cases.

who have been exposed in warm climates to all the causes which powerfully operate in deranging the liver, and suffer severely from the morbid effects of such operation, experience not only great relief, but also most decided advantage from the use of certain mineral waters; such persons may, by means of the Aërating Apparatus, *readily prepare an artificial mineral water of the description required, and which shall be equal in virtue and efficacy to that of the natural spring.* All that will be necessary will be to introduce the salts into the recipient flask and draw off the charge of aërated water or lemonade, and in a few seconds the draught will be ready. These waters, too, are found highly serviceable in every form of dyspepsia, and in many complaints peculiar to the *fairer* sex, and consequently a ready means of imitating the composition and curative virtues of the particular mineral is of paramount importance in practice.

Pyrosis, or Water Brash.—This is a disease in which the patient constantly brings up a large quantity of watery fluid, variously impregnated, from the stomach. Sometimes it is evacuated in very large quantities, and the patient throws up every few minutes three, four, or more ounces of fluid. It proves extremely distressing and annoying, as the unfortunate individual can never trust himself in any society, owing to his unfortunate malady. The evacuated fluid often consists of almost pure water, but frequently it is acidulous from the presence of hydro-chloric and possibly acetic acid. In such cases the alkaline and earthy carbonates, as of soda or magnesia, afford great and often lasting relief. Aërated soda or magnesia water with or without opium, are valuable remedies, and in order to give tone to the stomach, the carbonate of iron should be combined. I lately met with a case of this sort in which large quantities of acidulous fluid were evacuated. The acid was the hydro-chloric, and a mixture of carbonated soda and magnesia, with some carbonate of iron dis-

solved in aërated water never failed to afford great relief. As an adjunct, gum kino and opium should be given in sufficient doses in the intervals. In several instances I found this plan effectual. In a case of an inveterate description which I lately had an opportunity of seeing, the patient had the singular power of ruminating, and could bring up the contents of the stomach into the mouth, at pleasure.

In *scirrhus* of the liver, spleen, pancreas, &c., the appropriate remedies may be often administered more gratefully and not unfrequently with much greater effect in aërated water or lemonade as may appear most advisable.

Icterus or Jaundice.—This is a disease in which the bile, instead of passing off in the natural way, is absorbed, conveyed into the blood and deposited in the skin and superficial tissues, giving a completely yellow tinge. All the secretions and excretions, if we except the fœces, become impregnated with bile.* Hence bile may be detected in the urine, saliva, &c., but the alvine evacuations are white or clay coloured from want of the due admixture with bile. In this disease the vegetable acids have been much celebrated as auxiliaries in the treatment. Hence aërated lemonade, bitartrate of potass, and the other curative agents may be given together, and such combinations will be found useful. The acidulous or carbonated mineral waters have been found to relieve jaundice, which no other mode of treatment could effect. In some cases a chalybeate impregnation has been found extremely beneficial, and I lately met a case which, after having resisted all the usual methods, gradually gave way to an artificial imitation of the Carlsbad water.

Jaundice sometimes depends upon gall-stones, and sometimes upon peculiar organic states of the liver. Some of the mineral waters promise fair in such affections, and on reference to the compositions of these, the practitioner will be at no loss in making his choice.

* For the chemical examination of bilious admixtures, see *Practical Guide to the Urinary Cabinet, &c.*, by the Author.

DISEASES OF THE GENITO-URINARY ORGANS.

PERHAPS there is no order of diseases in which carbonic acid, and its compounds, have been more used, than in that of the urinary system. Alkaline or acidulous remedies seem to be almost invariably indicated. In many cases they seem to act directly upon some one or more of the organs constituting this system; not unfrequently completely changing the characters, sensible, mechanical, and chemical, of these secretions, and often inducing diametrically opposite properties. These effects sometimes result from the direct transmission of the medicinal agent, without the slightest alteration of either its chemical composition or properties. Sometimes the agent undergoes, at least a limited decomposition, and a corresponding change in its chemical constitution; and it frequently happens that upon these changes depend the curative powers ultimately exerted by the remedy. It is evident, therefore, in an order of diseases in which so much is to be effected by carbonated compounds, and in which practitioners trust so much to these agents, that any means of rendering them more agreeable, ought of itself even to be sufficient to claim our attention; but if such means have the additional advantage of enhancing the virtues, and increasing the curative effects upon the system, they make the most powerful appeal to the consideration and judgment, which it is possible to prefer.

Diuresis. — By this term we generally understand a more than natural flow of urine. But this must be permanent or habitual, and at the same time some deviation from the normal conditions of the excretion, to constitute disease. The general properties of the urine are so readily affected by the slightest changes in the ordinary habits — diet, air, exercise, &c., that the true normal conditions admit of a wide range. Thus, immoderate thirst indulged to the full extent will in-

crease the quantity of urine, reduce its specific gravity, and effect an apparent deviation from the normal chemical composition; while, on the other hand, severe exercise in hot sultry weather will greatly diminish the flow, notwithstanding the accompanying thirst should be fully satisfied, increase the specific gravity, and give to the urine a degree of apparent concentration, which would, without these considerations, most unequivocally infer disease. But under the conditions stated, the phenomena in the first case result from the normal activity of the kidneys, relieving the blood of the superfluous water with which it had been inundated: in the second, the skin being excited, deprives the blood of its due proportion of water, while the kidneys, by way of compensation as it were, are satisfied with removing the effete and noxious principles under the form of salines, leaving the blood the almost undisturbed possession of the small remnant of its watery portion. We must, therefore, before we pronounce disease, accurately distinguish between transient or vicarious and positive, and absolute alterations in quality. Diuresis, therefore, will be indicated when the urine holds foreign principles, either dissolved or in mechanical suspension; or some of the natural constituents, but in absolute and considerable excess. It will be advisable to characterize the different forms of diuresis, according to the predominant principles.

Diuresis simplex.^{*}—In this form the watery portion

* The arrangement and nomenclatures here adopted has been taken principally from my own lectures, as published in the Medical Gazette in 1838-39. Those desirous of becoming more intimately acquainted with the chemical composition of both healthy and diseased urine, and the general nature of the natural and morbid urinary principles are referred to that journal, or to Dr. Prout's valuable work. For a general summary and the method of distinguishing and determining the nature and character of morbid urine, the reader may consult the Practical Guide to the Urinary Cabinet, &c.—Knight and Sons, Foster Lane, Cheapside.

is simply increased without any great increase of the other constituents. On the contrary, if not positively, they are often relatively deficient. Sometimes the alkaline principles are in excess, but by no means in a proportion at all corresponding to the excess of the watery fluid. The sp. gr. is generally low, about 1.002, or hardly even that; the urine is passed in excessive quantity; the health is much disordered; there is often insatiable thirst, inordinate appetite, and extreme emaciation. A disease of this kind often attacks weak, lax, delicate children, and who present many of the features of a scrofulous diathesis. Such persons, even though considerably advanced beyond infancy, are apt to void the urine in bed, and to wet their clothes. I lately met with two or three cases of well-grown girls, who could not, by any exertions whatever, control this unfortunate result or concomitant of their peculiar disease.

I have described a disease of a somewhat analogous character affecting children, and producing extreme emaciation, and from the obvious association of this with the errors of the urinary system, I named it the "*Tabes diuretica, or urinary emaciation of children.*"* Hysterical females are frequently affected with diuresis, the urine being pale, watery, and of low specific gravity. It is also frequently associated with spasm, nervous atony, or mental depression.

Diuresis ureosa.—In this form the uresis is always accompanied with an excess of urea, so much so that this principle crystallizes and separates on the addition of nitric acid. The quantity of urine secreted is often not so excessive as to excite much attention, and but little being passed at a time, it is the frequent micturition, that on the whole renders the quantity inordinate. This is often a fore-runner of diabetes, a most formidable disease. The characters which determine this kind of uresis will be found detailed either in my lectures

* Pract. Treat. on Diabetes.

upon urinary diseases, or in the Practical Guide to the Urinary Cabinet.

Uresis chylosa.—The peculiar feature in this species is that the chyle, instead of forming into blood, passes through the kidneys, and is found in the urine. In cases of this sort the liver is often much implicated, as we might infer from the fact that the disease is most prevalent amongst the natives of hot climates, or those persons who have resided for a long period in hot climates.

Uresis serosa.—In this form the serum of the blood seems to be intermixed in the urine. When heated to about 160° Fahr. a dense coagulum immediately forms. Such urine, as has been already observed, prevails after some of the exanthemata. As has been observed by Drs. Bright, Christison, and others, it often appears in dropsical affections, and then indicates a peculiar or granular disease of the kidneys. However, it must be allowed that it does not invariably denote such a condition, and that a serous state of urine sometimes prevails without any peculiar morbid condition of these organs, sufficient at least to account for the phenomena.

Treatment.—It would be foreign to the present purpose to enter at length upon the treatment, because this would involve subjects far beyond the limits prescribed to this essay and its immediate objects. The therapeutics will be found detailed at length in the lectures published in the Medical Gazette, 1838-39, to which I refer. I shall, therefore, merely observe here, that the conditions of the different organs,—more particularly the digestive and excretory—and the state of their functions should be strictly examined, and all errors corrected. This will often require the adoption of means very different both in their nature and effects. In all the derangements which have just been enumerated, as soon as the inflammatory or other opposing symptoms have been subdued or controlled, iron has been found a valuable auxiliary, and

various preparations have been proposed. There can be no doubt that the proto-carbonate would have been preferred, if it could conveniently have been preserved in its pure and active state. Hence it is that patients suffering from these diseases frequently resort to the chalybeate springs, and the benefit they thence often derive is a proof of the superior efficacy of the iron in the lower degree of oxidation.

It frequently happens, however, that circumstances prevent a resort to these springs, and it will prove a great benefit to those afflicted, to have at their disposal the means of imitating these waters, or of preparing and preserving the most effectual of the salts of iron. I have had an opportunity of giving the proto-carbonate of iron in two cases of chylous urine, and with the most decided benefit. In these two cases, after reducing the inflammatory action by venesection, the tincture of the sesquichloride was exhibited, but it mostly proved too stimulating, and did not seem to exert any useful control upon the state of the urine. Having in consequence determined to try the proto-carbonate, this was administered in aerated water, and was found not only to agree well, but completely to control the disease. The chalybeate was given in combination with the "liquor opii sedativus;" and the acetic extract of colchicum in pill night and morning.

The digestive system often seems here to require the use of mercury; but such a state of urine as characterises the diseases under consideration, seems to prohibit entirely any resort to its use. The digestion unquestionably improves, but the urinary phenomena become much aggravated, and the kidneys ultimately seriously engaged. Under these circumstances the practitioner frequently finds himself greatly embarrassed, and in the lectures already alluded to, I suggested chlorine in such cases as a substitute for mercury. During my researches upon the curability of phthisis by oxymuriate of mercury, I observed that this

preparation could be continued for a very long period without inducing that irritation in the system, which principally renders mercurial courses so pernicious. I was induced, therefore, to try the oxymuriate in some of the cases under consideration, and from these trials I have every reason to believe that where a mercurial is indicated in such circumstances, we may fearlessly and confidently resort to the above preparation.

Diuresis Saccharina, or Diabetes.—A saccharine condition of the urine is the characteristic feature in this complaint. The general symptoms are: voracious appetite, insatiable thirst, a dry or viscid mucus adhering to the lips and angles of the mouth, a red sulcated clammy state of tongue, a harsh dry skin, and emaciation more or less considerable; such may lead us to suspect diabetes, more especially if the urine be voided in excessive quantity. But this is not absolutely necessary, as the urine may contain a large proportion of sugar without being sensibly increased in quantity. In the lectures already referred to, I have detailed the history of two cases of this description, and since then I have met with several others of a similar nature. I have now one, the case of a man of about fifty years of age, who some years since had suffered severely from cutaneous affections, and stricture caused as it is supposed by frequent attacks of gonorrhœa. The general symptoms are feverishness, thirst, clammy state of mouth, tongue reddish, dry, deeply sulcated, appetite very good, emaciation if any very trifling; the urine between two and three pints daily, of a pale straw colour, little or no odour, taste saline, and occasionally bitterish, hardly ever sweetish; specific gravity 1032·5; slightly reddened litmus paper. This urine sometimes contains urea in large proportions; at other times this principle is replaced by sugar, which however is never in very large quantity. It also often contains serum, oily matter, and occasionally even blood. Such is an average summary of the characters

of the urine in this case. This patient also suffers at times severely from pulmonic symptoms, closely resembling those of phthisis, and indeed there is strong evidence of the process of pulmonary tuberculation, and which when I first saw him was advancing rapidly; and it was the pulmonary symptoms which first attracted his attention, and caused him to apply for medical assistance.

The most distressing symptoms to the patient arise principally from the irritation in the system, and appear in the febrile heat and insatiable thirst. Nitre in small doses seems to afford the most effectual relief to the first, and some of the mineral waters to the second. With respect to thirst, we should remember, that it is to be allayed or subdued, not to be satisfied. Aërated waters appear to be the best quieters of this thirst, and nitre administered in a moderate quantity of effervescing water, I have found the most effectual remedy against these two distressing symptoms. Emetics in nauseating doses have a powerful effect in allaying thirst,* and the *vinum ipecacuanhæ* in appropriate doses, with or without opium, as the object may or may not be a due activity of the skin, I have found the most effectual means. The nitre, ipecacuanha, and laudanum may be combined in the same formula, and administered in aërated water.

The Hotwells of Bristol and similar waters, especially those of Leamington, have been long celebrated in diabetic cases, and consequently an artificial preparation of them offers to the invalid remedial means, which his circumstances probably could not otherwise attain. With these means regularity of regimen is of the utmost importance; but this does not properly come within the scope of these observations.

Tonics form one of the most essential of our means, and no remedy has attained such universal approval

* See Lectures on the Diseases of the Urinary Organs,—Medical Gazette, 1838-39.

as iron. The great difficulty has been a proper formula, so as to exhibit the mineral at its *minimum* of oxidation. Hence various preparations—and especially the phosphate as more uniform—have been selected. The proto-carbonate surpasses all in value and effect, and as it can now, by means of the aërating apparatus be administered in its most efficient state, it no doubt will supersede most other chalybeate preparations. To insure the fullest possible advantage, the other approved tonics—the citrate and phosphate, for instance, may be given with the aërated proto-carbonate, and the excess of carbonic will hold a portion at least of the phosphate in solution.

Tonics seem to act by invigorating the system generally, and the digestive organs in particular; hence recourse should be had to those which exert these effects in the highest degree. The disulphate of quina, therefore, in the advanced stages, is a most valuable medicine, and may be combined and administered in the same formula with the remedies already noticed. I can state that the means just recommended, although far from promising perfect recovery, will be found, I think, to afford both greater and more permanent relief than any other with which I am acquainted.

Calculi. — Calculi generally form in the kidneys, where they form a nucleus, upon which, when passed into the bladder, more calculous matter continues to be deposited, and their gradual enlargement is thus effected. Calculi, however, in different cases, consist of very different materials, at least chemically considered, and hence require the treatment to be adjusted to their chemical composition. The calculous phenomena originate in a peculiar condition of system, named “calculous diathesis,” and consequently the means of correcting this diathesis, and obviating its effects, present the true principles of treatment. In a therapeutical point of view, these diatheses may be

considered under the following heads:—the lithic, the oxalic, the carbonic, the phosphatic, the cystic, the xanthic, and the fibrinous diatheses. We shall therefore proceed to consider these diatheses in order.

Lithic Acid.—These series comprehend not only pure or free lithic acid, but also the compounds of this acid with the bases, both alkaline and earthy. The alkalies and alkaline-earths, seem to be the appropriate remedies; but of these, potass and magnesia are in most repute. Caustic potass cannot be used in a sufficient dose, and the carbonated alkali is found to answer equally well. Indeed, the alkaline salts constituted with an organic acid are found to answer very well, as they are converted *in transitu* into carbonates. The bicarbonate of potass in sufficient quantity may be put into the pressure flask, and the aërated water drawn upon it, when the draught will be ready. The dose may be from five grains to half a drachm, or even a drachm. Even liquor, or solution of caustic potass may be used, as the large excess of carbonic acid will counteract the irritating effects of the alkali, and will also hold the phosphates in solution, the deposition of which the alkali might otherwise favour. We may also give in conjunction with the bicarbonate, the citrate of potass; or if a larger proportion of the bicarbonate be taken, by using aërated lemonade, instead of aërated water, as the vehicle or solvent, citrate will be formed.

Purgatives frequently form an essential part of the treatment, and for this purpose nothing seems superior to the tartrate of potass, or the potassio-tartrate of soda, and they may be conjoined with the other ingredients in the aërated vehicle. Much however of the good effects appear to be owing to the diuretic rather than the chemical agencies of these remedies; and as purging controls, and to a certain extent suppresses the diuretic action, this should be excited or promoted by the addition of turpentine, juniper, &c.

Magnesia has been found very effectual, and, on account of its milder causticity, and the great solubility of the lithate of magnesia, in many instances preferable to potass. It may be given in aërated lemonade as already proposed, either with or without the diuretics, according to the particular circumstances.

Soda forms with lithic acid, those gouty concretions named chalkstones, consequently it does not seem so well adapted to the lithic acid diathesis; and hence perhaps "soda-water" is not quite so applicable to these cases as seems to be the prevailing opinion; and even calculous concretions of this description are to be met with. However, it has been very satisfactorily determined, that the bi-borate of soda is capable of dissolving lithic acid in large proportion. This salt, therefore, may be given in aërated water, and I think I can venture to assert, that in this way it will be found to answer very well. I have adopted this plan lately in one or two cases of crystallised gravel, and I am inclined to believe, with marked success; nor need this prevent our having, occasionally, recourse to the potass. The compounds of lithic may be treated much upon similar principles. Indeed, lithate of ammonia, by far the most frequent, is soluble in the alkaline carbonates, a double decomposition being effected, a carbonate of ammonia and a lithate of *the alkali* resulting; and indeed this solubility in the alkaline carbonates distinguishes the lithate of ammonia from the pure lithic acid.

With the above, an occasional diuretic proves eminently serviceable; such as infusions or decoctions of the wild carrot; the alchemilla arvensis, or parsley, break stone, and the pyrola or winter green, to which we may add parsley, mint, nasturtions, capers, asparagus, parsnips, carrot, horseradish, onion, &c. These act both as diuretics, and possibly much more energetically by their diluent effects when taken as infusions or decoctions.

Oxalate of Lime.—In this diathesis there seems to be no little difficulty. Acids that will hold oxalate of lime in solution in the requisite doses, cause the separation of the lithic acid. It seems highly probable that the carbonated alkalies, especially potass, exert a solvent power, but their solvent action should not be reduced. The solvent powers seem to depend upon a chemical decomposition, causing a mutual interchange of principles, whence result carbonate of lime and oxalate of potass. The carbonate of lime is insoluble, but in excess of carbonic acid even the earthy carbonate is soluble. But I have some grounds for believing that even the oxalate of lime itself is to a certain extent soluble in a large proportion of carbonic acid, and this solubility may be still further effected by conjoining the hydrochloric or nitric acid—matters really requiring no further comment.

Carbonic Acid, combined in neutral proportions with lime, has been found, but very rarely, aggregated into calculous masses. It need scarcely be observed that the mineral acids—the hydrochloric and the nitric, and even the carbonic itself in excess, present the proper solvents of this species. The mode of employing them has already been sufficiently explained.

Phosphatic.—This diathesis comprehends those in which the earthy bases—lime and magnesia, the latter with ammonia, either separately or mixed, united to phosphoric acid—form the urinary concretions. These are dissolved by the mineral acids, and the diathesis is also counteracted by the vegetable acids, especially the citric. These concretions are also dissolved by carbonic acid in considerable excess. The mineral acids, the hydrochloric and nitric, readily dissolve these calculi; but they produce when long continued, great irritation. Hence the citric acid has been occasionally substituted, but even this cannot be always endured to the necessary extent. Carbonic acid is free from these objections. “It has been found, however, that water

impregnated with it, (the carbonic acid) taken as a common beverage, diminishes the earthy phosphates, particularly the phosphate of ammonia and magnesia, rendering the urine transparent, which before had been turbid. Where it does so far succeed, it must be preferable to any of the other acids, both as being less likely to cause any separation of uric (lithic) acid, and as having the advantage that it can be taken for any length of time, without any reluctance, has no injurious effect on the stomach, and admits of being used in that *irritable state* of the bladder which sometimes precludes the use of the others." *

In the *phosphatic* diathesis, especially when the mixed phosphates† abound, the urine is mostly neutral, and sometimes even becomes alkaline before it is voided. The bladder itself becomes highly irritable, and this morbid sensibility becomes much aggravated by the alkaline state of the urine. In such cases nothing affords greater relief than restoring the urine as nearly as possible to its normal state. For this purpose, perhaps, nothing is preferable to the phosphoric acid administered in water, strongly impregnated with carbonic acid. They both tend to acidulate the urine; and to them we may add the hydrochloric, as lately done by myself with full effect.‡

It is often difficult, however, to render the urine in such cases acidulous, and here perhaps it is of the utmost importance. The benzoic acid has been strongly recommended by Mr. Ure; which, according to him, is converted into the hippuric acid. In consequence of these views the benzoic acid was given in the two instances referred to below, and the result may be learned by a reference to the cases. In one of these a crust was since extracted from the urethra, rather

* Murray's *Materia Medica*, Art. *Lithontriptics*, p. 368.

† The ammonio-phosphate of magnesia with phosphate of lime.

‡ See *Observations on Therapeutical Fallacies*, with two cases published by me in the *Med. Gazette* of June 16th, 1843.

concave on one side, and slightly convex on the opposite surface, somewhat resembling a layer detached from a calculus. It consists principally of triple phosphate, and possibly, being but thinly and very recently deposited, may have been detached by the action of the remedies.

Cystic.—This, the xanthic, and the other diatheses require but little remark here. In the cystic diathesis, acids or alkalies may be indicated, but the rarity of these affections naturally precludes observations in this place.

Solvents of stone in the bladder.—It has been proposed to attempt the solution of stone in the bladder, by the injection of solvents into the organ itself. The attempt has been made, and, as it appears, with success by Sir Benjamin Brodie. I must confess that I at one time entertained great doubts as to the safety of the attempt. However, subsequent experience has in a considerable degree modified my apprehensions. I some time ago attempted the solution of lithic acid in the bladder, by a warm solution of the bi-borate of soda, and by this means, and the exhibition of the proper remedies internally, the calculus^a seemed to be broken up, and considerable fragments passed with the urine. I have, however, had but one opportunity of trying injection in the lithic acid concretion. In the phosphatic diathesis I have met with five opportunities. The injection consisted of distilled water saturated with carbonic acid, retained without artificial pressure, with occasionally a small proportion of diluted phosphoric or hydrochloric acid. To be in any degree effectual, it requires a long perseverance and continued application; and, assisted by the judicious use of suitable remedies internally, I believe much may be done towards effecting the breaking up of some stones, especially if the circumstances be favourable to the disintegration, and an operation perhaps ultimately

rendered unnecessary.* Carbonic acid is a very useful addition to the injection, because it is tolerable to an irritable bladder, and exerts a considerable solvent power.

Cystirrhœa, or catarrhus vesicæ.—This consists in a diseased action of the mucous lining of the bladder, whereby a large proportion of mucus, sometimes intermixed with pus, and of a very viscid description, is secreted. It sometimes prevents the discharge of urine, and if a catheter be introduced, the eyes become so clogged up that the urine cannot pass. In such cases, especially if at all severe, the urine becomes alkaline (ammoniacal) even in the bladder, causing the greatest agony and distress. Acids, and the phosphoric particularly, dissolve the mucus and counteract its viscosity. The carbonic likewise exerts a similar power; and an injection of phosphoric acid, in conjunction with aërated distilled water, I have seen produce the happiest effects in several instances. These acids also should be administered internally, with the infusions of Pareira brava, Diosma crenata or buchu, alchemilla arvensis, uva ursi, &c.

When the violence of the disease has been subdued, then a tonic is indicated, and a chalybeate has always appeared to me the preferable description. The proto-carbonate of iron, prepared as already proposed by means of BAKEWELL'S AERATING APPARATUS, is unquestionably superior to every other form.† It exists, as already observed, in the state of a proto-salt; the most efficient, and at the same time the least irritating of the compounds of iron; and being held in solution by the excess of carbonic acid, is administered under

* The reader is referred to my lectures for more ample information, Medical Gazette, August, 1839.

† The citrate of iron, which appears to be one of the best of the ferruginous preparations, I find, is a citrate of peroxide, or more properly sesquioxide. Prepared, however, by aërated lemonade, and exhibited as previously suggested, this remark will not hold good.

circumstances best adapted for the exertion of its full effects upon the system.

Spasm of the Sphincter vesicæ.—This sometimes gives rise to retention of urine, the spasmodic contraction of the sphincter preventing all egress from the bladder. In cases of this sort the tinctura ferri sesquichloridi of the London Pharmacopœia, it is said, acts almost like a charm. I have found the addition of a little of the liquor opii sedativus, with ether, a highly useful adjunct. I have had no opportunity of trying the aërated solution of proto-carbonate of iron, but I am satisfied from analogy that it would prove no less efficacious. It, at least, offers a useful and agreeable vehicle for the exhibition of the tincture of sesquichloride.

Incontinence of urine.—This may arise from several causes, and proves very distressing, the urine constantly passing off from the bladder, the patient frequently unconscious and almost always an involuntary agent. It prevails mostly in early life, and again in advanced age. I have lately seen several cases in young girls, one in particular, in which it was attributed to idle habits, and the patient severely punished. The urine is generally unnatural.

In a disease depending upon so many and such various causes, no fixed principles of treatment will apply. The causes, however, being subdued, tonics are indicated, and none appears so suitable as iron. The aërated solution, therefore, of the proto-carbonate may be given in suitable doses, and unless depending upon some irremediable organic disease, this affection will be ultimately subdued.

There are many other affections of the genito-urinary system to which these observations might be extended, and the principles of therapeutics deduced. But as many of them are merely concomitants depending upon some of the foregoing affections, as their causes, the therapeutics will be readily inferred from

what has been already stated. It may, however, be observed, that there is no one system in the human frame, to the diseases of which, carbonic acid and its factitious compounds are more suited, as curative agents, than those of the genito-urinary system; and, indeed, there are none of these in which carbonic acid in some form or other, whether simply or combined, may not be administered with the utmost advantage.

APPENDIX.

HAVING in the preceding parts of this essay enumerated the principal applications and uses of carbonic acid, it only remains to notice a few combinations, and the mode of administering them. As much of the matter has been already stated, it will hardly be necessary in this place to devote much space to the subject. The preparation of aërated water, or aërated lemonade, must be already sufficiently understood. To prepare soda-water, all that is necessary is to dissolve the requisite quantity of sesquicarbonate of soda, in a gallon of water, and introduce the solution into the aërating portion of the apparatus, and when thoroughly impregnated it may be drawn off as required. But when soda-water is only occasionally required, then water only should be introduced into the aëerator, and impregnated with carbonic acid. From three to ten, or even twenty grains of sesquicarbonate of soda introduced into the pressure flask, and this attached, when the aërated water has been drawn off, an effervescing draught of soda of the corresponding strength will be ready. For the above, either simple water aërated, or aërated lemonade, as may be preferred, can be used. In any of the above, a raspberry, strawberry, or lemon ice, or even a piece of common ice, presents the means of making a highly grateful and luxuriant beverage, especially in the hot summer months.

When the object is a pure, simple, or unmixed chalybeate, the best mode of preparing it, is to place a coil of iron wire in the bottle, and draw off the aërated water into the flask, and then detach and

invert it : in a few hours an active chalybeate, consisting of *proto-carbonate* of iron, held in solution by a large excess of carbonic acid, will be generated ; nor will this have the disagreeable taste which mostly belongs to chalybeates, as it will be entirely masked by the effervescing state of the solution. If aërated lemonade be used, an effervescing ferrocitrated proto-carbonate of iron, all in solution, will be obtained.

If the impregnation with an alkaline sulphate be no objection, we may use any of the following :—

R Potassæ carbonatis, gr. viij
Ferri protosulph. gr. v. M.

R Potass. bicarb. gr. xij
Ferri sulph. gr. v. M.

R Sodæ carbonat. (exsiccat.)
Ferri sulph.—ā ā gr. v. M.

R Sodæ bicarbonat. gr. viij
Ferri sulph. gr. iij. M.

Any of the above* or any portion of them may be introduced into the flask, and the aërated water, lemonade, &c. drawn upon them, and the chalybeate is instantly prepared and ready for immediate use.

NARCOTICS.

R Tinct. hyoscyami, ℥x—5℥
Aquæ aërat. 5viij. M. Ft. haust.

R Liquor opii sedativ. ℥x—xx
vel
Acetat. morphinæ, gr. $\frac{1}{8}$ — $\frac{1}{2}$
Acet. distillat. ℥iij
Aquæ aërat. 5viij. M. Ft. haust.

* The proportions of course may be varied according to circumstances ; as above, the alkali is in excess, which ensures the complete decomposition of the sulphate.

- R Liq. opii sed. ℥ x
 Syrupi papav. f ʒij
 Spir. cinnamom. f ʒj
 Aquæ aërat. ʒviij. M.
- R Tinct. camph. c. ʒij
 Syrupi papav. ʒj
 Liq. opii sed. ℥ vj
 Tinct. hyoscy. ʒj
 Aquæ aërat. ʒviij. M.

ANTISPASMODICS.

- R Tinct. castorei, ʒj
 Æth. sulph. ℥ xij
 Liq. opii sed. ℥ vj
 Aquæ aërat.
- R Tinct. opii, ℥ x
 Vin. ipecac. ʒss
 Syrup. simp. ʒiij vel. ʒss
 Sodæ carbonatis. ʒj
 Aquæ aërat. ʒviij.

TONICS.

- R Ferri citratis, gr. x
 Quinæ sulph. gr. v
 Aquæ aërat. ʒviij.
- R Ferri citratis, gr. iij
 Ferri gr. iij
 Quinæ sulph. gr. vj
 Aquæ limon. aërat. ʒviij.

TONIC.

Cathartics and Aperients.

- R Magnesiae sulph.
 Sodæ sulph.—utriusq. ʒss
 Ferri sulph. gr. v
 Sodæ carbonat. gr. x
 Aquæ aërat. ʒviij.

- R Sodæ tart. ʒij
 ——— carbonat. ʒj
 Aquæ aërat. ʒviij.
 Diuretic and Cathart.
- R Sodæ carbonatis. ʒij
 Ferri sulphatis, gr. iij
 Magnesiae carbon. ʒj
 Acid. sulph. dil. f ʒx
 Aquæ aërat. ʒviij. Ft. haust.
- R Potassæ bitart. ʒij
 ——— nitratis, gr. vj
 Ferri protocarb.
 Aquæ aërat. ʒviij.

DIURETICS.

- R Potassæ nitrat. gr. x
 Spir. junip. c. ʒfs
 ——— Æth. sulph. ʒj
 Aquæ aërat. ʒviij.
- R Potassæ acetatis, ʒj
 Vin. colchici. m x
 Spir. junip. c. ʒfs
 Aquæ aërat. ʒviij.

REFRIGERANTS.

- Sumat Potassæ nit. gr. xv
 ex Aquæ aërat. ʒviij.
- R Liquor ammon. acet. ʒfs
 eodem modo adhibeatur.

ANTILITHICS.

Lithic Acid Diathesis.

- R Sodæ carbon. gr. x
 Magnes. carb. gr. xv
 Aquæ aërat. ʒviij.

R Sodæ boratis. gr. viij
 Sodæ carb. gr. x
 Aquæ aërat.

R Potassæ carbon. gr. xv
 Sodæ potassio-tart. ʒiij
 Aquæ aërat. ʒviij.

Phosphatic Diathesis.

R Acid. hydrochlor. dil. ʒß—ʒj
 Aquæ aërat. ʒviij.

R Acid Benzoic. gr. x
 Adhibeatur vel per se aut
 ex Aquæ aërat. ʒviij.

R Acid. phosph. dil.
 Acid. hydrochlor. dil.—ā ā ʒß
 Aquæ aërat. ʒviij
 Liquor opii sedativ. ℥ iij. Ft. haustus
 ter 4 quaterve in die.
 In the oxalate of lime diathesis.

Formulæ might be introduced in almost endless variety, but quite enough has been stated to illustrate the uses to which the AERATING APPARATUS may be applied.

In the table giving the analyses of some of the most celebrated Mineral Waters, the views of Dr. Murray have been adopted. The quantities of the components are those contained in a wine gallon of water, or 58,327 grains troy, of pure water at 60. It was intended to adjust the quantities, or rather to reduce those specified to the ratio of a half-pint; but the first attempt satisfied me, that it would only serve to confuse, without the slightest practical utility. If a mineral water be the object, the requisite proportions of each principle for a gallon should be obtained, and

when all mixed,* introduced into the water in the aëerator, when the carbonic acid gas may be disengaged. But if the apparatus is to be applied to other purposes, then the sum of the constituents may be divided into sixteen equal parts, one of which introduced into the flask, and the aërated water drawn off, will give an exact imitation of half-a-pint of the mineral water. Sulphureous and carburetted waters may readily be imitated, by impregnating the factitious waters, already charged with the other principles, with the sulphuretted, carburetted and nitrogen gasses. The means, however, though sufficiently simple, and easy of accomplishment, do not properly fall within the scope of this essay.

I have now endeavoured, after much attentive consideration, and careful experiment, to suggest the various uses to which the AERATING APPARATUS may be applied. It is not, perhaps, that these objects have been hitherto absolutely unattainable, but their accomplishment was attended with so much difficulty and inconvenience, that their attainment even would hardly compensate the trouble and inconvenience. I trust, therefore, that whoever will attentively consider the matters stated in this essay, will be satisfied that the maxim of Asclepiades, that we “safely, quickly, and agreeably cure,” if not completely attainable, yet will admit of much nearer approach.

* When sulphate of iron is used, it should not be made up with the other principles, lest it peroxidize. The best plan is to introduce a small coil of iron wire, which will soon be acted on.



ANALYTICAL TABLE OF THE PRINCIPAL MINERAL WATERS.

WATERS.	CUBIC IN. OF GASES.				CARBONATES OF			SULPHATES OF			CHLORIDES OF				Oxide of Iron.	Silica.	Temp. Fahr.
	Carbonic Acid.	Sulphur. Hydrogen.	Carbur. Hydrogen.	Nitrogen.	Soda.	Magnesia.	Lime.	Soda.	Magnesia.	Lime.	Sodium.	Magnesium.	Calcium.				
Carbonated.	138	..	..	..	109.34	..	..	..	..	..	54.03	45.7	26.9	..	..	Cold.	
	208	..	..	..	11.5	80	34.8	14.9	44.5	54.5	..	..	11.6	4.5	..	Cold.	
	104	..	..	..	12.93	35.3	10.6	..	..	..	..	..	1.3	4.5	..	Cold.	
	40	..	..	..	51.96	..	..	70	..	..	20.2	..	13.44	0.12	2.5	165°	
Sulphureous.	4.25	14	4.15	8	12.8	..	..	..	..	..	752	29.2	65.75	..	..	Cold.	
	5.25	6.4	4.65	6.5	14.75	..	..	..	..	..	735	43	71.5	..	..	Cold.	
	..	44	..	..	37	..	3.3	..	..	..	231.5	32	37.3	2.4	..	143°	
	12	20	..	..	..	..	..	254.2	..	..	120	26.4	7.9	63.68	Trace.	Cold.	
Saline.	9.6	..	..	..	..	..	3.2	263.7	..	..	280.2	70.4	29.6	Trace	..	116°	
	1.5	..	..	4.6	1.62	..	8.9	62.64	..	..	430	161.3	229.1	..	..	82°	
	28	..	..	..	..	..	12	44.4	..	..	280.2	70.4	29.6	..	..	74°	
	..	..	..	..	..	..	4	0.63	..	5.76	..	8	2.25	..	..	Cold.	
Chalybeate.	8	..	..	..	..	..	4	18.6	..	..	168	..	166.5	1.36	..	Cold.	
	..	..	..	..	..	..	4	29.6	..	..	101.6	..	161.6	..	..	Cold.	
	..	..	..	..	..	..	..	7.2	..	..	..	..	..	..	..	Cold.	
	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Cold.	
Chalybeate.	..	..	..	..	8.26	..	..	1.97	..	..	289.5	10.8	31	2.4	0.4	Cold.	
	..	..	..	..	0.29	..	..	1.5	..	..	0.9	0.3	1.85	2.22	0.4	Cold.	
	..	..	..	..	..	..	..	14.68	..	18.8	..	6	11.4	[+]	1.12	Cold.	
	..	..	..	..	4	..	..	260.4	..	..	264	38.4	16.5	6.4	..	Cold.	

* Quantity not ascertained.

† The iron exists as sulphate in the proportion of 1.4 to the gallon.

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