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CAR. I. TABORIS.

THE PHYSIOLOGY & THERAPEUTICS OF THE HARROGATE WATERS

THE PHYSIOLOGY & THERAPEUTICS OF THE HARROGATE WATERS, BATHS AND CLIMATE APPLIED TO THE TREATMENT OF CHRONIC DISEASE

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PREFACE

In submitting this work to the Medical Profession our aim has been to supply evidence showing that the therapeutics of the local waters and baths rests on a secure foundation, comparable to that of drug therapeutics. We have collected the data bearing on the subject and have exercised care in excluding matter that is not supported by experimental research or clinical experience.

The Waters, Baths, and Climate are dealt with in separate sections, and the method adopted is uniform throughout. Firstly, remarks are made on the general principles involved; secondly, the physiological action is discussed; and thirdly, the therapeutic application. Finally, a section is included on the Spa treatment of chronic disease, which, it is hoped, will serve as a guide to medical men sending patients to a health resort.

We have pleasure in expressing our obligations to Professor Brodie for helpful suggestions regarding the introduction, and to Dr. Biernacki for valuable criticism of the manuscript.

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SECTION I

THE PHARMACOLOGY AND THERAPEUTICS OF THE NATURAL MINERAL WATERS

INTRODUCTORY

A DESCRIPTION of the nature, pharmacology, and therapeutics of the waters used internally, may be prefaced by a few remarks on the action of mineral waters generally. In this direction our knowledge is far from complete—indeed, quite fragmentary—and what follows is intended merely to mark the lines along which further research will, in our opinion, enable us in time to arrive at a true conception of the processes taking place in the absorption and utilisation of such complex saline solutions as the natural mineral waters.

Water.—Exclusive of the mineral content, the quantity and absorption of the water taken must first be considered. Patients undergoing Spa treatment are frequently advised to drink a pint or more of some mineral water before breakfast, and often a similar quantity during the day. Under ordinary conditions of life the average intake of water is about 2·5 litres, or 4½ pints. The quantity excreted is somewhat in excess of this, as a small portion is formed in the body by the oxidation of hydrogen. The channels of elimination are the kidneys, skin, lungs, and bowel. Formerly it was believed that a large part of the water ingested was absorbed from the stomach, but this belief has proved erroneous. Von Mering[1] has shown that absorption of water is not a function of the stomach, and it is safe to assume that if any is absorbed the quantity is infinitesimal. His first set of experiments consisted in cutting across the duodenum close to the pylorus and sewing each end to the skin. In this way he obtained two fistulæ, the upper one communicating with the pylorus, the lower with the intestines. After the dog recovered from the operation, water was given on various occasions, and it was found to be ejected from the stomach in gushes of two to six a minute, the quantity expelled each time varying from 2 to 15 c.c. In less than half-an-hour all the water taken by the mouth escaped in this way. Curiously, the water did not quench the dog's thirst; on the contrary, the thirst was aggravated by the administration of fluid. As the dogs only survived the operation for a brief period, von Mering devised a second series of experiments, by which the observations stated were corroborated and extended. In these he first sutured the duodenum to the abdominal wound, including in the sutures the parietal peritoneum. Three days afterwards he incised the wall of the duodenum down to the mucous membrane. Finally the mucous membrane was cut through and a fistula was established. During each experiment he inserted into the lower part of the fistula a caoutchouc bag distended with water to prevent any fluid gaining access to the lower bowel. In one experiment 500 c.c. of water was given to a large dog, and in twenty minutes 400 c.c. were expelled; in another similar experiment 490 c.c. were ejected in twenty-five minutes. The experiments further "proved that a state of repletion of

[1] *Ueber die Function des Magens.* Wiesbaden, 1893.

the small intestine reflexly slows the evacuation of the stomach, and that psychical excitement also inhibits its evacuation."[1]

J. S. Edkins,[2] working independently of von Mering, came to the same conclusion regarding the non-absorption of water by the stomach, but his experiments are not so convincing.

Water is absorbed by the intestine, chiefly the small intestine. Heidenhain[3] has shown that the greater part of the water is taken up by the capillaries of the villi, and not by the lacteals. Even after the absorption of an excessive amount of water the composition of the blood is stated to be little altered.

Several writers assert that warm water is absorbed more readily than cold, and that the secretions, such as the gastric and pancreatic juices, are increased by an excess of water. Experimental proof of these statements is lacking.

Water acts beneficially by flushing out the tissues, and thereby facilitating the removal of waste products. It probably aids the action of the bowels, although very large quantities have been known to produce constipation. Physiologically, it would be better if fluids were taken half-an-hour before meals instead of with them.

Mineral Substances in Solution.—The Harrogate waters consist of an aqueous solution of various mineral substances, of which the most abundant is sodium chloride.

In the Old Sulphur Well this salt amounts to as much as 1·25 per cent. The physiological action of the waters depends largely upon the presence of these salts,

[1] Gamgee, "Physiological Chemistry of the Animal Body," vol. ii.
[2] *Journal of Physiology*, 1892. [3] *Arch. f. d. ges. Physiol.* Bonn, 1888

and it is consequently desirable to consider briefly what is known as to the state in which salts exist in aqueous solution. For this purpose it is necessary to enter somewhat minutely into the physico-chemical properties of salts dissolved in water, and we shall assume that our readers have no special knowledge of the subject.

Electrolysis.—What is known at present, and the theories that have been advanced to explain the experimental facts, are based, in the first place, on the behaviour of solutions of salts when electric currents are passed through them. The passage of a current produces a movement of matter towards the two terminals at which the current is led into and out of the solution, the whole phenomenon being termed electrolysis. Whereas pure water is a very feeble conductor of electricity, its power in this respect being so weak that apparatus of the most delicate nature is required to detect it, as soon as certain substances are dissolved in it a current of electricity can be readily conveyed through the solution. The added substance is commonly termed an electrolyte, though the term is more properly applied to the solution which conducts the electric current. Thus, normal saline solution can conduct a current, and in this instance the electrolyte is chloride of sodium.

The acids, bases, and salts are almost the only substances in solution which exhibit this property. We speak of electrolytes, half-electrolytes, and non-electrolytes, but there is no sharp line differentiating them. The electrolytes comprise nearly all the inorganic salts, strong acids, and bases; the half-electrolytes include the weak acids and bases, such as acetic acid and ammonia; while sugar, serum albumin, and urea are examples of non-electrolytes.

If a battery be connected to two flat platinum electrodes immersed in an aqueous solution of NaCl a current will flow between them, and the solution undergoes certain chemical changes; the sodium travels in the direction of the current and accumulates at the electrode connected to the negative pole of the battery (kathode), while the chlorine accumulates at the opposite electrode (anode). Apparently, therefore, the current has decomposed the sodium chloride into its two constituent elements, which, becoming separated, are carried in opposite directions towards the electrodes. The parts into which the decomposed salt is separated are termed ions; those which travel to the anode are spoken of as anions; those which move to the kathode, as kations. Thus, in our instance, Na is the kation and Cl the anion. But while there is no question that the ions are thus conducted in the two directions, there is much evidence suggesting that the ions already exist as such in the solution before the current is passed, and that all the latter does is to direct the movement of the kations with itself, and the anions against itself. It is conventional to call the electricity which travels with the chlorine negative, and that with the sodium positive. The anions include chlorine, bromine, iodine, fluorine, and the acid radicles, such as SO_4 and NO_3. The kations comprise all the metals and hydrogen.

The view usually accepted as to the state in which an electrolyte exists in solution is that a certain number of its molecules are *dissociated* into their respective ions, the numerical proportion of molecules thus dissociated to those not dissociated varying with different substances and with the concentration of the solution. The more dilute the solution, the greater is the degree of dissociation of its dissolved molecules. Arrhenius was the first to suggest that an electrolyte might be completely dissociated in solution. The theory is now generally accepted that the ions at the moment of separation become negatively and positively charged, and exhibit great freedom of movement. As soon as the ions, owing to the passage of a current, begin to concentrate in the neighbourhood of the electrodes, secondary reactions with the solvent begin to occur. In the case of NaCl the kation Na decomposes the water to form NaOH, setting free another kation, H, which appears as gas on the kathode. At the opposite pole the Cl becomes HCl, setting free O on the anode.

Another example may be given. Suppose the liquid to be a solution of sodium sulphate in water to which some neutral litmus has been added. The current causes the sodions Na_2 and sulphions SO_4 to pass towards the poles, and determines a secondary chemical action by which the sodium combines with the water producing $2NaOH + H_2$. Similarly, the anion SO_4 combines with the water, giving rise to sulphuric acid and oxygen—$SO_4 + H_2O = H_2SO_4 + O$. Thus, shortly after the circuit is completed liberation of oxygen takes place at the anode, where the liquid becomes red (acid reaction), and of hydrogen at the kathode, where the liquid turns blue (alkaline reaction).

Faraday formulated the following laws:—

(1) That the amount of decomposition in the solution is proportional to the amount of current which flows through it; that each gramme of hydrogen liberated corresponds to the passage through the electrolyte of 96·560 coulombs of electricity.[1]

[1] The unit quantity of electricity, viz. that conveyed by a current of one ampère per second, is termed a coulomb.

(2) That the amount of different substances liberated by the same quantity of electricity is in the ratio of their chemical equivalents. If a current is passed through a solution of sulphuric acid, oxygen and hydrogen are evolved at the anode and kathode respectively, and, after the initial subsidiary reactions are complete, are liberated in chemically equivalent proportions, *i.e.* 2 of hydrogen to 16 of oxygen by weight (or 2 volumes of H to 1 volume of O).

Migration of the Ions.—Preconceived ideas might lead to the expectation that the anions and kations would traverse the liquid at the same rate of speed. This is not so. Some ions travel at a greater rate than others. Hydrogen is the fastest of all ions, being the smallest. Hittorf ascertained that, after the ions begin to deposit their charges at the electrodes, there is a change in the concentration of the solution around the electrodes, and from this change he calculated the relative speed of the ions. His experiments show that with a solution of potassium chloride the ratio of the velocity of the anions to the kations was as 51 to 49.

An ion moving through a liquid experiences a considerable resistance, and cannot travel any appreciable distance with constant acceleration. An ion unmolested may reach an electrode and there give up its charge, or it may collide with a molecule, breaking it up into its ions, and after the collision travel onwards to the electrode, or it may re-combine with another ion of the opposite kind. The velocity of an ion depends upon the intensity of the electric current (known also as the potential gradient) driving it. The current density in an electrolyte is the product of three factors: (1) the charge of an ion, (2) the number of ions per cubic centimetre, and (3) the velocity with which the ions are moving. Ohm's law may be stated thus: The current density is proportionate to the potential gradient; and it may be concluded that the ionic velocities are proportional to the potential gradients producing them.

Conductivity of Electrolytes.—Electrolytic conductivity increases as the solution becomes more dilute until a point is reached where all the ions are dissociated, which point corresponds to the maximum conductivity, and is called *molecular conductivity at infinite dilution*. As regards chloride of sodium, the salt is entirely dissociated (ionised) at a dilution of 1 in 10,000.

Molecular conductivity depends upon the number of ions and their rate of speed. Temperature has an important influence on the conductivity of liquids, a rise tending to equalise the mobilities of the ions. When the temperature of the solution is raised, its fluid friction diminishes. Corresponding to this, an increased rate of diffusion and ionic migration occurs.

From the foregoing it will be clear that the quantity of electricity carried to the electrode in a given time depends upon the number of ions in the solution and the speed with which they travel.

Diffusion and Osmosis.—That the molecules of a dissolved substance are in movement within the substance of the solvent is indicated by the process of diffusion. If we take two solutions, one of sodium chloride and the other of magnesium sulphate, and pour the former carefully on the latter so that two layers are formed, the dissolved substances commence to diffuse throughout the liquid until the whole is of equal concentration in its different parts, providing the temperature of the solution is uniform. Acids diffuse about twice as quickly as neutral salts, whereas substances like albumin diffuse slowly. A study of the processes of diffusion, therefore, entails the assumption that the molecules of a dissolved substance are in active movement within the solvent. Hence when they come to the surface of the solvent they may either pierce the surface and leave the liquid, or they may be reflected back again into the mass of the solvent. In the case of solutions of most solids the latter is entirely the case. This being so, it follows that the dissolved molecules must exert a pressure upon the containing surface. This pressure is called the osmotic pressure, and it is essential to remember that it is a pressure exerted upon the surface of the solvent, and not upon the walls of the vessel containing the solution. With the aid of semi-permeable membranes it can be shown that dissolved substances do exert such a pressure. Traube was the first to prepare these precipitation membranes by bringing into contact solutions of certain substances which precipitate each other and form insoluble pellicles or fine films. If a porous earthenware jar be filled with copper sulphate solution and placed in a beaker of potassium ferrocyanide solution, a membranous precipitate of copper ferrocyanide is formed in the pores of the jar. This membrane possesses the peculiar property of permitting water to pass through it, but prevents the passage of particles of dissolved substances, such as sugar or sodium chloride. Hence it is termed a semi-permeable membrane. The use of such a separating membrane supplies a means of directly estimating the pressure due to any dissolved substance.

Thus, if we place a solution of common salt inside such a porous pot and then immerse it in water, it is found that the water passes through the semi-permeable membrane into the salt solution, but no salt passes through into the pure water. If the end of the porous pot be closed by a tube placed vertically it will be found that the water will continue to pass into the solution, which will therefore rise in the tube until it reaches a certain height, at which it will remain constant. This hydrostatic pressure is a measure of the osmotic pressure; in fact, it has been made to balance that pressure. It has been found in such experiments that the height to which the fluid pressure rises is in direct proportion to the concentration of the solution—*i.e.* it is inversely proportional to the volume of the solute—and that, in the second place, the pressure increases uniformly with a rise of temperature. From a quantitative examination of the behaviour of pressures exerted by solutes as the temperature and pressure are varied, it has been shown that pressure, temperature, and volume are all related to one another in a manner exactly analogous to the three same properties of a gas. This highly important generalisation was first made by van't Hoff, who expressed it by saying that a solid in solution behaves as if it were a gas contained within the same volume as is occupied by the liquid. There is yet a further important generalisation which again brings further confirmation of the closeness of the analogy. Thus it is found that if an equal number of molecules of two different substances are dissolved in the same volume of water, the osmotic pressure of the two solutions is the same, this being an exact analogue of Avogadro's law for gases. But when we come to study the osmotic pressures of salts dissolved in water it is found that they do not conform to Avogadro's hypothesis; the pressure is higher than it should be according to calculation. A similar phenomenon is well known to occur with many gases, and these discrepancies are due to the fact that in many gases condensation or dissociation may occur, and that consequently there may be a greater or less number of molecules present—a difference which will account for the lower or higher pressure observed in the two cases respectively. The same line of argument has been applied with great success to explain the anomalies of salt solutions. Thus it is suggested that the osmotic pressure of a solution of sodium chloride is greater than it should be from calculation, because many of the molecules are at once dissociated into sodium and chlorine ions respectively. Each ion is then capable of exerting the same pressure as one molecule of the undissociated salt, and consequently it should be possible to calculate the number of molecules which are dissociated. When this is done it is found that the numbers agree very well with a second determination made by the electrolytic method, a result which in a great measure supports the foregoing hypothesis of the nature of saline solutions.

We can recognise in osmotic pressure the cause of the diffusion of substances in solution. Just as in gases we have movement from places of higher pressure to regions of lower pressure, so in solutions we have movement from places of higher osmotic pressure to regions of lower osmotic pressure.

The method by which osmotic pressure is produced is still a subject of inquiry. Two suggestive possibilities have been advanced: (1) The theory of direct molecular bombardment—that the osmotic pressure is due to the impact of the molecules of the solute on the walls of the membrane, which is impervious to them but permeable to the molecules of the solvent; (2) that the cause of the pressure is the force of chemical affinity between the solute and the solvent, which tends to make the solvent enter the osmotic cell and combine with the solution. These two theories appear antagonistic to each other, but in reality it may be that they both in some unexplained way play a part in the production of osmosis.

Salts of the Blood.—The serum of the blood holds in solution the salts of sodium, potassium, magnesium, and calcium. These are chiefly in the form of chlorides and phosphates, and are in a state of electrolytic dissociation. The preponderating salt is sodium chloride; the potassium salts are sparingly represented. Upon the comparatively large content of chlorine the osmotic pressure of the blood largely depends. The molecular concentration of the serum varies very slightly, a fact which is shown by the constancy of the freezing point. Wide variations in concentration would interfere with the normal activities of the various cells. It has been mentioned that serum albumin is a non-electrolyte. The organic materials of the body do not transmit electricity; it is conducted by the saline constituents of the blood and tissue fluids.

The excretion of sodium chloride in the urine is, in health, quite independent of metabolic functions. It depends entirely upon the amount taken with the food. Sodium chloride has, however, an important bearing upon the absorption of food-stuffs. If the intake be diminished, absorption is defective. It is well known that in cattle impaired nutrition follows a diminished intake of salt. Further reference will be made to the action of this salt in physiological processes under diseases of the blood, stomach, and kidneys.

Whether the salts in solution in natural mineral waters are in a state of more complete dissociation than similar solutions compounded artificially is not definitely known, but it is unlikely that this is the case. The alleged greater activity of natural waters over their corresponding imitations is supposed to be due to this cause.

The preceding considerations may be applied by attempting to picture the processes taking place when a considerable dose of a water such as the Old Sulphur has been ingested.

After its introduction into the stomach little or none of the water is absorbed from the organ. On the contrary, inasmuch as the percentage quantity of sodium chloride it contains (1·25 per cent.) is greater than the amount contained in the blood (·9 per cent.), a determination of water from the blood to the stomach is set up owing to the difference in osmotic pressure between the two fluids. (Sodium chloride being the salt present in largest amount in both, the other salts in solution may be disregarded in so far as they play a part in producing osmosis.) Thus the concentrations of the two fluids tend to become equalised. Now, as has been previously stated, the sodium chloride content of the blood is practically constant; hence, as the withdrawal of fluid tends to increase the concentration, an equivalent quantity of fluid must be taken up by the blood from elsewhere in order to preserve its constancy. This fluid is supplied from the tissues, and its passage to the blood is brought about by changes in osmotic pressure set up in turn between the two. Probably the equalisation of concentration between the fluids is also favoured by the absorption of some of the sodium chloride by the cells of the stomach. These processes take place with some rapidity if the state of the separating membranes be normal, and are accelerated by the active ionisation or dissociation of the salts in the fluid ingested. They are, however, only initiated in the stomach. Periodically, fluid is driven out into the bowel, where similar processes take place to a much greater extent, until the concentration of the fluids is equalised, that is to say, until they are isotonic. Meanwhile the absorption of salts proceeds, each to exert its appropriate action, until the fluid is finally expelled from the body.

Though physical processes, were they completely understood, would in all probability suffice to explain the changes in fluid relations, the absorption of salines is governed by the vital properties of cells, the nature of which action is still obscure. It is impossible to follow minutely the absorption and fate of all the varied constituents present in these mineral waters. The effect of the more active may be traced, a notable instance being barium chloride. Apart, however, from the specific action of absorbed materials on the tissues, it is not difficult to see how the ingestion of mineral waters may produce changes, not only in the alimentary canal, but also in the blood and tissue fluids.

A GENERAL SURVEY OF THE MINERAL WATERS

A striking characteristic of Harrogate is the number and variety of its medicinal springs. It is a very remarkable fact that no less than eighty springs of different chemical constitution should emerge within the compass of a few acres; and it is still more remarkable that waters arising within such a short distance of each other should show such wide differences in character and should maintain their individual compositions approximately constant year after year. Geologically, this is ascribed to the fact that the underlying strata are here tilted to the surface and the springs, arising from unknown depths, gain exit between layers which are impervious.

About sixteen of these waters are used internally, the remainder being devoted to bathing purposes. In their natural state the waters are athermal, but are heated artificially by an ingenious apparatus called a "therma," which has been successfully designed with the object of raising the temperature of the solution without any of its ingredients being deposited. Each water is drawn through a hot and cold tap so that a mixture from the two may be dispensed, the amount from each tap varying according to the temperature required.

Surveying the waters collectively, the first prominent feature is the presence of a saline constituent more or less common to all, though varying within very wide limits in different waters. A second feature next in prominence is the presence, in addition to the salines, of other compounds, either of sulphur or iron, each appearing practically to the exclusion of the other. These characteristics provide a convenient means of classification of the waters into two groups, saline-sulphur and saline-chalybeate respectively, as shown in the following table, in which the subdivision into strong, medium, or mild is determined by the amount of total solids present in each water, the quantities being expressed in grains per gallon.

CLASS I.—SALINE-SULPHUR WATERS

A. Strong . .	1. Old Sulphur Spring (1047 grains).	
	2. Strong Montpellier Well (1002 grains).	
B. Medium .	3. New Sulphur Well (654 grains).	
	4. Mild Montpellier Well (485 grains).	
C. Mild . .	5. No. 36 (292 grains).	
	6. Magnesia Well (280 grains).	
	7. Crescent Saline (149 grains).	
	8. Starbeck Sulphur Well (151 grains)	alkaline waters.
	9. Harlow Car Well (45 grains)	
	10. Beckwith Spring (33 grains)	

CLASS II.—SALINE-CHALYBEATE WATERS

A. Strong . .	11. Kissingen Well (874 grains).
	12. Chloride of Iron Well (465 grains).
	13. Alum Well (394 grains).
B. Medium .	14. Alexandra Well (218 grains).
C. Mild . .	15. John's Well (10 grains).
	16. Tewit Well (10 grains).
	17. Pure Chalybeate (9 grains).

THE SALINE BASE

The salines present consist chiefly of chlorides, carbonates, and sulphates, the chlorides being largely in excess in most of the waters.

Chlorides.—*Sodium chloride* forms the chief ingredient in both Saline-Sulphur and Saline-Chalybeate waters, with few exceptions. It varies in quantity from 1 to 3 grains per gallon in the Mild Chalybeate and Alkaline-Sulphur waters, upwards through progressive amounts in the Medium Sulphur waters, and attains its maximum of 890 grains in the Old Sulphur water.

Potassium chloride is present in but small amount. It occurs in seven out of the ten Sulphur waters, and in four of the Iron waters, and varies from ½ grain in the Harlow Car water to 28 grains in the Magnesia spring.

Magnesium chloride appears in larger quantities in the same waters, and reaches its highest point, 65 grains, in the Kissingen spring. The Magnesia water contains only 1·2 grains, and derives its name from its relatively large content of magnesium carbonate (12·7 grains).

Calcium chloride occurs in five Sulphur waters and two Iron waters, and reaches the considerable amount of 94 grains per gallon in the Chloride of Iron water.

Barium chloride.—This powerful drug is present in at least four of the waters—the Old Sulphur, the Mild Sulphur, the Magnesia, the Chloride of Iron, and probably also in others. It varies from a mere trace up to a maximum of 6·5 grains in the Old Sulphur water.

Strontium chloride appears in minimal quantities in four Sulphur and two Iron waters, the maximum amount being 2·8 grains in the Strong Montpellier. It is probably of little importance therapeutically.

Carbonates.—These are represented by the salts of sodium, calcium, magnesium, and potassium, and occur in much smaller absolute quantities than the chlorides. Sodium carbonate reaches its maximum of 16 grains in the Beckwith water, calcium carbonate 29 grains in the Old Sulphur water, magnesium carbonate 13 grains in the Magnesia water, while potassium carbonate only occurs in minimal quantities not exceeding 2 grains. Relatively to the chlorides the carbonates vary considerably in amount, reaching a much higher proportion in the Starbeck water than in the waters preceding it in the table; in two waters, the Harlow Car and the Beckwith, the total carbonates largely exceed the total chlorides in quantity.

Sulphates.—The sulphates of sodium, calcium, barium, strontium, magnesium, and aluminium are present in small quantities in a few of the waters, and are of negligible importance. In the Crescent saline (sodium sulphate 10 grains) and the Alexandra water (calcium sulphate 9 grains) they appear in larger amounts, but with the exception of the Alum spring, none of the waters contain sulphates in sufficient quantities to render them at all comparable to the sulphated waters of other Spas. The Alum well contains aluminium sulphate 89 grains, calcium sulphate 56 grains, and magnesium sulphate 57 grains, ferrous sulphate 78 grains, ferric sulphate 69 grains, and is therefore a strongly sulphated water. It is remarkable in presenting such a wide difference in composition from any of the other local springs.

Additional Compounds

Sulphur.—Apart from its occasional presence as sulphates, sulphur occurs in the Saline-Sulphur waters in the form of sodium sulphydrate NaHS, sodium sulphide Na_2S, or sulphuretted hydrogen gas H_2S. It appears to be a matter of considerable difficulty to differentiate these satisfactorily and to determine in a given water whether the sulphur compound exists as sulphuretted hydrogen in solution or as sodium sulphydrate. The latter compound is variously named by different analysts, some preferring to designate it sodium hydrosulphide (Fairley). In the Old Sulphur, the Mild Sulphur, the Crescent, and the Beckwith waters, sodium sulphydrate is present, the maximum quantity, 6·8 grains, occurring in the Mild Sulphur. In the Strong Montpellier, Mild Montpellier, No. 36, Magnesia, Starbeck, and Harlow Car waters the sulphur constituent is given by various analysts as sodium sulphide, and varies from 14·5 grains in the Strong Montpellier to ·7 grain in the Magnesia.

Sulphuretted hydrogen is present in the Old Sulphur and Mild Sulphur, and probably also, though not stated in the analyses, in the Strong and Mild Montpellier and the No. 36 waters.

Iron.—This appears in the Saline-Chalybeate waters chiefly as the proto-carbonate, in quantities varying between 1·5 grains in the Mild Iron waters, 5 grains in the Alexandra, 9 grains in the Kissingen, and 11 grains in the Chloride of Iron water. The latter also contains 13 grains per gallon of the proto-chloride of iron, being the only spring in which this salt occurs. Thus its total content of iron salts amounts to the considerable quantity of 24 grains per gallon. In the Alum well, iron occurs in abundance as the proto- and per-sulphate.

THE WATERS CONSIDERED INDIVIDUALLY

It is unnecessary to discuss, except in a general way, the pharmacology and therapeutics of the several constituents of these waters, for, though the action of each salt when given singly may be fairly well understood, it does not follow that the same action takes place when they are given collectively in the complex relationship in which they exist in their natural state.

Even assuming this to be the case, it would be a matter of impossibility to follow the separate effects of the different constituents, to ascertain how far they act in conjunction and how far in opposition to each other, or to indicate precisely to which constituents the *net* effect is to be ascribed.

Each water, therefore, must be considered individually as a compound drug, and its pharmacology and therapeutics stated so far as they have been established empirically or experimentally. In conformity with this plan the detailed analysis is given under each water, together with a more recent skeleton analysis, in order to show the changes that have taken place in some of the waters with the lapse of time.

In the analytical tables the ingredients of the waters are arranged to show at a glance the constitution of the saline base and the additional element. For easier reference, the waters are numbered in accordance with their place in the classification table.

CLASS I.

THE SALINE-SULPHUR WATERS

No. 1. OLD SULPHUR WELL

CHEMICAL ANALYSIS BY THORPE IN 1875

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	1047·561
Saline base—	
Sodium chloride	893·670
Barium chloride	6·566
Strontium chloride	Trace
Calcium chloride	43·635
Magnesium chloride	48·281
Potassium chloride	9·592
Lithium chloride	0·753
Ammonium chloride	1·031
Magnesium bromide	2·283
Magnesium iodide	0·113
Calcium carbonate	29·768
Magnesium carbonate	5·953
Silica	0·701
Sulphur element—	
Sodium sulphydrate	5·215
Sulphuretted hydrogen	10·16
Gases—	
Carbon dioxide	40·10

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1011·18
Total solids	1026·20
Chlorine	614·78
Sulphur	6·54

This is unquestionably the most valuable water Harrogate possesses, and is of great service in many functional and in more definite pathological conditions. Owing to its large content of sulphuretted hydrogen it is not pleasant to drink, and in a few instances it produces nausea.

Pharmacology.—The dose varies from 10 to 24 ounces, and is almost invariably taken in the early morning. The dose is divided into two equal portions, the first being taken an hour before breakfast, and the second twenty minutes later. This mode of administration is adopted with all the waters when taken in large quantities, and need not be referred to again in connection with the pharmacology of the different springs. Some other water having a suppletory action is frequently given during the course of the day.

The warm saline dilates the vessels of the mucous membrane and clears away any mucus from the stomach. A very small portion of the saline material is absorbed from the stomach; the remainder passes into the duodenum and stimulates the intestinal mucous membrane. When fluids containing a moderate percentage of sodium chloride are administered, the salts of the urine are naturally increased, not only those of sodium, but also potassium. Similarly the ingestion of potassium salts increase the excretion of the sodium compounds. This is explained by the fact that there is an interchange of basic and acid components, for when sodium chloride comes into contact with potassium in the blood some potassium chloride is formed, and this being an extrinsic substance is excreted by the kidneys. If potassium carbonate reaches the blood it changes some of the sodium chloride into sodium carbonate, while potassium chloride is formed, but only in small amount, for the blood and tissues hold sodium chloride very tenaciously, and so in effect protect themselves against injury. It will save repetition to state here that these remarks apply to all the saline group.

The Old Sulphur water being hypertonic to the blood attracts fluid from the tissues, and by increasing peristalsis produces a copious and watery evacuation, more fluid being passed by the bowel than is taken by the mouth. It differs from most other aperients in several respects. There is, as a rule, no griping, the patient merely experiencing a sense of slight uneasiness in the abdomen shortly before the bowels are evacuated. Its action may be described as a flushing out of the whole alimentary tract, but in this respect is much milder than that of the cathartic salts. There is also the marked difference between them that patients can take the sulphur water daily for weeks without feeling enervated; on the contrary, most of them feel brighter and more energetic; more especially is this the case after the third or fourth day. This noteworthy result is due to one of its constituents, barium chloride, a drug which has a very marked effect in raising the blood pressure. In this regard it probably ranks next to suprarenal extract, and although the rise in pressure due to barium chloride is not so sharp, it is more sustained. The depressing effect of the saline ingredients is thus counterbalanced by the barium salt.

The beneficial effect of the water in many disorders is undoubtedly due to the daily cleansing of the alimentary canal by the removal of partially digested and irritating fragments of food. It generally acts within two hours of ingestion, and it is necessary to impress upon patients that if it should fail to produce a liquid motion, feelings of oppressive distension, and even nausea, may be experienced. These usually wear off as the water is excreted by the kidneys. In the unusual event of the sulphur water failing to exert its laxative effect, a sufficient quantity of some saline aperient should be added to the first morning draught. The sulphur water improves the appetite, stimulates the gastric functions, and may possibly supply material for the formation of hydrochloric acid. Like the other members of the saline-sulphur group, it is also a diuretic. While taking this water patients frequently complain of thirst during the day, a fact which puzzles them. The explanation of course is, that a certain amount of fluid has been withdrawn from the tissues by the osmotic attraction of the solution during its course through the alimentary canal, and a further loss is occasioned by the diuresis it produces. The slight variations in the osmotic pressure of the blood induced by these factors facilitate the lymph flow, and the resulting interchange of fluid must tend to remove waste products from the tissues.

We have experimented repeatedly with this and other waters to ascertain their influence on metabolism as evidenced by variations in the constituents of the urine.[1] Fixed conditions of diet and exercise were maintained before, during, and after taking the waters, and the

[1] Bain and Edgecombe, "The Physiological Action of certain Mineral Waters and Baths on the Blood and on the Excretion of Urea and Uric Acid," *Journal of Physiology*, 1899.

total urine for the twenty-four hours was collected for examination. The results of these investigations are given under each of the waters concerned.

The administration of the Old Sulphur water causes an increase in the excretion of urea and a diminution in the excretion of uric acid and sulphates, as the following tables show:—

Table I.—*Subject A. Old Sulphur Water.*

Date June.	Uric Acid, grms.	Urea, grms.	Quantity, c.c.	Remarks.	Date June.	Uric Acid, grms.	Urea, grms.	Quantity, c.c.	Remarks.
6	·718	39·4	985		12	·674	36·0	1095	Old S. water.
7	·688	37·8	1305		13	·604	37·0	1365	
8	·541	38·8	1340		14	·563	37·6	1880	
9	·615	35·4	1075		15	·490	37·17	1650	
10	·768	35·1	990		16	·553	37·7	1425	
11	·631	37·0	1000		17	·616	37·18	1430	
Averages before, ·680, 36·94, 1116.					Averages during, ·583, 37·11, 1474.				
					18	·639	37·4	1170	
					19	·718	38·35	1300	
					20	·685	40·6	1160	
					21	·679	38·55	1285	
					Averages after, ·680, 38·73, 1228.				

Table II.—*Normal Subject. Old Sulphur Water.*[1]

Date Sept. 1900.		Quantity, c.c.	Urea, grms.	Sulphates, grms.	Uric Acid, grms.	P_2O_5, grms.	Acidity in terms of Oxalic Acid, grms.
Fixed Diet	16	920	31·74	1·96	·525	2·16	3·24
	17	1750	31·50	1·92	·477	1·97	3·08
	18	1430	29·17	1·85	·496	2·06	2·45
Old Sulph. Water	19	1135	32·12	1·79	·425	1·75	3·05
	20	1280	31·16	1·79	·435	1·79	3·53
	21	1610	30·59	1·76	·476	1·99	3·43

[1] Bain, "Observations on Metabolism during the Administration of certain Harrogate Waters," *Scottish Medical and Surgical Journal*, 1905.

The diminution in the sulphates is unquestionably due to purgation, and in all probability the same explanation holds good for the decrease in uric acid, namely, the removal of its antecedents from the alimentary canal. A supplementary cause may be assigned for this diminution. It has been repeatedly observed that an increased excretion of urine is accompanied by a slight decrease in the excretion of uric acid, though in this case it is insufficient to account for the diminution observed. The increase in urea is only slight; it would probably be greater were it not for the flushing out of the alimentary tract. We have some evidence bearing upon the point that the diminution in the excretion of uric acid and of sulphates is due to the aperient action of the water. Quite recently one of us, while on a fixed diet, was taking this water, and it failed to act on the bowels. During the four days on which the water was taken the uric acid and sulphates were unaffected, but the urea was markedly increased.

The effect of this water on the blood is to produce a considerable fall in the worth of the corpuscle, as the following charts indicate:—

After discontinuing the water the worth gradually returned to normal, attaining its original level in four days.

In Chart 1 the morning observations taken before breakfast alone are recorded. The diminution in the hæmoglobin value of the corpuscle is chiefly due to sulphuretted hydrogen gas. Experimental proof of this statement is furnished by the following test. The sulphuretted hydrogen was got rid of by exposing the water for twenty-four hours in a shallow basin, and then the water was taken in the ordinary way while on a fixed diet. Mr. Frankling was associated with us in this experiment. Unfortunately a portion of the alkaline sulphide was decomposed by the liberation of the

Chart I.

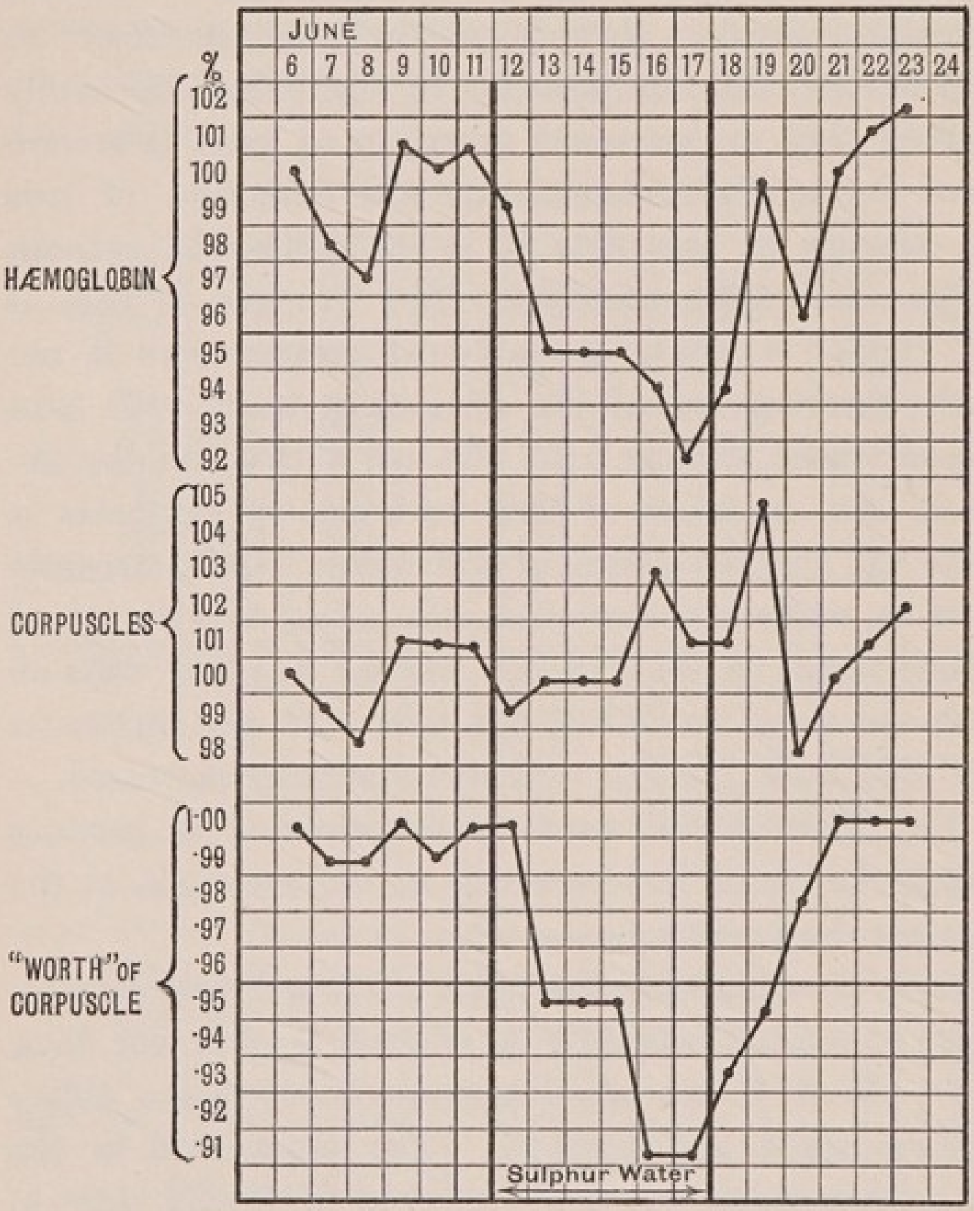


Fig. 1.—Subject *A*. Old Sulphur Water. Morning observations.

hydrogen sulphide and escaped. The blood was not affected in any of three subjects, the worth of the corpuscle remaining stationary; otherwise the results were almost identical with those obtained when the water contained sulphuretted hydrogen (see Table III.).

CHART II.

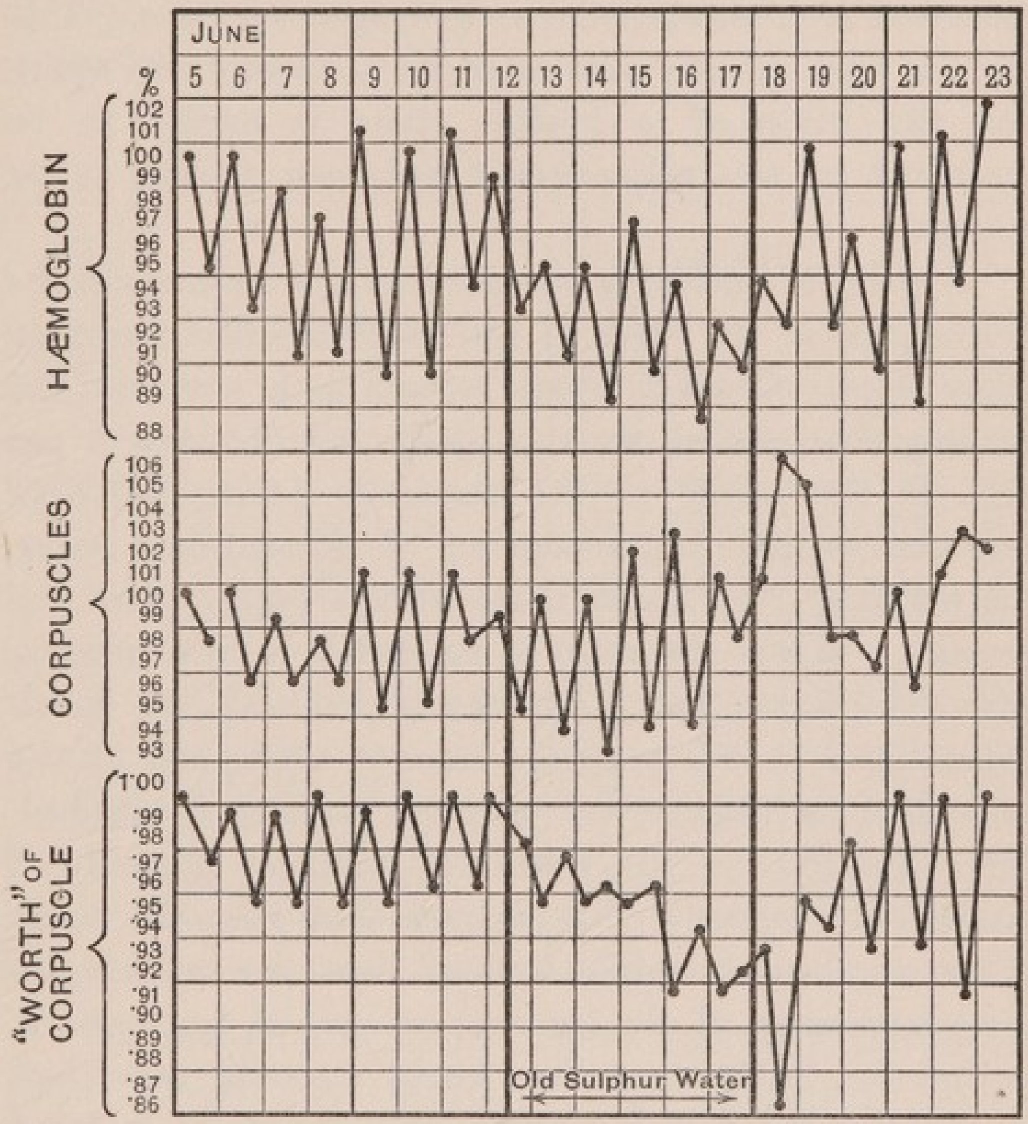


FIG. 2.—Subject *A*. Diurnal variations, showing reversal and diminished amplitude of variation. Morning and evening observations.

TABLE III.—*Normal Subject.*

	Average of Four Days.	Average of Four Days on Old Sulphur Water, minus H_2S.
Quantity, c.c.	1066	1420
Urea, in grms.	36·9	38·34
Uric Acid, in grms. . . .	·557	·507
P_2O_5, in grms.	2·25	2·13
Acidity in terms of Oxalic Acid, in grms.	2·66	2·86

We believe that the value of the water would be enhanced if it contained less hydrogen sulphide. This gas has been greatly over-rated as a therapeutic agent, and the value of a health resort is hardly to be measured by the sulphuretted hydrogen content of its springs.

A point of interest is the effect of the water upon the diurnal fall in the value of the corpuscle that normally takes place. Chart 2, which records both morning and evening observations, shows a daily fall of about 5 per cent. in the worth of the corpuscle during the days previous to the administration of the sulphur water, the morning observation being always higher than the evening. While the water is being taken this variation becomes reversed and a day rise is observed, the worth being lower in the morning than at night, and at the same time the amplitude of variation becomes diminished. After cessation of the water the ordinary diurnal fall immediately returns. This suggests that when the worth of the corpuscle is rapidly lowered there is a tendency to the conservation of the lessened amount of hæmoglobin, so that the further loss that would normally take place during the day does not occur, or may even be replaced by a rise.

Another striking property of this water is its stimulating action on the liver. This was demonstrated by an increase in the quantity and solids of the bile observed by one of us[1] during its administration to a patient with a biliary fistula. No other drug or mineral water experimented with produced such a striking increase in both

[1] Bain, "The Action of certain Drugs and Mineral Waters on the Secretion and Composition of Human Bile," *Journal of Anatomy and Physiology*, vol. xxiii.

the quantity of bile and of bile solids as the Old Sulphur Spring. The results of the investigation are embodied in the following table:—

TABLE IV.

Number of Days on which Drugs were given.	Drugs Administered.	Quantity of Bile in c.cms.	Bile Solids.		Bile Salts.	
			Total in grms.	Per cent.	Total in grms.	Per cent.
16	Without Medication . .	775	15·893	2·07	4·197	·55
4	Old Sulphur Spring . .	878	18·584	2·14	5·870	·69
4	Kissingen Spring . . .	845	16·330	1·97	4·734	·55
2	Carlsbad Mineral Water .	809	18·352	2·24	5·560	·68
5	Euonymin	836	17·300	2·03	5·031	·60
1	Benzoate of Soda . . .	856	18·514	2·16	...	...
3	Salicylate of Soda . . .	797	17·215	2·14	5·462	·68
4	Iridin	788	17·764	2·35	5·088	·68
2	Podophyllo-resin . . .	744	18·714	2·48	7·774	·73
1	Podophyllo-toxin . . .	758	14·311	1·88	4·044	·56
5	Strong Montpellier Spring	747	15·318	2·00	3·853	·50
2	Chloride of Iron Spring .	808	17·314	2·10	5·241	·64
1	Pint of Hot Water. . .	785	16·519	2·09	4·207	·53
1	Pint of Soda Water . .	783	16·612	2·10	...	...

We suspect the sulphur water increases the motor power of the gall bladder. This supposition would partly explain its beneficial influence in cases of cholelithiasis.

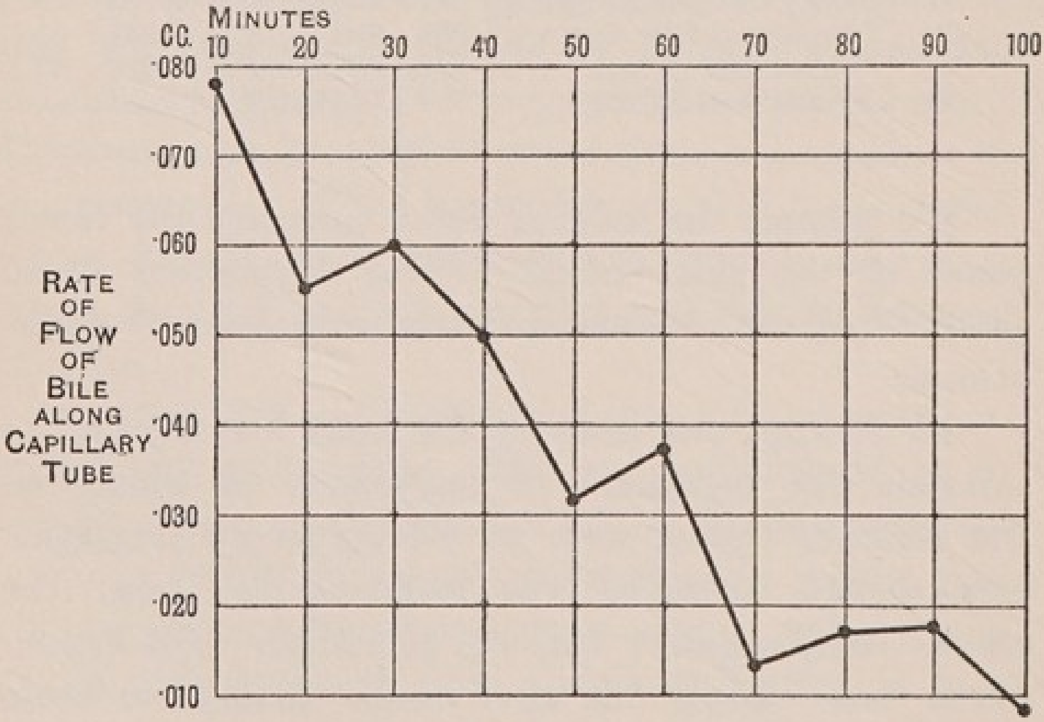
An attempt was made by the same investigator[1] to ascertain the ingredient or ingredients to which the Old Sulphur Spring owes its efficacy as a cholagogue. Sulphuretted hydrogen was found to be inert: the results being negative were not published. The experiments were carried out in a similar manner to those

[1] Bain, "An Experimental Contribution to the Study of the Mechanism of Bile Secretion," *Journal of Anatomy and Physiology*, vol. xxxiv.

described below. Certain German experimenters also came to the conclusion that this gas had no effect on the secretion of bile.

The method adopted was as follows: A dog was put under an anæsthetic and a canula inserted into the common bile duct, the cystic duct being clamped. The canula was attached by rubber tubing to a glass capillary tube about three feet six inches in length, having a capacity of one cubic centimetre, and graduated into 100 divisions, each division being divided into halves, so that readings could easily be taken and timed. Coloured water was used as an index, and the capillary tube kept in a horizontal position. The following chart shows the gradual fall that normally occurs in the rate of secretion as the bile drains away from the system:—

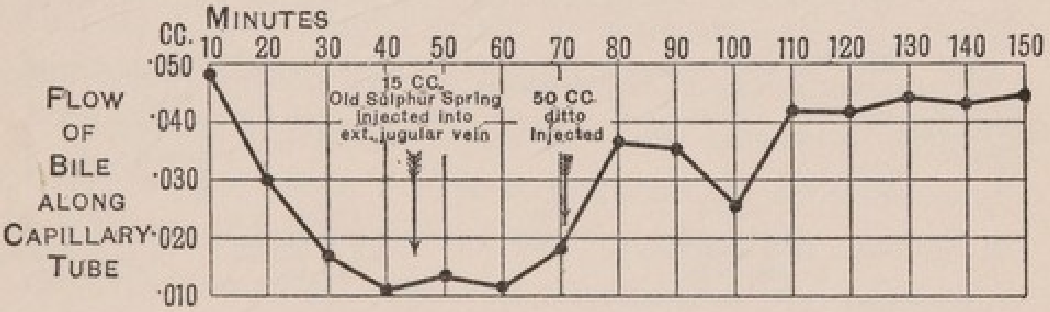
CHART III.



It may be mentioned that in one of the experiments 50 c.c. normal saline injected into the jugular vein had scarcely any appreciable effect on the secretion of bile, the flow closely resembling that represented in the above chart.

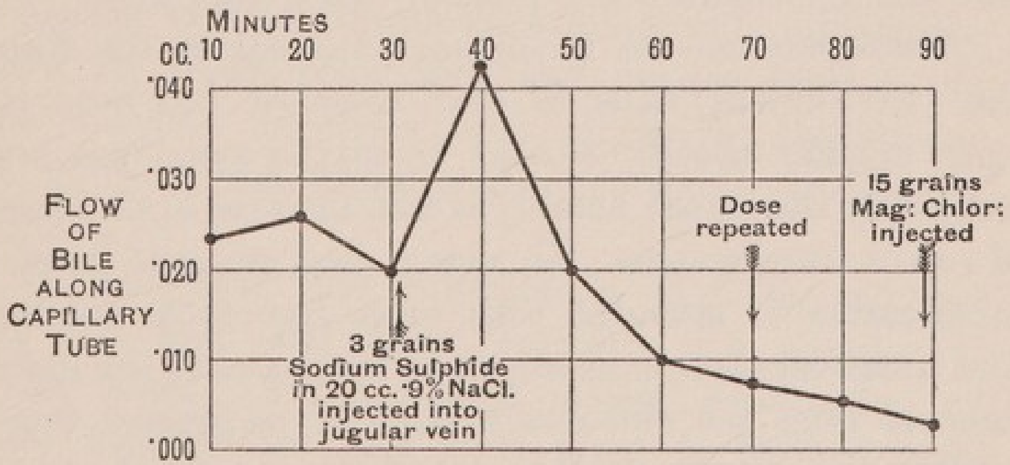
Chart IV. shows the effect of injecting sulphur water directly into the circulation, from which it will be seen that a marked increase in the rate of flow of the bile took place. This coincides with the results obtained in the case of biliary fistula.

CHART IV.



Charts V. and VI. show the effect of injecting sodium sulphide, magnesium chloride, and barium chloride respectively, all ingredients of the Old Sulphur Well.

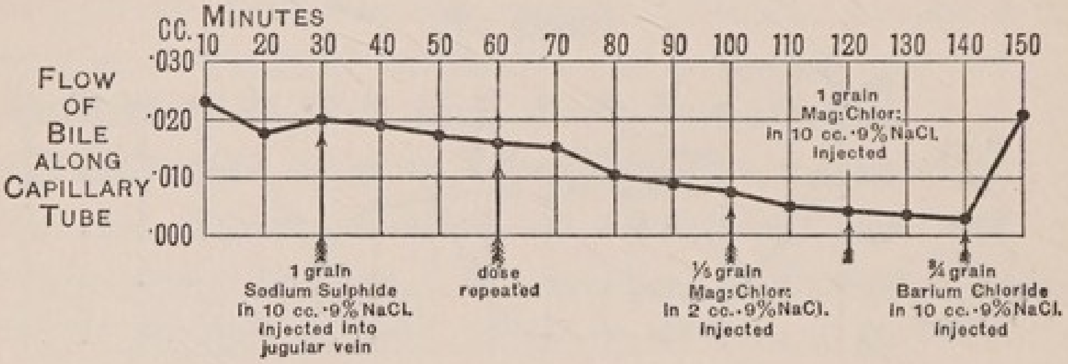
CHART V.



A distinct rise occurred after the first injection of the sodium salt, but on repeating the dose no effect was observable. On injecting 15 grains of magnesium chloride the dog immediately died.

In Chart VI. the effect of a small dose of sodium sulphide is shown. It merely delayed the fall in secretion that normally occurs as the organism is depleted of its bile. The increase following barium chloride is conspicuous, but unfortunately the dog died 15 minutes

CHART VI.



after the injection, the dose being rather large for a small animal. The experiments do not supply conclusive evidence regarding the particular ingredients which have a stimulating action upon the liver—sodium sulphide and barium chloride are probably both concerned.

Therapeutics.—In functional affections of the liver the Old Sulphur water is most effective, and even in some organic diseases of that organ the symptoms are frequently alleviated; notably is this the case in cirrhoses of recent development. In many cases of gout its administration is attended with most favourable results. The beneficial effect is mainly to be attributed to the daily removal from the alimentary canal of undigested fragments of food and possibly putrefactive material which would have an injurious effect. In others there may be some further action which is referred to under the treatment of gout. Whatever the explanation may be, the fact remains that many cases of gout derive very great benefit from the use of this water, the improvement in the patients' condition lasting several months. Some cases of chronic rheumatic arthritis appear to improve during its exhibition, while others remain stationary. The effect on these two diseases is very different; in gout the benefit is soon apparent, whereas in rheumatic arthritis the response is sometimes difficult to detect. Muscular rheumatism generally yields readily to its influence, a fact which tends to differentiate this form pathologically from the arthritic type of rheumatism.

Remarkable results are sometimes obtained with it in cases of gallstones. It is no uncommon occurrence to find a distended gall bladder so diminished in size after a month's treatment that its recognition by palpation is difficult or impossible, though previously easy. In catarrhal and other affections of the stomach and intestines, in phosphaturia, toxic anæmia, and in some cases of obesity and glycosuria, it is distinctly advantageous. The water is prescribed with varying degrees of success in skin affections, uterine and ovarian disorders, in some respiratory and cardiac troubles, in some nervous affections with digestive disturbance, and in conditions where a non-depressing aperient is desirable.

In plumbism the sulphide is said to combine with the lead and thus promote the elimination of the latter. For a similar reason, substituting of course mercury for lead, it is given in chronic mercurial poisoning, and is recommended as a preventive of mercurial salivation.

No. 2. STRONG MONTPELLIER WELL

Chemical Analysis by Attfield in 1879

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	1002·586
Saline base—	
Sodium chloride	827·371
Strontium chloride	2·816
Calcium chloride	79·936
Magnesium chloride	57·989
Potassium chloride	4·811
Lithium chloride	Trace
Ammonium chloride	0·996
Calcium carbonate	8·750
Barium sulphate	0·418
Strontium sulphate	·529
Sodium nitrate	0·900
Silica	3·570
Sulphur element—	
Sodium sulphide	14·500
Gases—	
Carbon dioxide	60·00
Carburetted hydrogen	2·3
Nitrogen	3·70

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1007·85
Total solids	781·90
Chlorine	391·00
Sulphur	4·78

This spring holds a subsidiary position owing to the outstanding popularity of the Old Sulphur Well.

Pharmacology.—The dose is similar to the preceding water. Our knowledge of its pharmacological action is almost entirely empirical. Unlike the Old Sulphur Spring, it does not appear to have any particular effect on the liver. The result was negative in the case of the patient with a biliary fistula (see Table IV.), and this accords with clinical experience. Apart from this, it has not been submitted to any experimental tests; therefore its pharmacology has to be gleaned in some slight degree from the known effects of its chief ingredients and from empirical observation. The action of sodium chloride has already been discussed. Sodium sulphide causes increased peristalsis and some increase in the intestinal secretions. Magnesium chloride aids the action of these substances, and the resultant effect is a precipitate expulsion of a portion of the intestinal contents. When the contents are hurried on the absorption of fluid from the bowel is diminished, and as this water is also hypertonic to the blood, the evacuations are more fluid. Professor Thorpe analysed the water in 1881, and found that it contained nine grains of barium chloride to the gallon. Since then the total solids have diminished, obviously through pumping the water for delivery at the Royal Baths some little distance from its source. If this well were treated like its rival, the probability is that it would be found to be almost equally efficacious. The belief that it contained no sulphuretted hydrogen doubtless led the authorities to think that it was inexpedient to conserve it. We hope in future this well will receive the same attention as the Old Sulphur Spring, and be dispensed at its source.

Therapeutics.—It is given in the same class of cases as the Old Sulphur Spring, with the exception of liver affections. In certain gouty cases, where the disagreeable odour of the latter water cannot be tolerated, beneficial results are sometimes obtained. It is also used in stomachic and intestinal disorders. We occasionally employ it with mercurial inunction. It is prescribed for its aperient action in constipation and many other conditions, such as hæmorrhoids, fissure of the anus, and stricture of the rectum.

No. 3. NEW SULPHUR WELL (MILD SULPHUR)

Chemical Analysis by Miller in 1869

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	654·87
Saline base—	
Sodium chloride	582·95
Barium chloride	Trace
Calcium chloride	16·70
Magnesium chloride	2·39
Potassium chloride	11·34
Lithium chloride	Trace
Silica	2·40
Sulphur element—	
Sodium sulphydrate	6·89
Gases—	
Sulphuretted hydrogen	14·18
Carbon dioxide	13·22
Nitrogen	2·01

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1004·37
Total solids	448·00
Chlorine	220·23
Sulphur	2·14

This water is extensively prescribed. It is generally used to supplement the Old Sulphur Spring, which it closely resembles in chemical constitution, but it is sometimes given alone.

Pharmacology.—The dose varies according to the time of administration: taken before breakfast, 20 ounces; at other times, from 4 to 10 ounces. No experimental work has been carried out with this water, although the clinical results are satisfactory. It may be pointed out that a fixed diet for weeks becomes irksome, and the daily analysis of the urine and the blood examinations involve a great expenditure of time, which is a serious drawback in making these investigations. In large doses before breakfast it is mildly aperient; in small doses it appears to have a slightly astringent effect.

Therapeutics.—It is given to delicate or debilitated subjects suffering from gout, rheumatism, or other disorders where it is undesirable to prescribe a stronger water. When the patient's condition improves a more concentrated water may be substituted. Even in more robust cases it is sometimes advisable to start treatment with it.

In chronic dysentery 4 or 5 ounces three times a day are frequently very effective. Similarly, in intestinal disorders with a tendency to several loose motions a day, small doses three or four times daily are generally beneficial. In some of the local manifestations of gout, such as bronchial catarrh, it frequently allays irritation. It is useful in skin affections and in respiratory disturbances in children.

No. 4. MILD MONTPELLIER WELL

CHEMICAL ANALYSIS BY ATTFIELD IN 1879

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	485·258
Saline base—	
Sodium chloride	388·800
Strontium chloride	·619
Calcium chloride	31·296
Magnesium chloride	27·589
Potassium chloride	5·691
Ammonium chloride	·656
Calcium carbonate	16·711
Strontium sulphate	·913
Sodium nitrate	·370
Silica	3·836
Sulphur element—	
Sodium sulphide	8·777
Gases—	
Carbon dioxide	54·00
Carburetted hydrogen	·80
Oxygen	3·20

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1004·96
Total solids	455·00
Chlorine	243·24
Sulphur	2·70

This water has also a considerable repute in the treatment of a number of ailments.

Pharmacology.—The dose is similar to that of the Mild Sulphur. The effect on the blood is to reduce slightly the worth of the corpuscle. The reducing substance is probably sulphuretted hydrogen. Although in the analysis it is not stated to be present, Mr. Hayton Davis, the consulting chemist to the Corporation, assures us that nearly all the Saline-Sulphur group contain small quantities of this gas. Judging by the sense of smell, we have no hesitation in accepting Mr. Davis' statement. A slight diminution in the excretion of uric acid occurs during its administration, but the urea is practically unaffected.

TABLE V.—*Subject A. Mild Montpellier Sulphur Water.*

Previous averages, ·680, 36·9, 1116.				
Date.	Uric acid, grms.	Urea, grms.	Quantity, c.c.	Remarks.
June 28	·673	35·7	1400	Mild Montpellier sulphur water.
„ 29	·643	37·3	1405	„ „ „
„ 30	·600	37·6	1600	„ „ „
July 1	·520	37·4	1740	„ „ „
Averages, ·609, 37·02, 1536.				
July 2	·520	36·1	1405	
„ 3	·694	36·1	965	
„ 4	·771	38·7	1020	
Averages, ·661, 37·01, 1130.				

In pint doses before breakfast it is mildly aperient, while in small doses it has a somewhat astringent effect. From laboratory experiments it cannot be recommended as a solvent for biurate deposits. (See Tables VIII. and IX.)

Therapeutics.—The indications for its use are very similar to those of the Mild Sulphur. The charge of sodium chloride being slightly less in the latter, the Mild Montpellier may be selected when it is desired to produce a little more stimulation of the gastric mucous membrane. Its relatively large content of sodium sulphide leads to its choice in preference to the Mild Sulphur either alone or as a supplement to the Strong Sulphur waters in cases of skin disease. Like the Mild Sulphur in small doses, it is often effective in checking the diarrhœa due to intestinal irritation or neuroses.

No. 5. No. 36 SULPHUR WELL

CHEMICAL ANALYSIS BY HAYTON DAVIS IN 1884

Solids in Grains per Gallon.

Total solids	292·95
Sulphur element—	
Sodium sulphide	6·95

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1003·36
Total solids	292·00
Chlorine	155·54
Sulphur	2·85

For some years this well was completely ignored by the profession, and even now is seldom prescribed. This may be partly due to the fact that we have no detailed analysis of the water. Certain drugs of no great merit become popular, and others of equal or greater value are disregarded, and the same has doubtless been experienced with the mineral waters. The No. 36 water, for example, may possess properties of no mean kind.

Pharmacology.—We must frankly confess that our experience of this water is very limited, and from the clinical side the data are of the most meagre description. Experimentally we obtained recently some curious results with it, but these experiments ought to be repeated and the results corroborated before reliable inferences are drawn regarding its therapeutic value.

One of us took 10 ounces of the water three times a day for four consecutive days while on a fixed diet. The experimental conditions were similar to those previously mentioned (see p. 23), with the exception that Chittenden's[1] method of collecting the urine was adopted, *i.e.* an

[1] "Physiological Economy in Nutrition."

aliquot part of the total excretion of each day's urine was taken, and the parts corresponding to the periods of fixed diet and of taking the water were respectively mixed together for analysis. This plan saves the investigator's time, and gives an accurate average result. The only objection against it is that in dealing with patients the daily examination of the urine renders any divergence from the fixed diet easy of detection, while by this method such detection would be impossible.

The results are given in the following table :—

TABLE VI.

	Average of Four Days on Fixed Diet.	Average of Four Days on No. 36 Water.
Quantity, c.c. . .	1145	1620
Urea, in grms. . .	30·91	30·37
Uric Acid, in grms. .	·598	·665
P_2O_5, in grms. . .	2·09	2·17
Acidity in terms of Oxalic Acid, in grms.	2·74	2·55

It will be observed that there is a marked increase in the uric acid excreted, an increase which is as surprising as it was unexpected. We have experimented on various occasions with a number of the local waters, and this is the first and only time that we obtained an increase in the excretion of this acid during their administration. Before offering an explanation of this experimental result, further observations and an extended experience of its clinical use are required.

It will also be noticed that the urea is practically unaffected, while there is a slight increase in the phosphorus pentoxide and a slight diminution in the acidity.

The water has no aperient action. Subsequently the same subject took it in pint doses before breakfast without any laxative effect. From the incomplete analysis it will be seen that it contains a relatively large amount of sulphide. The elimination of this ingredient by the skin was impressed upon the subject who took it for experimental purposes. He was in the habit of taking a hot bath before dinner in addition to a comparatively cool morning plunge. After the hot bath the presence of sulphuretted hydrogen in the room was unpleasantly noticeable, but after the morning bath the odour of this gas was not perceived.

Therapeutics.—The water having no aperient action, only a small proportion of the sulphur it contains is carried off by the bowel, hence more is available for elimination by the skin. It is therefore employed chiefly in skin diseases.

No. 6. MAGNESIA WELL

Chemical Analysis by Muspratt in 1867

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids—	280·413
Saline base—	
Sodium chloride	215·896
Barium chloride	1·222
Magnesium chloride	1·792
Potassium chloride	27·913
Ammonium chloride	Trace
Lithium chloride	Trace
Calcium carbonate	18·476
Magnesium carbonate	12·799
Magnesium bromide	Trace
Magnesium iodide	Trace
Silica	1·608
Sulphur element—	
Sodium sulphide	·707
Gases—	
Carbon dioxide	11·50

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1002·28
Total solids	196·00
Chlorine	103·87
Sulphur	·68

This water is generally used to supplement or modify the action of some other water. It may be given either alone, or mixed with another water; for example, equal quantities of the Magnesia and the Crescent Saline. It is usually taken two or three times a day, in addition to the early morning draught of an aperient water.

Pharmacology.—The dose varies from 6 ounces to a pint. The chief characteristic of this water is its stimulating effect on the kidneys. It is a powerful refrigerant diuretic, an effect which is probably in great measure due to the potassium salts it contains, for it is known that the excretion of these salts is accompanied by an increased secretion of urine. It has, as a rule, no aperient action.

The effect on the blood is merely one of dilution, no change taking place in the worth of the corpuscle, the hæmoglobin and corpuscles falling in equal proportions. The uric acid is very slightly diminished, but the urea is unaffected.

Table VII.—*Subject B. Magnesia Water.*

Previous averages, ·546, 35·768, 1032.				
Date.	Uric Acid, grms.	Urea, grms.	Quantity, c.c.	Remarks.
July 5	·554	40·09	2110	Magnesia water
„ 6	·483	32·64	1280	„
„ 7	·463	36·58	1557	„
„ 8	·591	33·6	1120	„
Averages, ·522, 35·7, 1516.				

A number of drugs have been recommended for their solvent power on biurate of sodium, while others have been vetoed in the treatment of gout on account of their supposed inhibitory effect on the solvency of this salt. In connection with the latter point, the sodium salts have been much discussed. Experiments in vitro showed that if sodium chloride were added to distilled water or blood serum containing biurate, the solubility of the latter was somewhat diminished. From these experiments it was inferred that mineral waters with a small content of sodium salts were better solvents of biurate than those containing a moderate amount of these salts. A further inference was that the waters with a small content of sodium salts were the more beneficial in cases of gouty deposits, but this inference cannot be accepted. It must be borne in mind that mineral waters are not simple saline solutions, but may contain one or more substances modifying the influence of the sodium salts on the solubility of biurate. This point is exemplified by Luff's chemical experiments with the mineral ash of spinach: the ash proved specially solvent, although rich in sodium salts.

A series of experiments was carried out by one of us[1] to test the solvent power of various mineral waters containing different proportions of the sodium salts. The methods employed are described in the paper, and closely followed those adopted by Sir William Roberts and Dr. Luff. The results are given in the appended tables:—

[1] Bain, "The Solvent Action of certain British and Foreign Mineral Waters on the Biurate of Sodium," *British Medical Journal*, 1899.

TABLE VIII.—*Showing the Solubility of Sodium Biurate in 100 c.c. of Distilled Water, at a Temperature of 38° C., and in Distilled Water containing 1 per cent. of the different Mineral Waters.*

Solvent.	Sodium Biurate Dissolved.
	Per 1000.
Distilled water	1·110
Magnesia water, Harrogate . . .	1·100
Beckwith Water, Harrogate . . .	1·080
St. Ann's Well, Buxton	1·075
Source Pavillon, Contrexéville . . .	1·068
Teiplitz	1·060
Celestin Spring, Vichy	1·050
Mild Montpellier, Harrogate . . .	1·020
Morrison Well, Strathpeffer . . .	1·010

TABLE IX.—*Showing the Solubility of Sodium Biurate at a Temperature of 38° C. in 100 c.c. of Artificial Blood Serum, and in Artificial Blood Serum containing 1 per cent. of the undermentioned Mineral Waters.*

Solvent.	Sodium Biurate Dissolved.
	Per 1000.
Artificial blood serum	0·104
Magnesia, Harrogate	0·102
Beckwith Water, Harrogate . . .	0·100
St. Ann's Well, Buxton	"
Sulis Water, Bath	"
Royat	"
Source Pavillon, Contrexéville . . .	"
Elizabeth Brunnen, Homburg . . .	"
Gichtwasser, Wiesbaden	"
Vittel	"
Ems	"
Teiplitz	0·099
Rakoczy, Kissingen	"
Celestin Spring, Vichy	"
Choussy-Perriere, La Bourboule . .	0·097
Marienbad	"
Morrison Well, Strathpeffer . . .	0·096
Carlsbad	"

The methods are open to criticism. In the first place, the absence of continuous and prolonged agitation involves a marked divergence from the conditions under which the solvents would be present in the blood; and, secondly, the chemical compounds that come into contact with the biurate in the test bottle are by no means necessarily identical with those that come into contact with it in the tissues after absorption. In illustration of this point, spinach given to a case of chronic gout[1] while the patient was on a fixed diet had no apparent effect on the solubility of biurate, as evidenced by the excretion of uric acid in the urine.

Therapeutics.—In cases of gouty albuminuria it has a marked effect in diminishing the absolute amount of albumin in the urine. For example, we have repeatedly observed the albumin reduced from one-fourth by volume to a mere trace. In cases of glycosuria a similar but less pronounced diminution in the quantity of sugar has been noted without the aid of any other treatment. It is advisable in prescribing this water to warn patients that occasionally it deranges the gastric functions. The diseases and conditions in which it is most frequently employed are, besides those stated, phosphaturia, oxaluria, chronic cystitis, gravel, oligæmia, chronic alcoholism, &c.

[1] Bain, "The Action of various Drugs and Diets on the Excretion of Nitrogen in Gout," *Trans. Med. Soc., Lond.*, 1900.

No. 7. CRESCENT SALINE (LEAMINGTON SPA)

Chemical Analysis by Fairley in 1873

Solids in Grains per Gallon.

Total solids	149·984
Saline base—	
Sodium chloride	88·167
Sodium carbonate	13·774
Calcium carbonate	5·606
Magnesium carbonate	4·095
Magnesium chloride	6·862
Potassium chloride	5·827
Silica acid	1·128
Ammonia	0·022
Organic matter	0·970
Sulphur element—	
Sodium hydrosulphide	·568
Sodium sulphate	10·224
Calcium sulphate	0·031

From the analysis this water would be classed in the Alkaline-Sulphur group, but it is extremely doubtful whether it contains any alkaline carbonates. Freysenius says that these carbonates cannot exist in the presence of the chlorides of calcium and magnesium. In the absence of recent analysis, it may safely be assumed that if any carbonates are present the quantities are merely minimal.

The water is used internally to dilute some of the stronger waters, and, if given with equal parts of the Magnesia water, tends, as already mentioned, to diminish or prevent the digestive derangement which sometimes accompanies the use of the latter. All the Saline group are more or less diuretic, and where a mild diuretic is required, this water is occasionally prescribed. It is used for bathing purposes, and is then known as the Façade bath, and is employed as a spray or douche in various affections.

BECKWITH, HARLOW CAR, AND STARBECK SPRINGS

No. 8. BECKWITH SPRING

Chemical Analysis by Hayton Davis in 1880

Solids in Grains per Gallon.

Total solids	33·339
Saline base—	
Sodium chloride	3·374
Sodium carbonate	16·147
Magnesium carbonate	4·222
Calcium carbonate	5·947
Calcium sulphate	·580
Potassium chloride	·610
Lithium chloride	Trace
Silica	·530
Sulphur element—	
Sodium hydrosulphide	1·929
Ferrous sulphide	Trace

No. 9. HARLOW CAR SPRING

Chemical Analysis by Muspratt in 1860

Solids in Grains per Gallon.

Total solids	45·56
Saline base—	
Sodium chloride	3·12
Magnesium chloride	5·44
Calcium chloride	1·28
Potassium chloride	0·48
Calcium carbonate	10·48
Magnesium carbonate	1·12
Potassium carbonate	0·48
Sodium carbonate	15·2
Magnesium sulphate	4·16
Silica	·96
Sulphur element—	
Sodium sulphide	3·2

No. 10. STARBECK SULPHUR WELL

CHEMICAL ANALYSIS BY FAIRLEY IN 1879

Solids in Grains per Gallon.

Total solids	151·59
Saline base—	
Sodium chloride	116·44
Barium chloride	Trace
Lithium chloride	Trace
Ammonium chloride	Trace
Magnesium bromide	Trace
Magnesium iodide	Trace
Calcium carbonate	10·01
Magnesium carbonate	3·51
Potassium carbonate	·65
Sodium carbonate	14·47
Calcium sulphate	1·88
Silica	3·27
Sulphur element—	
Sodium sulphide	1·36

These waters are very much alike both in chemical composition and therapeutic use; therefore it is unnecessary to give a separate description of their pharmacology and therapeutics. The Starbeck differs from the other two in containing a larger quantity of sodium chloride, but the importance of this dissimilarity lies chiefly in their external application, as they are used extensively for bathing purposes.

While most of the waters are alkaline to litmus, the exception being the Alum Well, only the three under consideration can consistently be described as alkaline.

Pharmacology.—The carbonates of sodium, potassium, and magnesium owe their specific action to the non-metallic ions; the metals in this respect may be disregarded. The carbonates dissociate readily into the Na, Mg or K ions, and CO_3, but the latter quickly combines with the hydrogen of the water, and the hydroxyl ion OH is liberated. Upon the hydroxyl ion the pharmacological effect of alkalies depends, the alkalescence being ultimately referable to the presence of these ions in the blood and lymph.

One important effect of the administration of these alkaline waters is a slight increase in the alkalinity of the body fluids, which is soon followed by a diminution in the acidity of the urine. In neutralising acids, the important element in the reaction that takes place is the combination of the hydroxyl ion with the hydrogen ion of the acid. Alkalies dissolve proteids, changing them into alkali proteids, and to a certain extent they tend to saponify fats. The effect of carbonates in the stomach has been the subject of much controversy, and owing to the conflicting evidence it is difficult to ascertain their precise rôle. That they either neutralise a portion of the free hydrochloric acid in the stomach or combine with some fatty acids that may be present is admitted, but whether they stimulate the secretory glands to greater activity is a disputed point. Reichman does not believe they have any effect in this respect, and his opinion is supported by experimental evidence obtained from dogs with gastric fistulæ; in these animals the carbonates had no effect on the gastric secretion. They probably act as mild stimulants to the mucous membrane, and thereby improve the circulation through the organ. By the liberation of carbonic acid they increase to a slight extent the movements of the stomach, but as to their effect on its power of absorption there is an absolute lack of material evidence. They undoubtedly tend to render mucus less tenacious, and in some instances may liquify it; hence in catarrhal affections of the stomach, bronchial mucous membrane, and of the urinary passages they may be of service.

Regarding their action on the excretion of nitrogen and uric acid the evidence is again contradictory, some investigators obtaining an increase, others a diminution, and the remainder no appreciable effect.

They have no direct action on the secretion of bile, but may, indirectly, through the duodenum, have some slight influence on hepatic affections. It has been supposed that they increase oxidation in the tissues, as evidenced by the oxygen absorbed and the carbonic acid exhaled, but from a consideration of a large number of investigations upon this point, it is evident that the amount of tissue change effected by them is very much less than was formerly believed.

Therapeutics.—In health, alkaline waters act injuriously by neutralising a portion of the uncombined hydrochloric acid, and thus impairing its digestive and antiseptic properties. Since the pancreas is stimulated by the acid chyme that passes through the pylorus, any decrease in the normal acidity of the chyme diminishes to a certain extent the flow of the pancreatic juice, and impairment of the intestinal digestion follows.

In conditions of the stomach where there is an excess of mucus, alkaline waters, by rendering the mucus less viscid, assist the action of the gastric juice upon the food, and digestion proceeds more rapidly. In fermentation of the gastric contents, the alkali, by neutralising acidity, tends to diminish pain and any distension that may be present, and this carminative action is augmented by the carbonic acid set free. In hyperchlorhydria, excessive acidity of the urine leading to discomfort or even pain, and in jaundice by lessening duodenal irritation, they are of service.

Resolution of minute calculi may be promoted by these waters through the liquefaction of the mucus sometimes induced by alkalies, and in cases of gravel they are undoubtedly of value.

The Starbeck water is a degree more irritating to the mucous surface, and should be selected in catarrhal affections in which greater stimulation is required, while the Beckwith or Harlow Car water is to be preferred when the condition demands more soothing remedies. These waters should be taken not less than half-an-hour before meals.

The diseases in which they are employed comprise a large number, such as stomachic and intestinal affections, renal and bladder affections, skin diseases, bronchial affections, diabetes, gout, and rheumatism.

CLASS II.

SALINE-CHALYBEATE WATERS

Before considering separately the waters included in this group, it is advisable to discuss briefly the absorption of iron.

It is well known that iron is essential to most, if not all, forms of protoplasm, and in the animal kingdom it is indispensable for the efficient performance of metabolic functions. It has indeed been suggested that the iron content of cell protoplasm may act as a vehicle of oxygen, taking up that element from the blood to become a ferric compound, and then undergoing a partial reduction back to the ferrous state as the oxygen is utilised. The amount required to maintain the normal worth of the corpuscle in an adult subject is about 8 or 10 milligrammes (about one-fifth of a grain) per day, and this is contained in the food in a state of organic combination. It exists in the yolk of eggs, in vegetables, especially spinach, in the bran of wheat and other cereals, in the nuclei of most cells, in the hæmoglobin of the blood, and in muscular fibres. The total amount of iron present in a healthy subject is approximately 40 grains. The blood contains about 30 grains, the liver about 4 grains, and the remainder is present in the other organs. Iron is excreted chiefly in the fæces, and about 1 mg. in the urine.

Absorption of Iron.—After the administration of the salts of iron, this substance is found increased in the blood, liver, spleen, and other organs. Bunge's theory that inorganic salts of iron are not absorbed has been disproved by Stockman. Bunge held that only the organic iron could be absorbed, and that the benefit derived from the administration of inorganic salts in chlorosis was due to those salts combining with the sulphides (which he supposed were formed in excess in this affection) and thus permitting the organic iron of the food to become absorbed. Stockman showed that ferrous sulphide cured chlorosis, and that bismuth, which ought to neutralise the sulphides, had no beneficial effect on chlorotic patients.

Experiments on animals have conclusively proved that inorganic iron is absorbed. This has been done by placing the tissues for microscopical examination in a solution of ammonium sulphide, which gives a black reaction, or in a solution of potassium ferro-cyanide and hydrochloric acid, which gives a blue reaction. Inorganic iron readily undergoes electrolytic dissociation, and on this account forms these precipitates, but organic iron does not give the reactions. If an animal be killed within twenty-four hours after the administration of inorganic iron, and the tissues stained with either of these reagents, iron granules can be seen in the epithelium of the duodenum, but not in the mucous membrane of the stomach or intestine. They can also be detected in the mesenteric lymph glands, are present in large numbers in the spleen, and, in lesser numbers, in the liver and cortex of the kidney. If the animal be kept alive for several days the reaction of the liver is much more intense, and the epithelial cells of the large intestine also give a reaction. What probably happens is this: after the iron is absorbed from the duodenum the leucocytes convey it first to the spleen and subsequently to the liver, where some of it is stored, and a part synthetised into various complex combinations with albumin. The latter is immediately used to supply the bone marrow with the iron necessary for the red corpuscles.

Complementary to and as a résumé of the subject, the following paragraph may be quoted from Cushny :—

"To sum up what is known regarding the fate of the iron preparations, they are partially formed into the chloride, and then into the albuminate in the stomach, pass into the duodenum from which the great bulk is carried on into the lower parts of the intestine, while some is absorbed by the epithelium and leucocytes in solid form and perhaps in solution. This small quantity passes through the lymph vessels to the mesenteric glands, and thence through the thoracic duct to the blood vessels. It is then deposited in the spleen, where it may undergo some changes in form, is later taken up by the blood and deposited in the liver, and perhaps in the bone marrow. Where the supply of iron has been inadequate for the formation of hæmoglobin, the originally inorganic iron is probably worked into higher forms and eventually into hæmoglobin in the liver, and it seems likely that ferratin is one of the intermediate steps in this synthesis. When there is no deficiency of iron for the formation of hæmoglobin the liver slowly yields its store of iron to the blood, which carries it to the cæcum and large intestine, by the epithelium of which it is finally excreted. It is to be noted that the iron absorbed does not increase the amount of iron in the urine, bile, or other excretions."

No. 11. KISSINGEN WATER

Chemical Analysis by Attfield in 1879

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	874·740
Saline base—	
Sodium chloride	674·598
Potassium chloride	21·425
Ammonium chloride	0·439
Barium sulphate	·509
Barium carbonate	2·136
Strontium chloride	·887
Calcium chloride	87·377
Magnesium chloride	65·391
Calcium carbonate	8·858
Silica	3·57
Iron element—	
Ferrous carbonate	9.59

Gases—	
Carbon dioxide	21·3
Oxygen	1·5
Nitrogen	5·2

Skeleton Analysis by Hayton Davies in 1904.

Specific gravity	1004·18
Total solids	437·50
Chlorine	234·71
Ferrous carbonate	0·307

Unfortunately this water, probably through pumping, varies in composition during the day, the early drinkers getting a more concentrated solution. Notwithstanding this great defect it is a useful remedy, and is very commonly prescribed.

Pharmacology.—The dose varies from 6 to 20 ounces. A frequent combination is the Kissingen in pint doses before breakfast, and the Chloride of Iron or Alexandra water twice during the day. Another effective combination, but in quite a different class of case, is the Old Sulphur water in the early morning, and the Kissingen water in the afternoon.

In large doses it is slightly aperient, and it also possesses diuretic properties. The quantity of iron in it is generally so small that its administration is not attended by any augmentation of the hæmoglobin value of the corpuscle. A slight diminution in the excretion of uric acid occurs, somewhat similar to that resulting from the Magnesia water, but the output of urea is increased, as is shown in the following table :—

TABLE X.—*Subject B. Kissingen Water.*

Date.	Uric Acid, grms.	Urea, grms.	Quantity, c.c.	Remarks.
July 9	·471	35·07	1063	
„ 10	·447	38·25	1700	
Averages, ·459, 36·66, 1354.				
July 11	·413	41·16	1960	Kissingen
„ 12	·459	38·34	1660	„
„ 13	·467	38·25	1530	„
„ 14	·389	37·12	1530	„
Averages, ·437, 38·71, 1670.				
July 15	·560	34·2	950	
„ 16	·473	31·45	850	
„ 17	·584	36·00	800	
Averages, ·539, 33·88, 867.				

It may be stated that the fall in urea after stopping the water was in the case of Subject A merely to normal.

The Kissingen water undoubtedly increases the flow of bile, and to a very slight extent also the bile solids (see Table IV.).

Therapeutics. — Following a course of a strong sulphur water, Kissingen is very frequently given for its tonic effect. It is useful in some cases of anæmia, when its action is supplemented by a strong chalybeate water. It is prescribed in a large number of ailments, among which the following may be cited: sluggish liver, debility during convalescence from various maladies, Bright's disease, neurasthenia, hysteria, atonic gout, obesity, uterine and ovarian disorders, diabetes, chronic alcoholism, chronic malaria, &c.

No. 12. CHLORIDE OF IRON WELL

CHEMICAL ANALYSIS BY THORPE IN 1880

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	465·200
Saline base—	
Sodium chloride	277·561
Barium chloride	5·204
Barium sulphate	0·222
Potassium chloride	3·205
Ammonium chloride	0·406
Strontium chloride	0·624
Calcium chloride	94·015
Magnesium chloride	57·318
Manganese chloride	·971
Lithium, iodides, bromides, fluorides	Traces
Silica	1·414
Iron element—	
Ferrous carbonate	11·050
Ferrous chloride	13·213
Gases—	
Carbon dioxide	53·55

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1004·59
Total solids	444·50
Chlorine	227·53
Ferrous carbonate	2·84

It has been stated that this water is the richest chloride of iron spring in Europe. It may be so. We are not in a position either to confirm or refute such an assertion, but we do know that it possesses some special properties.

Pharmacology.—The dose varies from 6 ounces to a pint. Its effect on the blood is graphically depicted on the appended chart. The chart gives the morning observations for a week, during which the water was taken three times daily in doses of 6 ounces:—

CHART VII.

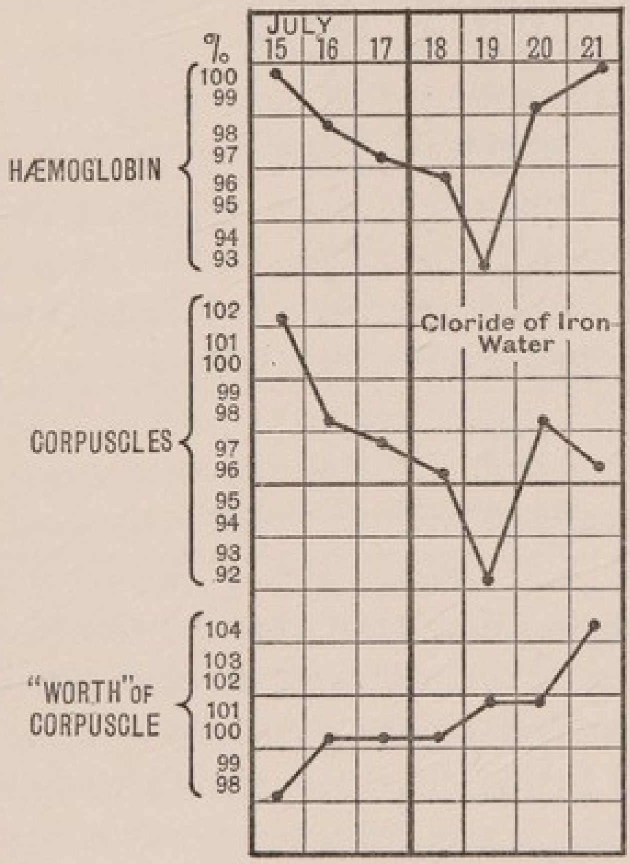


FIG. 3.—Subject *B*. Chloride of Iron Water.

It may be remarked that in the case of Subject A the high level of the worth of the corpuscle was maintained for two days after the withdrawal of the water before falling back to the normal.

The uric acid is markedly diminished under the influence of this water, but immediately on its cessation it returns almost to normal in contrast with the gradual return that occurs after discontinuing the Old Sulphur water. The urea is distinctly increased, the increase being sustained after the water is stopped.

TABLE XI.—*Subject A. Chloride of Iron Water.*

Date.	Uric Acid, grms.	Urea, grms.	Quantity, c.c.	Remarks.
July 15	·716	37·17	1180	
„ 16	·753	35·85	995	
„ 17	·787	39·60	890	
Averages, 755, 37·54, 1021.				
July 18	·742	39·6	880	Chloride of Iron water
„ 19	·655	43·2	1350	„ „ „
„ 20	·632	45·1	2050	„ „ „
„ 21	·588	41·6	1600	„ „ „
Averages, ·654, 42·37, 1470.				
July 22	·735	44·98	1475	
„ 23	·705	38·59	1135	
Averages, ·720, 41·78, 1305.				

The only explanation that can be offered of the diminished excretion of uric acid is that some of its antecedents are utilised for the synthesis of urea. Urea is chiefly formed in the liver, and the Chloride of Iron water evidently has a very stimulating effect upon that organ. It was given to a case of biliary fistula with the object of testing the alleged effect of iron in reducing the quantity of bile. It must be noted that it contains, in addition to the protochloride of iron, appreciable quantities of the chloride of barium, magnesium, and potassium. The dose given was 20 ounces before breakfast, and agreed perfectly with the patient. It had a pronounced effect in augmenting the solids of the bile. The average of 808 c.c. bile secreted (see Table IV.) is somewhat misleading. The day before commencing the water the quantity of bile was 820 c.c., and the day after it was stopped the quantity rose to 864 c.c., and the solids to 19·457 grammes, the largest amount recorded during the investigation.

Therapeutics.—A note of caution must be sounded in regard to the administration of this complex solution. In some cases it appears to retard the action of the gastric secretion. This is not observed in young people before the age of twenty, but after that age care must be exercised in prescribing it. The cholagogue action makes it peculiarly suitable for cases of sluggish liver with anæmia. It is employed in most forms of anæmia and chlorosis with conspicuous success. In those cases where it is not well borne the Alexandra Well may be substituted for it. It is used in the debility accompanying nervous breakdown, but if the patient be excited or the pulse tension high it is better omitted. In this connection it should be remembered that it contains about five grains of barium chloride to the gallon. It is also prescribed in malaria, syphilis, and other chronic cachetic conditions—in short, whenever iron is indicated.

No. 13. ALUM WELL

Chemical Analysis by Hayton Davis in 1870

Solids in Grains per Gallon.

Total solids	394·41
Saline base—	
Sodium chloride	33·96
Aluminium sulphate	89·47
Calcium sulphate	56·91
Magnesium sulphate	57·33
Potassium sulphate	3·14
Ammonium sulphate	2·19
Silica	3·27
Iron element—	
Ferric sulphate	69·33
Ferrous sulphate	78·76

This powerfully astringent water is not used internally but is applied in the form of a douche or spray in affections of the pharynx and larynx; in the latter especially it should be diluted with plain water or the Crescent saline. It is unfortunate that no satisfactory investigation of the water has been undertaken beyond a chemical analysis thirty-five years ago.

No. 14. ALEXANDRA WELL

CHEMICAL ANALYSIS BY HAYTON DAVIS IN 1870

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	218·804
Saline base—	
Sodium chloride	176·370
Potassium chloride	1·130
Ammonium chloride	Trace
Manganese chloride	Trace
Magnesium chloride	4·736
Calcium sulphate	9·097
Calcium carbonate	13·762
Magnesium carbonate	5·785
Lithium, bromide, iodide, and fluoride	Traces
Silica	·675
Organic matter	1·45
Iron element—	
Ferrous carbonate	5·80
Gases—	
Carbon dioxide	17·04
Oxygen	·31
Nitrogen	8·98

Skeleton Analysis in 1904.

Specific gravity	1002·46
Total solids	196·70
Chlorine	101·16
Ferrous carbonate	2·77

This water is not liable to increase any existing gastric derangement, therefore it may be prescribed without reserve in cases of anæmia in which indigestion is a fairly prominent symptom. In cases in which this is more pronounced it may be advisable to give in addition some digestive aid.

Pharmacology.—As there is an entire absence of experimental data bearing upon the Alexandra water our remarks must necessarily be restricted to the statement, clinically substantiated, that when the hæmoglobin value of the corpuscle is diminished (providing the cause which produced the diminution has ceased to operate) it will tend to make good the deficiency of iron in the blood.

Therapeutics.—Like the Chloride of Iron spring, it is given in most forms of anæmia and chlorosis. So far as we know it has no special effect on the liver, certainly no influence that can be recognised clinically. In anæmic cases associated with hepatic inactivity, and in cases of so-called tropical liver, the Chloride of Iron should be prescribed, otherwise the indications for the use of the two waters are very similar, and it is unnecessary to recapitulate them.

PURE CHALYBEATE, TEWIT, AND JOHN'S SPRINGS

No. 15. PURE CHALYBEATE

Chemical Analysis by Hayton Davis in 1854

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	9·839
Saline base—	
Sodium chloride	1·625
Ammonium chloride	Trace
Manganese chloride	Trace
Lithium, bromide, iodide, and fluoride	Trace
Calcium sulphate	·74

Saline base—	
Calcium carbonate	1·532
Magnesium carbonate	1·952
Potassium carbonate	·262
Sodium carbonate	1·103
Silica	·502
Organic matter	·75
Iron element—	
Ferrous carbonate	1·364
Gases—	
Carbon dioxide	13·74
Oxygen	·82
Nitrogen	8·0

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1000·18
Total solids	7·70
Chlorine	·76
Ferrous carbonate	·92

No. 16. TEWIT WELL

CHEMICAL ANALYSIS BY HOFFMAN IN 1854

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	10·521
Saline base—	
Sodium chloride	·280
Potassium chloride	1·325
Ammonium chloride	Trace
Manganese chloride	Trace
Lithium, bromide, iodide, and fluorides	Traces
Calcium sulphate	·697
Calcium carbonate	1·435
Magnesium carbonate	2·667
Potassium carbonate	1·057
Silica	1·041
Organic matter	·063
Iron element—	
Ferrous carbonate	1·358
Gases—	
Carbon dioxide	11·85
Oxygen	·4
Nitrogen	5·33

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1000·29
Total solids	14·35
Chlorine	1·14
Ferrous carbonate	1·84

No. 17. JOHN'S SPRING

Chemical Analysis by Hoffman in 1854

Solids in Grains, and Gases in Cubic Inches per Gallon.

Total solids	10·753
Saline base	
Sodium chloride	1·543
Ammonium chloride	Trace
Calcium sulphate	·307
Calcium carbonate	2·264
Magnesium carbonate	3·039
Potassium carbonate	·991
Sodium carbonate	1·338
Silica	Trace
Iron element—	
Ferrous carbonate	1·271
Gases—	
Carbon dioxide	14·95
Carburetted hydrogen	·15
Oxygen	·67
Nitrogen	6·35

Skeleton Analysis by Hayton Davis in 1904.

Specific gravity	1000·16
Total solids	14·00
Chlorine	1·14
Ferrous carbonate	1·38

No useful purpose would be gained by describing these three waters separately, since they are so much alike in chemical constitution and therapeutic effect.

Pharmacology.—The non-existence of any experimental data renders their pharmacology a matter of surmise. Clinically, they may be recognised as tonics and diluents.

Therapeutics.—These waters, containing, as they do, very small quantities of iron, are liable to be regarded as almost inert and little more than a placebo. We venture to think that their properties are under-estimated. Because their content of iron is small it does not necessarily follow that their therapeutic value is proportionately insignificant. There are certain patients so peculiarly susceptible to the influence of iron that, unless weak solutions easily assimilated are prescribed, the remedy has to be abandoned. It is in cases of this description that these waters are particularly efficacious. They are also given to those who merely complain of feeling jaded without presenting any objective symptoms. Finally, they are useful in the malnutrition and anæmias of children, by whom they are readily taken.

SECTION II

THE BATHS OF HARROGATE

DESCRIPTION OF THE BATHS

Introductory.—After the foregoing description of the nature, action, and uses of the mineral waters, and in order to complete the survey of the resources that are at the disposal of Harrogate for the relief of the many forms of disease that are sent there for treatment, it is necessary to include some account of the baths, their varieties, constitution, and action, both physiological and therapeutical. The use of various forms of baths (using this term in its widest sense) has become so valuable an adjunct to Spa treatment as to assume an importance which cannot be overlooked—the more so as of late years a great deal of sound work has been done by various observers on the physiological action of baths, without a proper understanding of which no intelligent therapeutic use of them can be made. The whole system of Balneotherapeutics, which formerly afforded opportunities for adverse criticism on the part of the profession at large, may now be said to rest to a great extent on a solid physiological basis and is becoming more and more recognised as an element of real value in the Spa treatment of disease. The many varieties of baths which are available at Harrogate will therefore be briefly described. That they are extensively used is shown by the fact that a few years ago it became necessary to greatly increase the accommodation available for patients, and to erect, at a cost of £120,000, a new and magnificent suite of baths, which, for comfort and completeness of detail, are at the present time probably unrivalled in Europe. The extra facilities provided are now, however, proving inadequate to meet the requirements at the height of the season, and very shortly further extensions will be required.

It will be convenient to deal with the subject under the following headings:—

The Varieties of Baths, their Nature and Constituents.

The Physiological Action of Baths in general and in particular.

The Therapeutic Uses of the Baths.

CLASSIFICATION OF THE BATHS

1. Those depending for their action mainly on the element of temperature; they may be styled the *Thermal* baths, and include—

Plain water baths, hot, indifferent, and cold.
The Turkish bath.
The Berthe bath.
The Russian or vapour bath.
Local vapour baths—Berthollet baths.
Superheated air baths—
  Greville system (non-luminous heat).
  Dowsing system (luminous heat).
Local douches, depending on temperature for their effect.
The Still Sitz bath.

2. Those depending for their action not on temperature alone, but having the superadded effect of the

chemical constituents of the mineral water employed. They may be styled the *Thermo-chemical* baths, and include—

The Sulphur baths, which may be further subdivided into—

Saline sulphur: Natural. / Strong. / Mild.

Alkaline sulphur: Starbeck Spring. / Beckwith " / Harlow Car "

The Nauheim bath (still).
Medicated vapour baths (Berthe system).
Peat baths.
Brine baths.
Pine baths.
The Schwalbach bath.
The Liver Pack.

3. Those in which there is, added to the effect of temperature, the mechanical action of water in the form of sprays, douches, effervescence, &c., with or without the mechanical effect of massage. These may be styled the *Thermo-mechanical* baths, and include—

The Needle bath.
The Combined Needle and Douche bath.
The Nauheim bath (aerated).
The Schwalbach bath.
The Plombières bath.
The Running Sitz bath.

And those with massage—

The Aix Douche.
The Vichy Douche.
The Turkish bath (with shampooing).

4. Those in which to the thermal element is added the factor of electricity, in the form of a current passing through the water. These may be called the *Thermo-electric* baths, and include—

The Galvanic bath (constant current).

The Faradic bath (interrupted current).

The Sinusoidal bath (alternating current).

5. Those in which the factor of electricity is the sole or dominant one, and which may be styled the *Electric* baths proper. They include—

The D'Arsonval High Frequency Current.

The Electric Light and Ozone bath.

The X-Rays.

The foregoing classification is somewhat arbitrary, for the factors that come into play are in many cases multiple, so that some of the baths fall into two or more groups. For example, the aerated Nauheim bath belongs to the thermo-chemical group, being a mineralised bath, and to the thermo-mechanical group from the mechanical factor of effervescence which comes into play. Similarly, the electric immersion bath given with mineral water combines three factors, the thermal, the mechanical, and the electrical (excluding from consideration here the factor of pressure from the weight of water which obtains in all immersion baths, and which will be dealt with later); while in the electric light and ozone bath are combined the effects of heat, of light, of the inhalation of ozone, and of the high frequency electric current. The arrangement is, however, made for convenience of description, and is based on what appears to be the most prominent factor in each bath.

1. Thermal Baths

The Turkish Bath may be shortly described for the benefit of those to whom the mode of procedure is unfamiliar. The bather, after stripping, is provided with a sheet towel and a loin cloth; he then enters the first of the hot rooms, which is usually at a temperature of about 130° F., and, after douching the head with cool water, remains for a few minutes in the room until he gets used to the heat; or he may begin, as is frequently done, with a few minutes in an adjoining chamber supplied with moist steam heat. He then passes to the second room at a temperature of 170°–180°, where he remains a brief period until accustomed to the atmosphere, after which he proceeds to the hottest room, temperature 210° F. Here he stays for 5 or 10 minutes until sweating begins, when he returns to the middle room and remains for 10–15 minutes or more until sweating has freely taken place. He then goes back to the first room for a further 10–15 minutes, where sweating still continues, after which he passes to the shampooing room to be shampooed from head to foot. During exposure to the hot rooms perspiration is materially hastened by the slow sipping of cold water. The next proceeding is a wash with soap and water, to be followed by a needle bath begun at a temperature of 98° F. and gradually cooled down to 70°, 60°, or 55° F., according to taste or prescription; after which a plunge bath, if desired, at a temperature of about 65°, concludes the bath, and leads the bather to the cooling room, where he reclines on a comfortable couch and cools off, with the accompaniment, if so disposed, of coffee and a cigarette.

A common mistake made by those unaccustomed to the Turkish bath is to proceed slowly from the room of lowest temperature to that of the highest; this is apt to throw a strain on the heart and to lead sometimes to fainting. The correct way is to proceed rapidly to the hottest room and work slowly downwards to the lower temperatures. By this means the great heat is best endured when the heart is still fresh and not enfeebled by exposure to it. Another point worthy of emphasis is that as little movement as possible should be performed in the hot rooms, otherwise the strain of movement added to that of the heat is apt to tell severely on the heart and to cause uncomfortable palpitation, if not actual fainting.

It is advisable for those taking the bath for the first time not to enter the hottest room at all; in a subsequent bath, if the first has been well borne, they may venture on the entire proceeding.

The Berthe Bath is given either alone, or as a preliminary to the Vichy douche. It consists of a wooden box in which the bather sits, with his head protruding from an aperture in the top, a mackintosh sheet and a towel being closely applied to the neck to prevent the escape and consequent inhalation of vapour. Steam is then admitted to the box at a temperature of 120° for twenty minutes or more. Certain volatile oils, such as eucalyptus, rosemary, or pinol, may be vaporised with the steam, and impart an agreeable fragrance to the bath, but thus externally applied their therapeutic effect is negligible.

The Russian Bath consists of a room or chamber filled with steam at a temperature of about 120° F., into which the bather enters and remains seated for fifteen to twenty minutes. It is followed by a shampoo, as in the

Turkish bath, and a subsequent needle bath, if desired. In its mode of action it resembles the Berthe bath, but is less pleasant to take, because the steam-laden atmosphere is inhaled, whereas in the Berthe bath the head, being out of the box, is not exposed to the vapour.

The Berthollet Bath is designed for the application of steam heat locally to any given portion of the body, for example, the knee, foot, or hand. It consists of light metal cases, adapted in shape to various parts of the body, and connected with a central cylinder from which the steam is supplied. The affected limb is placed within the case, securely packed to prevent the escape of steam, and exposed to the vapour at as high a temperature as can be borne—generally 120°–125° F.—for a varying period up to half-an-hour or more. It is usually followed by sponging with salt water and by massage, and is a valuable method of treatment in cases of chronic enlargement of the joints.

The Greville Bath is designed for the application of dry air at a high temperature to the whole or to any separate part of the body. The apparatus consists of light aluminium cases, differently shaped for adaptation to particular parts of the body. Within them are stretched on metal frames, immediately beneath the surface, an immense number of fine wires like the strings of a harp. When an electric current is passed through these a dull heat is set up, which can be regulated to a nicety by shutting off from the circuit more or less of the wires, while with all in play the temperature can, if necessary, be raised to over 500° F. The lightness of the cases and their portability render their adjustment to any part of the body an easy matter. Careful observation of the temperature is ensured by a thermometer which protrudes through the casing. The baths are usually given for periods of from twenty minutes to one hour, at temperatures ranging from 200° to 400° or over, the part being protected from scorching by packing with asbestos and swathing in lint. It is probable that the temperature of the air space of the box largely exceeds that at the surface of the skin; it has, indeed, been shown that for each layer of lint applied to the part 100° F. of heat approximately is lost.

The Dowsing Bath resembles the Greville in general principle, differing from it in respect of the source of heat which is derived from incandescent electric lamps, and is, therefore, a luminous heat. The cases are constructed of burnished copper, from the inner surface of which the heat and light rays are reflected on to the skin. Whether the light rays induce any definite therapeutic effect in addition to that of the heat rays alone is a question which is still unsettled. As a rule, the temperature which can be borne without discomfort in the Dowsing system is not so high as in the Greville, the usual range in the former being from 250° to 350° F. for periods up to three-quarters of an hour.

Local Douches vary in form, and include simple douches, local needle douches given through a rose, and the wave douche: they need no special description.

The Still Sitz Bath in its simplest form is merely an ordinary hip bath. In the special sitz bath arrangements are provided whereby an ascending simple douche, or a needle douche, can be given, if desired, to the perineum or vagina coincidently with the sitz bath.

2. Thermo-Chemical Baths

This group includes the *Sulphur Baths,* divided as indicated into *Saline-Sulphur* and *Alkaline-Sulphur,* with their subdivisions. The water to supply these baths (excluding for a moment the alkaline sulphur) rises from various springs not used for drinking purposes, and is carried by pumping or gravitation into large storage tanks. The springs differ somewhat in individual composition, though generically they are the same, and their waters mingle in the tanks, where they remain until drawn off for bathing purposes, deterioration being prevented by the use of floating air-tight covers made of vulcanite. Separate reservoirs are used for storing the strong and mild waters. These in their natural state being athermal, artifical means of heating them are adopted, as in the case of the waters used for drinking. A *natural* sulphur bath consists of the strong sulphur water, undiluted, raised to the required temperature by passing on its way to the bath through a "therma" or heating apparatus of coiled tubing. The *strong* sulphur baths consist of the same water raised to the required temperature by dilution with hot plain-water, while the *mild* sulphur baths are drawn from reservoirs in which the milder waters are stored, and are diluted with hot plain-water in the same way.

Constituents — Saline-Sulphur Baths. — The total quantity of solids in the natural sulphur bath amounts on the average to 243 grains per gallon, and consists chiefly of the chlorides and carbonates of sodium, calcium, and magnesium, the chlorides being largely in excess, and the carbonates forming relatively a very small proportion of the whole; hence the name "saline" sulphur. Of the chlorides, that of sodium greatly preponderates. Besides the saline constituents there is the important ingredient sodium sulphide, which amounts on the average to 1·88 grain per gallon, and about 2 cubic inches of sulphuretted hydrogen gas. In the strong sulphur baths the total solids amount to an average of 155 grains per gallon, the sulphide to ·96 grain per gallon, while the mild sulphur bath contains rather less than half these quantities. Considerable variation takes place in the amount of these constituents, the sources of variation being as follows: firstly, the varying yield of water from the different springs; secondly, the loss of sulphide and sulphuretted hydrogen entailed in the process of pumping to, and storing in, the reservoirs; thirdly, the loss that takes place, in the case of the natural sulphur bath, in the process of heating in the therma; and, fourthly, the weakening that results, in the case of the strong and mild sulphur baths, from admixture of a varying amount of hot plain-water to raise the bath to the required temperature. The first source of variation is uncontrollable. The second, resulting in loss of sulphide and gas, is reduced to a minimum by the special methods adopted in pumping and storing to prevent access of air, thereby obviating the deposition of sulphide and the escape of gas. The third, in the heating by the therma, is unavoidable, though fortunately the loss is insignificant. The fourth source of variation, resulting in a varying proportion of saline constituents in the bath, is obviated by keeping the diluting water at as high and constant a temperature as possible (190° F.), so that approximately the same amount shall be required at any time to bring a bath up to a given temperature. Thus every effort is made to ensure the baths being as constant in composition as circumstances will permit. It will be seen from a comparison of the above figures that the strong sulphur bath is somewhat over half the strength of the natural, the pure sulphur water requiring to be diluted with a nearly equal volume of hot plain-water to raise it to an average temperature, *e.g.* 98° F.

Alkaline-Sulphur Baths.—Of these there are three varieties, the Starbeck, Beckwith, and Harlow Car Springs. The latter is supplied in a local bathing establishment in the immediate vicinity of Harrogate; the two former have been isolated and conducted to the town, where they are now available for bathing purposes. In composition these baths differ in important respects from the saline-sulphur baths. The Starbeck water contains, besides a relatively large quantity of sulphide (1·3 grain per gallon), the same salines, but in widely different proportions, the carbonates (of sodium, calcium, and magnesium) being increased, and amounting on the average to as much as one-fifth of the chlorides. The Beckwith water contains 2½ grains per gallon of sodium sulphide in 33 grains of total solids, of which as much as 26 grains is made up of carbonates, while the chlorides amount to only 4 grains per gallon. The Harlow Car water resembles the preceding closely, containing a slight increase of total solids and sulphide; the carbonates and chlorides, however, are in the same relative proportion.

From the point of view of treatment this distinction is important, for chlorides in solution are stimulating to the skin, while carbonates exercise a sedative action; hence the alkaline-sulphur baths are peculiarly fitted for the treatment of certain cases of skin disease in which hyperæmia or undue sensitiveness of the skin preclude the use of the more stimulating saline-sulphur baths.

The sulphur baths are usually prescribed at temperatures varying from 94° to 100° or over, the duration being fifteen minutes to half-an-hour; twenty minutes is perhaps the most common period used.

The Nauheim Baths.—The *Still* baths are made in imitation of the natural water at Nauheim by the addition of salines to plain-water, or, if desired, to sulphur water. The milder baths are obtained by dissolving sodium chloride in the proportion of 1 per cent., or 5 pounds, to a bath of 50 gallons, and the strength is gradually increased in subsequent baths to 2 per cent., 3 per cent., or more, while if thought advisable to promote cutaneous excitation, chloride of calcium may be added in the proportion of ·2 per cent. (or about 15 oz. to 50 gallons), and gradually increased to ·3 per cent., or eventually to ·5 per cent. For the production of carbonic acid effervescence in imitation of the *Aerated Nauheim baths,* sodium bicarbonate and hydrochloric acid are further added in increasing proportions to obtain successive degrees of effervescence corresponding to the milder and stronger natural waters at Nauheim. Four different baths are commonly employed at Harrogate, the respective strengths of which to 50 gallons of water is shown in the following table:—

	No 1.	No. 2.	No. 3.	No. 4.
Sodium chloride	11 lbs.	13 lbs.	15 lbs.	11 lbs.
HCl . . .	10 oz.	11 oz.	15 oz.	25 oz.
Sodium bicarbonate	8 oz.	9 oz.	12 oz.	20 oz.

The calcium chloride is usually omitted, as it has not been found to produce any additional effect at all commensurate with its cost when obtained by evaporation of the natural Nauheim water.

In No. 4 bath the effervescence is much increased, while the proportion of sodium chloride is diminished to that of the weakest bath.

The strongest bath at Nauheim, the flowing Sprudel, in which a constant stream of naturally aerated water is flowing through the bath, cannot be artificially imitated.

The Nauheim baths are also given at Harrogate by the use of Sandow's tablets and powders, the former of which appear to consist of an acid sulphate of potash, the latter of sodium bicarbonate. A brisk effervescence can be obtained by these means and can be varied by the addition of more or less of the salts.

Thus to the thermo-chemical element in the still Nauheim bath is added the further factor of the mechanical action of the bubbles of gas impinging upon the skin in the aerated Nauheim bath, with a consequent marked increase in stimulating power.

The Medicated Vapour Baths have been shortly described under the heading of Berthe baths. They possibly have an æsthetic, but no therapeutic, value.

The Peat Baths.—The material for these baths is obtained from the moors in the neighbourhood of Harrogate, and consists of peaty earth, richly charged with organic acids, and containing a small proportion of iron. The peat is first cut, broken up, and mixed in a mechanical mixer to the consistence of a thick pulp; it is then placed in the bath and raised to the required temperature by live steam, which is driven through it. These operations take place outside the bathroom; when ready, the bath is run on rails through an aperture in the wall into the bathroom proper, where there is a second bath of plain-water to be taken after the peat for purposes of cleanliness. The temperature of the peat bath varies from 98° to 104° or over, and the duration from twenty to forty-five minutes, according to the requirements of individual cases.

The Brine Baths.—For these brine is brought from Middlesborough, by rail, in large quantities. The usual procedure adopted is to dilute the brine one-half with hot water to the required temperature, the result being a bath of specific gravity 1·104 containing about 11,522 grains of brine to the gallon.

The Pine Baths are made by the addition to an ordinary plain-water bath of about 10 oz. of the liquid extract of pine tree prepared from the tops of *Pinus sylvestris*, and obtained from Homburg. It imparts a fragrant odour to the bath, but its therapeutic value is probably minimal.

The Schwalbach Baths, or carbonated chalybeate baths, are obtained artificially in imitation of those at Schwalbach by the use of Sandow's powders and tablets. These contain an alkaline carbonate and an acid sulphate of potash for the production of effervescence, while iron is incorporated in the form of ferrous carbonate, and forms an abundant reddish-brown flocculent precipitate, which deposits on the surface of the body. It is difficult to see how the iron can be of any therapeutic value, as there is no evidence to show that it is capable of absorption through the skin.

The Liver Pack.—This is unquestionably a most valuable adjunct to other modes of treatment in sluggish, congested, or enlarged liver. It consists of a huge poultice of mustard and bran, which is applied over the hepatic region from the mid-line in front to the spine behind, the patient being enveloped in blankets to promote sweating. It is kept on for twenty minutes, or as long as the patient can stand it, and is followed by a refreshing needle douche. It may be given twice or thrice a week, or even daily if the skin will bear the repeated counter-irritation.

3. Thermo-Mechanical Baths

The Needle Bath consists of a vertical cage constructed of tiers of circular, or rows of vertical, metal tubing supported by uprights, and pierced with innumerable pin-holes, through which the douche is projected upon the patient standing within. The pipes conveying hot and cold water meet in a mixing box—in which a thermometer is placed—before reaching the douche, so that the temperature can be regulated to any desired degree. The duration of the needle bath is usually two to five minutes, at a temperature of 98 degrees, which is gradually or quickly reduced to tepid, cool, or cold, as prescribed.

The Combined Needle and Douche Bath is of somewhat larger size than the ordinary needle bath, and in addition to the pin-holes for projecting the needle douche, has arrangements for administering other douches at the same time, viz. a descending "wave" douche, a shower douche, a vertical needle douche to the spine, and ascending and descending simple douches which can be directed to any spot. These supplementary douches can be given at varying or alternating temperatures, which may differ from that of the general needle bath. The platform on which the patient stands can be raised or lowered by hydraulic pressure to suit any particular height.

The Plombières Bath.—Quite recently facilities have been introduced at Harrogate for the administration of the sub-massive abdominal douche, and for washing out the colon, in the treatment of muco-membranous colitis and other abdominal affections, following the principles adopted with conspicuous success at Plombières. The bath is an ordinary immersion bath of plain or mineralised water, as may be desired, in which the patient lies at a temperature of about the body heat. Beneath the surface of the water is a flexible pipe terminating in a finely perforated rose, through which a hot douche of any required temperature can be given to the abdomen. To prevent undue raising of the general temperature of the bath by the addition of so much hot water, arrangements are provided for an inlet of cool water and an overflow outlet, by which means the temperature can be kept practically constant, notwithstanding the fact that the hot douche may be flowing the whole time.

For washing out the colon a hydrostatic douche is given through soft rubber rectal tubes, which can be readily sterilised by boiling. Any prescribed mineral water can be given in douche form.

The Running Sitz Bath.—This is identical in form with the still sitz bath before described. It differs in detail, having a suitable arrangement of inlet and outlet pipes which permit a rapid and continuous flow of water through the bath, whereby the therapeutic effect is enhanced.

The Massage Douche on the Aix-les-Bains system has been extensively used since its first introduction at Harrogate some years ago. The patient is seated on a wooden stool and a continuous needle spray is directed against the spine, while massage is administered by one or more attendants, under a warm douche conveyed by a flexible tube passing over the shoulder of the masseur and playing between his hands. The massage is performed in the following order: the limbs, back, neck, chest, and lastly the abdomen; or it may be especially directed to any particular part. The temperature of the douche can be varied at will, and the bath may terminate by a general or local hose douche at a raised temperature, or by a needle douche graduated slowly to tepid, cool, or cold, according to the requirements of the particular case.

The Vichy Douche, introduced some years ago, resembles the Aix douche in principle, though differing from it in procedure. The patient lies in the recumbent posture on an india-rubber air mattress, while massage is administered under a spray douche projected from a series of brackets pierced with pin-holes and suspended above the table. The temperature and pressure of the spray can be varied at pleasure, and can be directed either generally, or locally to various parts. Owing to the position of the patient, massage to the body—and especially to the abdomen—can be more efficiently performed than in the Aix douche. The bath may be given alone, or following a hot air or vapour bath in the Berthe apparatus before described.

4. Thermo-Electric Baths

In the electrical department at the Royal Baths there is a complete installation of apparatus necessary for administering electric immersion baths. The constant or galvanic current, the interrupted or faradic, and the sinusoidal or alternating current can each be given, the dosage being carefully regulated by the milliampère meter. Either plain or mineralised water can be used. Also arrangements are provided for the local application of each form of current.

5. Electric Baths

In common with other health resorts, the D'Arsonval high frequency current has been much used of late years at Harrogate. Though no water is used, and, therefore, strictly speaking, it cannot be called a bath, yet it may be included under the generic term of baths, being in its general application a bath of electricity. A detailed description of the apparatus would be out of place here; special works on the subject must be consulted for the purpose. Suffice it to say that the instruments are kept completely up to date and the most modern appliances used. The modes of application are as follows:—

1. *Direct Application,* in which the current is passed through the patient by connection with the ends of the small solenoid.

2. *Unipolar Application,* in which the patient is connected to the solenoid by one electrode, the other being in the hands of the operator, who can thus direct the current to any particular part.

3. *Autoconduction,* in which the patient is enclosed within the solenoid, though not in actual contact with any part of it. The passage of the current through the solenoid induces high frequency currents through the patient, which may be rendered visible by drawing sparks from him on approaching any part closely with the finger.

4. *Autocondensation.*—This is the method most extensively used for general electrification of the body. The patient lies on a couch, the cushions of which consist of insulating material; beneath the cushion is a metal plate connected with one end of the solenoid, the other end being connected to two metal electrodes, which are grasped in the hands. The patient then becomes one armature of a condenser, the other arm being constituted by the metal plate.

5. *Local Application.*—In this method one end of the solenoid is connected to a spiral of thick copper wire, while from the other end a brush discharge or "effleuve" can be applied locally to any part by metal electrodes of various shapes, or by means of glass or vacuum electrodes of low resistance.

Application of the effleuve at a sufficient distance to avoid sparking has a soothing, anodyne effect; closer application with sparking produces a greater local reaction, and if unduly prolonged acts as an irritant.

Another mode of local application is the so-called *electric massage.* The electrode is attached to the wrist of the operator, who massages the patient through the clothes, the current passing through his hands and through the clothes, and sparking on the surface of the body. This method if severely applied acts as a brisk counter-irritant and produces marked local reaction, as shown by active hyperæmia of the skin, and sometimes a more or less persistent papular or erythematous rash.

The usual length of application of the D'Arsonval current in its various forms is from ten to twenty minutes, on alternate days, or sometimes daily; the dosage varies from 150 to 400 or more milliampères.

The Light and Ozone Bath consists of a large closed cabinet, in which is a glass shelf on which the patient lies in a supine position. Above him are suspended a series of incandescent electric lights, the rays from which are reflected vertically downwards on to the body, the face and eyes being protected from the glare by the interposition of a green shade. In the corner of the cabinet an active and continuous manufacture of ozone is proceeding by means of an electric current of high frequency streaming off a brush electrode of circular shape. By this means the atmosphere of the cabinet is highly charged with ozone, which can be readily recognised by its characteristic smell, and which probably has considerable therapeutic effect, as will be shown later. The patient remains in the cabinet for twenty-five minutes, during the last ten of which a high frequency current is passed through the body through a vacuum electrode held in the hand. The temperature of the cabinet averages about 100° F., and that of the surface of the body exposed to the light rays about 110°. Sweating early and freely takes place. There are thus many factors at work in the bath—the effect of heat, of light, of inhalation of ozone, and of the high frequency current.

The X-Ray apparatus needs no description. It is sufficient to enumerate it among the available resources.

The foregoing brief description of the nature and composition of, and the procedure adopted in, the various baths is necessary as a preliminary to what follows as to their physiological action. A more detailed account is superfluous, and would be tedious. It should be stated, however, that the mechanical arrangements provided at the Royal Baths are complete in every detail. The building has been so constructed as to permit of invalid-chairs being wheeled direct into the bathrooms without encountering any steps. In this way is avoided the necessity of subjecting crippled patients to the difficult or possibly painful proceeding of walking even a short distance.

THE PHYSIOLOGICAL ACTION OF THE BATHS

Within the limits of a work of this character it is impossible to enter minutely into a discussion of all the far-reaching physiological effects of bathing in its many forms. To do so would be beside the purpose of the writers, which is merely to indicate the main outlines of the subject, in order to serve as a guide to the diseases likely to derive benefit from such treatment, and also as a help to the better comprehension of the results obtained. The processes of the human organism that are disturbed in a greater or less degree even by simple baths are so many, and their interaction so complex, that it becomes a matter of great difficulty, in the first place to define the disturbances, and in the second place to estimate their relative importance; while with the more complicated baths where various factors—thermal, chemical, mechanical, or electrical—are brought into play, acting in different directions, often, apparently, in direct opposition to each other, the difficulty becomes even greater. Although we can ascertain approximately the physiological result in any given case, it is impossible to do more than draw inferences as to the mode by which that result was produced, and as to what extent one factor or another was concerned; our inferences must be more or less conjectural. The pursuit of exact knowledge in this respect belongs rather to the domain of the pure physiologist than the clinician, although the latter must have a clear conception of the processes involved as a basis for the intelligent use of bathing as a therapeutic agent.

The chief factors that come into play in these baths are: *temperature, chemical constituents,* the *mechanical factors of percussion and massage,* the *hydrostatic effect of water, electricity, light,* and *ozone.* It will be convenient to consider each of these separately in a general way, and to refer to particular baths where necessary.

Temperature

In most forms of bathing this is perhaps the most important factor at work, acting, as it does, most powerfully on the vaso-motor system. *Hot baths* (temperature 98°–105° F. or over) cause a momentary constriction of the cutaneous arterioles and a transient rise of blood pressure. This is followed immediately by a rapid dilatation of the peripheral vessels and a fall of pressure, sometimes considerable. Reaction of the vessels to heat (or cold) is probably in part a local and in part a reflex effect (Onimus). With the fall in arterial pressure a fall in venous pressure usually occurs, though to a less extent; sometimes even a rise in venous pressure may be observed.[1] For example:—

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[1] For detailed observations, see "The Effect of Baths, Massage, and Exercise on the Blood-pressure," Edgecombe & Bain, *Lancet,* June 10, 1899.

Hot Bath—10 Minutes, Temperature 106° F.

	Pulse-rate.	Arterial Pressure, mm. Hg. Maximum.	Arterial Pressure, mm. Hg. Mean.	Venous Pressure, mm. Hg.
Before . . .	62	185	130	20
After . . .	64	170	117	15

Warm Bath—15 Minutes, Temperature 100° F.

	Pulse-rate.	Arterial Pressure, mm. Hg. Maximum.	Arterial Pressure, mm. Hg. Mean.	Venous Pressure, mm. Hg.
Before . . .	60	190	135	17
After . . .	60	180	130	15

If we contrast the percentage fall of arterial pressure with the percentage fall of venous pressure, we find that the fall in venous pressure is in greater proportion than the fall in arterial pressure. A diminished output of the heart would tend to determine a rise in venous pressure; therefore, as we know that heat produces local vascular dilatation, these changes may be explained as a result, in the first place, of peripheral dilatation of the arterioles, and, secondly, of increased capacity of the relaxed vascular system.

This peripheral dilatation is probably to be interpreted as an attempt on the part of the organism to get rid of heat in order to diminish the effect of the increased heat supplied by the water. Diminished combustion takes place within the tissues, as the external application of heat requires less to be produced by metabolic processes for the maintenance of the normal temperature. A corroborative fact is found in the diminished output of carbonic acid which occurs during the hot bath.

The volume of a limb, as measured by the plethysmograph, is increased after immersion in hot water;[1] the increase, however, rapidly disappears, showing that it is mainly due to temporary affluxion of blood to the part, and therein it differs from the increase in volume resulting from exercise, which persists for a considerable period after cessation of movement.

Coincidently with peripheral vaso-dilation there is a compensatory central vaso-constriction, whereby the central organs are rendered for the time more or less anæmic. This is shown by the experiments of Winternitz,[2] who found that a hot sitz bath caused a decrease in the volume of the arm, and by those of Schüller,[3] who found, in rabbits, that immersion of the body in warm water caused a dilatation of the vessels of the exposed pia mater, followed immediately by a constriction proportionate to the amount of the body immersed.

These changes in blood-pressure, and in the distribution of the blood in the body, are accompanied by alterations in the state of the *blood* as estimated by the

[1] Winternitz, *Die Hydrotherapie auf physiologischer u. klinischer Grundlage*, 1890.

[2] *Ueber thermische Wirkungen auf die Blutvertheilung in die Hydrotherapie*, Band i., 1890.

[3] *Deutsche Archiv. für klinische Medecin*, Band xiv. For a useful epitome of the experimental work on thermal therapeutics by Naümann, Schüller, and de Mosso in animals, and by Winternitz, Istamanoff, de Mosso, and Bergesis in man, see Professor Hayem's *Leçons de Thérapeutique, les Agents Physiques et Naturels*, 1894, or Hare's translation of this work; also Baruch, *Hydrotherapy*, 1904.

means at our command. It has been shown by Winternitz,[1] Knoepfelmacher,[2] Mangranti,[3] and other observers that the leucocytes, erythrocytes, hæmoglobin, and specific gravity of the blood are all diminished after a general hot bath. For example:—

	Hæmoglobin.	Corpuscles.	Value of Corpuscles.
	Per cent.	Per cent.	
Before immersion . .	95	99	·96
After 15 minutes in a bath at 105° F. .	89	93	·96

The hæmoglobin and red corpuscles do not always fall in equal ratio, hence the blood-decimal or hæmoglobin value of the corpuscle becomes altered; usually it is reduced.

Further, a local hot bath to the legs causes an increase in red cells of the blood drawn from the part affected by the heat, and a diminution in that taken from a remote part, such as the lobe of the ear (Winternitz).

These changes are not to be explained by actual loss in the number of corpuscles, but are due to alterations in the relative proportion of plasma to blood-cells—a result partly of altered distribution of the blood, and partly of diminished transudation of fluid to the tissues. Loewy[4] showed that by exposing rabbits to a temperature of 86°-96° F. for twenty-four hours, the blood became reduced in density, in spite of perspiration, and that an equal thinning of the blood took place after a brief exposure of

[1] *Blätter für klinische Rundschau*, 1893.
[2] *Wiener klinische Rundschau*, 1894.
[3] *Giornale della Reale Accademia*, 1895.
[4] *Berliner klinische Wochenschrift*, 1896.

fifteen to thirty minutes to a temperature of 140°-150°. The tissues therefore became poorer in water, which was proved by the fact that the water content of the muscles was diminished. The density of the serum, however, remained unchanged. Through the stimulus of heat the sectional area of the peripheral blood-vessels is increased, the resistance to the blood-flow becomes less, the blood pressure falls, diminished transudation of plasma takes place from the vessels to the tissues, and there is therefore a relative increase in plasma, and a dilution of the blood. This cannot, however, be the whole explanation, for though the pressure is reduced in the small arteries it is not necessarily lowered in the capillaries, and the amount of transudation depends on the capillary pressure. Osmotic processes alone, therefore, cannot produce a thinning of the blood, as is maintained by Grawitz. Nor can the loss of fluid by evaporation suffice to cause increased viscidity, for sufficient loss cannot occur in a brief trial of thirty minutes to produce a marked increase in density. Though doubtless both these causes are contributory they are probably inadequate to explain the whole changes observed, and a further cause must be sought. According to Loewy, it is to be found in the fact that owing to the dilatation of the vessels minute channels are opened up which, hitherto filled with plasma alone, now contain corpuscles drawn from the larger vessels. Hence the blood in the latter becomes poorer in corpuscles, and apparently diluted. Cohnstein and Zuntz showed that changes in the capillary circulation are accompanied by alterations in the number of corpuscles in the blood, contracted capillaries leading to an increase, and dilated capillaries to a diminished number of red cells. These observations have been confirmed by Winternitz[1] and Knoepfelmacher.[2] A further factor must be taken into consideration, and that is the possibility of corpuscles being aggregated in large numbers in the internal organs after exposure to heat. Breitenstein,[3] after exposing rabbits to high temperatures, found an enormous increase in the corpuscles of the blood taken from the liver.

Such alterations in the composition of the blood may persist for a variable period—as much as two hours—after a hot bath, and are mainly due to altered distribution of blood in the body, since the volume of the blood is in all probability a practically constant quantity, subject only to the most transient variations.

The chemical constitution of the blood is said to be altered as the result of the hot bath. Strasser and Kuthy[4] showed that baths at a temperature of 110° F. caused an increase in the quantity of acid phosphate contained in the blood.

On the *heart* the effect of the hot bath is to cause a transient slowing of the beat, followed by an increase in frequency. If the latter be moderate, the output of the ventricle[5] may be increased, in which case it will tend towards raising the blood pressure, which, as we have seen, falls. If it be excessive, the output is usually diminished, in which case it will act in the same direction as the peripheral dilatation, and combine with it to lower the arterial and raise the venous pressure.

Respiration is increased, and this may be regarded as

[1] *Centralblatt für innere Medecin*, 1893.

[2] *Wiener klin. Wochenschrift*, 1893.

[3] *Archiv. für experimentelle Pathologie und Pharmakologie*, Bd. 32, 1896.

[4] *Deutsche medizinal Zeitung*, 1896.

[5] G. M. Stewart, "The Output of the Heart," *Journal of Physiology*, vol. xxii., 1897.

a further attempt on the part of the organism to promote loss of heat. Nevertheless the body temperature becomes slightly raised if the bath be hot and immersion prolonged. The secretion of sweat is increased, while the secretion of urine and, notably, the intestinal secretion is diminished. The excretion of urea is increased (Leichtenstern, Schleich, Godlewsky). The fatigue curve of muscle is shortened, and the muscular system is relaxed, the relaxation extending to unstriped muscle, such as the coats of the bowel. Along with diminished secretion, this affords an explanation of the constipation that occasionally results from too frequent use of hot baths. On the nervous system the hot bath exercises a distinctly sedative effect.

After the bath these effects persist for a variable period; they rapidly disappear if the temperature of the atmosphere be much below that of the bath, and persist for a longer time as the temperature of the latter is approximated.

The **Turkish Bath,** in which a much higher temperature can be borne than in an immersion bath, and for a much longer time, has a greater effect in dilating the peripheral arterioles, and lowers the arterial pressure to a greater extent. The venous pressure rises relatively or absolutely if observation be made during or immediately after exposure to the hot rooms. If made after the complete bath, the effect is modified by the massage administered during the shampoo, and by the cool plunge taken subsequently. These measures serve partially to restore the pressure, and to prevent the exhaustion and impairment of the vaso-motor compensatory mechanism which might otherwise result from prolonged exposure to great heat.

Examples :—

Turkish Bath—General Dry Heat.

	Pulse-rate.	Arterial Pressure, mm. Hg. Maximum.	Arterial Pressure, mm. Hg. Mean.	Venous Pressure, mm. Hg.
Before . . .	70	200	135	25
After seven minutes in hottest room at 210° F. . . .	120	155	100	20
In cooling room after shampooing . .	74	170	115	20
Before . . .	64	170	125	20
After twenty minutes in second room at 170° F. . . .	110	140	85	17
In cooling room after shampooing . .	70	155	110	20

Here the fall in arterial pressure after exposure to high temperature is considerable, while the fall in venous pressure is insignificant. These changes are accompanied by a marked increase in the pulse-rate, which is nearly doubled. In the light of Stewart's researches on the output of the heart, the diminished output that accompanies a great increase in the frequency of the pulse may share in the production of the lowered arterial pressure, for he finds that "in general when the pulse-rate increases considerably, the output per heart-beat diminishes, while the output per second may or may not alter, but is usually diminished too, although not in the same proportion as the output per beat." Arteriolar relaxation also takes place, and both factors act in the same direction and combine to lower the arterial pressure. During the cooling process the arterial pressure rises somewhat, but the net result is a fall, while the venous pressure in the one case remains the same, and in the other is slightly raised. The rate of the heart-beat has nearly returned to its original frequency.

On the volume of the blood the effect of the Turkish bath is modified by the profuse perspiration induced. The loss of fluid, derived ultimately from the blood, is indicated by a marked rise in hæmoglobin and corpuscles, which may be explained as due partly to changes in the distribution of the blood, and partly to a relative diminution in the amount of plasma to corpuscles, with apparent, though not actual, increase in their number.

	Hæmoglobin.	Corpuscles.	Value of Corpuscle.
Before bath . . .	98	98	1·00
After Turkish bath .	108	108	1·00

In fact there results a concentration of blood, which can be prevented to some extent by the copious ingestion of water during the bath. According to Klebs and Mayer,[1] a moderate leucocytosis occurs after sweating due to heat, the increase affecting chiefly the polymorphonucleated cells. They consider the therapeutic effects of sweating to be due, however, not to changes in the blood, but to changes in the circulation.

The effect of the Turkish bath on *metabolism* may be estimated by the changes it produces in the urine. According to Garratt,[2] the excretion of urea is slightly reduced, owing to the fact that a certain amount is carried off in the sweat. The uric acid is scarcely affected; a

[1] *Zeit für diätet u. physikal Therap.*, Bd. vi. Heft 7.

[2] *Journal of Physiology*, vol. xxiii. No. 3, 1898.

slight reduction sometimes occurs; an increase, however, has not been observed. The phosphates are slightly reduced in amount, while acidity, and the sulphates, are unaffected. The quantity of urine is of course markedly diminished; the diminution can be delayed, though not prevented, by freely taking water during the bath.

In the **Russian,** or **Vapour Bath,** inasmuch as the temperature, owing to the moisture of the atmosphere, cannot approach in height that of the Turkish bath, the circulatory changes set up are not so great, though they occur in the same direction. They may be modified when desired by the needle bath, which is often administered subsequently. Two examples show the effect of general moist heat with subsequent needle bath.

Russian Bath—General Moist Heat, 15 *Minutes at* 106° *F.*

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before	64	155	107	20
After bath and after needle douche two minutes, cooled to 70° F.	60	150	102	17
Before	72	175	130	25
After bath and after needle douche, cooled to 86° F. .	70	160	115	25

The needle douche administered after the bath was taken at a lower temperature (70° F.) by the first of these two subjects than by the second (86° F.); the resulting fall in arterial pressure is therefore less in the former case than in the latter, for the lowering of pressure by the moist heat is partially, though not entirely, abolished by the raising tendency of the cold and percussion.

The **Greville Bath** of "superheated" dry air at a temperature of 300° F. or over may be given to the whole body (excluding the head), or locally to any part, as a limb or a special joint. Applied locally it produces a local vascular dilatation, with determination of blood to the part. If the part exposed to the heat be relatively large, such as a leg, a general lowering of blood pressure in the systematic vessels may ensue. If the whole surface of the body be exposed, the result is a quickening of pulse and respiration, a marked fall in arterial pressure, and profuse sweating.

Example: normal subject.

	Mean Arterial Pressure.	Body Temp.
Before bath .	Radial artery (sitting) 115 mm. Hg.	97·4° F.
In Greville bath	" " (recumbent) 105 " "	
30 min. at 300° F.	" " " 80 " "	99·8° F.
15 min. after .	" " (sitting) 90 " "	98·6° F.
30 min. after .	" " " 100 " "	
80 min. after .	" " " 112 " "	

The body temperature may be raised 2 or 3 degrees F., or to a less extent if the bath be only local. It has been shown[1] that the application of dry heat by the Greville bath to the hind limb of a dog, at a temperature of 300° F. for forty-five minutes, will produce a rise of 1·8° F. in the general body temperature, and a rise of as much as 6·6° F. in the venous blood returning from the limb exposed to the heat.

The profound effect of these baths on the circulation renders caution advisable in their administration where

[1] Bain, *Journal of Balneology and Climatology*, April 1900.

the arterial tension is high, or where there is reason to suspect cardiac weakness.

To determine the effect of these and other baths on metabolism, a series of investigations[1] were made upon three subjects, all on fixed diet, before and during their administration. The blood was examined daily when most constant—viz. on rising in the morning—with respect to the hæmoglobin, red corpuscles, and leucocytes; observations were made on the blood pressure; the total output of urine was collected daily, and estimations made of the urea, sulphates, uric acid, phosphates, chlorides, and acidity.

A series of four Greville baths on successive days, at a temperature of 300° F. for thirty minutes to the whole body, caused an immediate diminution in the amount of hæmoglobin and corpuscles, with a subsequent rise to above the initial level shortly after the baths. The average hæmoglobin value of the corpuscle on the days before the baths was 1·00; during the four days on which they were taken the average rose to 1·02. The effect on the urinary constituents is shown in the following table:—

Normal Subject.		
	Average Daily Excretion before Baths.	Average during Baths.
Quantity	1190 c.c.	1320 c.c.
Urea	29·25 grm.	29·62 grm.
Sulphates	2·06 ,,	2·96 ,,
Uric Acid	·654 ,,	·729 ,,
Phosphates	2·17 ,,	2·45 ,,
Chlorides	11·13 ,,	11·65 ,,
Acidity in terms of oxalic acid	3·57 ,,	3·14 ,,

[1] For details see paper by Bain, Edgecombe, and Frankling, *Lancet*, April 29, 1905.

The urea does not show a diminution as occurs in the Turkish bath. Hence, as sweating is free and a certain amount of urea is lost through the skin, there is probably a relative increase in the amount excreted in the urine. This increase in urea and the marked rise in excretion of uric acid suggest that the circulatory changes excited have a distinct effect on metabolism, and consequently that they modify nutrition.

The **Dowsing Bath** has a similar effect to the Greville in reducing the arterial blood pressure, and in diminishing at first the red corpuscles and hæmoglobin, while subsequently increasing them.

Normal Subject.				
	Radial Pressure.	Mm. Hg.	Body Temp.	Volume of Corpuscles.
			Deg. F.	Per cent.
Before bath . . .	Sitting	115	97·2	98
	Recumbent	105		
Dowsing bath, temp. 280° to whole body, 30 min.				
In bath 20 min. . . .	"	65	99·2	
5 min. after bath . .	"	72	...	94
15 " " " . . .	"	...	99·4	
45 " " " . . .	Sitting	107	97·8	102

The fall in blood pressure is greater at a lower temperature than that obtained with the Greville, an effect probably due to the presence of the light rays. The hæmoglobin value of the blood is markedly reduced—in one case from 1·002 to ·957, in another from 1·00 to ·973 as a result of four successive baths at a temperature of 280° for thirty minutes. The cause of this fall in value or loss of hæmoglobin is difficult to explain. After the Greville baths a rise in value was observed. Since the only essential point of difference between the two baths is the presence of the light rays, it would therefore seem that to this cause must be attributed the fall in value, though it is stated by other observers that exposure to electric light rays causes an increase in hæmoglobin. On metabolism also the effects are dissimilar, a reduction in urea, sulphates, and acidity being observed; while in agreement with the results obtained with the Greville bath there is a marked increase in uric acid and phosphates eliminated.

Normal Subject, on Fixed Diet.		
	Average Daily Excretion on Free Days.	During Four Dowsing Baths.
Quantity	1251 c.c.	848 c.c.
Urea	32·01 grm.	30·41 grm.
Sulphates	2·21 „	2·19 „
Uric Acid	·687 „	·776 „
Phosphates	2·41 „	2·86 „
Chlorides	9·77 „	8·44 „
Acidity in terms of oxalic acid	3·22 „	2·54 „

Comparing the results obtained from the two forms respectively, it would appear that the effects common to both are an initial reduction in the volume of the corpuscles, with a subsequent increase, and a marked *plus* excretion of uric acid. On the other hand, the most important points of dissimilarity lie in the reduction of the hæmoglobin value of the blood by the Dowsing and its increase by the Greville, and in the greater fall in blood-pressure induced by the former at corresponding temperatures.

Whether there is any special therapeutic value in the presence of the light rays in addition to the heat rays is a debateable point. They give rise to a burning sensation, although they do not impinge directly on the skin, a layer of lint intervening through which they must pass before reaching the surface; consequently as high a temperature cannot be comfortably tolerated in the Dowsing as in the Greville bath. As has been pointed out by Finsen,[1] the incandescent electric light contains a very small proportion of the chemical rays —less, indeed, than in ordinary daylight—and though useful for sudatory purposes, exerts very little chemical effect. The opposite is the case with light from the electric arc. That radiant heat causes a greater reaction at a lower temperature, and raises the body temperature, local and general, to a higher degree than non-luminous heat, has been shown by one of us[2] in an experiment with the Dowsing bath, complementary to that mentioned under the Greville bath. The hind limb of a dog was exposed to a temperature of 250° F. (50° lower than in the Greville experiment) in the Dowsing box for forty-five minutes, at the end of which time the temperature of the venous blood returning from the limb had risen from 95·8° F. to 111° F., and the general temperature of the body from 95·8° F. to 99·3° F., a much more marked reaction than was obtained with the Greville system.

Cool or Cold Baths (from 90° F. downwards) give rise to effects practically the converse of those resulting from immersion in hot water. The peripheral vessels become contracted to a degree roughly proportionate to the reduction in temperature. At the same time compensatory dilatation takes place in the central vessels,

[1] *Meddelelser fra Finsen's Lys. Institut.*

[2] Bain, *loc. cit.*

notably those of the splanchnic area. Schüller[1] observed the vessels of the exposed pia mater in rabbits to dilate on immersion of the body of the animal in cold water, and Winternitz noted, in the human subject, an increase in the volume of the arm during a cold sitz bath. Conversely to the effect of the hot bath, peripheral constriction due to cold must be regarded as an attempt at preservation of heat by the organism in order to lessen the amount abstracted by the cold water; consequently the central temperature of the body becomes slightly raised if the bath be of brief duration. If it is more prolonged, abstraction of heat exceeds increased production, and the central temperature becomes lowered. With the increase in temperature more rapid combustion takes place, with accelerated tissue metamorphosis, which is shown by an increased output of carbonic acid, increased intake of oxygen,[2] and increased elimination of urea. According to Voit, there is augmented conversion of fat.

That the cold bath stimulates powerfully the metabolic changes which result in heat production has been shown by Zigelholts[3] by the following simple experiment. A bath containing 100 litres of water at 18° R. (22·5° C.) in a room at a temperature of 15° R. (18·7° C.) loses ·2° R. (·25° C.) in ten minutes. If an adult weighing 72 kilos, and having a body temperature of 36·7° C., be immersed in the bath for ten minutes, the temperature of the water rises ·8° R. (1·0° C.). That is to say, 100 litres of water become raised 1·25° C. by the heat of the

[1] *Loc. cit.*

[2] Winternitz and Popischl, *Neue Untersuchungen über den respiratorischen Gaswechsel unter thermischen und mechanischen Einflüssen*, 1893.

[3] *Deutsche medizinal Zeitung*, 1897.

body. Now, 125 calories are required to produce this rise in temperature. Hence the bather loses 125 calories in ten minutes, while at the same time his body temperature shows an increase of ·2° C. This illustrates in a striking way the relatively large quantity of heat produced by the body in a short time, the amount in this instance being equivalent to the energy contained in 30 grms. of albumin.

On the *arterial pressure* the effect of cold is to cause a rise which varies roughly in extent with the degree of cold employed, while the venous pressure falls. This result is brought about mainly by the peripheral resistance of constricted arterioles, but partly by increased cardiac contraction.

Cold Bath—2 Minutes at 55° F.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	70	190	130	25
After . . .	72	210	150	10
Ten minutes after .	70	185	125	25

The rise in pressure persists during the application of cold, unless the degree of cold be slight, in which case reaction may take place before it is withdrawn. In vigorous subjects reaction and fall in pressure may occur during the exposure to considerable degrees of cold.

The relative constitution of the *blood* is markedly altered by the cold bath, an increase in the leucocytes, erythrocytes, hæmoglobin, and specific gravity being observed.

	Hæmoglobin.	Corpuscles.	Value of Corpuscle.
	Per cent.	Per cent.	
Before bath . . .	102	99	1·03
After three minutes' immersion in cold bath, T. 45° F. . . .	106	103	1·03

Winternitz[1] in eighty observations found a maximum increase in red cells of 1,860,000 per c.mm., in leucocytes to three times the amount originally found, and in hæmoglobin of 14 per cent. He states that the maximum rise may not be observed immediately, but only after the lapse of a varying interval: that the leucocytes may remain increased after the red cells have begun to diminish: that the changes may persist for as much as two hours before returning to normal: and that in some cases, especially in anæmia, the blood does not return to its former level. These results have been confirmed in the main by Knoepfelmacher.[2] As a complement to these observations in the human subject on blood drawn from the surface, Rovighi has shown in animals that similar alterations take place in the blood of organs, such as the liver and spleen, following exposure to cold baths. Winternitz has further demonstrated that the application of cold locally determines an increase in red corpuscles at the point of application and a diminution in remote parts. As in the case of hot baths, these changes must be regarded as due mainly to altered distribution of blood in the body, and in some degree to a temporary concentration of the blood by transudation of fluid through the capillary walls, possibly the result of the

[1] Cohen's "System of Physiologic Therapeutics," vol. ix.

[2] *Wiener klinische Rundschau*, 1894.

increased pressure within the vessels. Though not due to actual increased formation of corpuscles, the resultant effect on metabolism is much the same, for cells are called into functional activity from the byways of the circulation, and become more available for purposes of oxidation.

On the *heart* the effect is, firstly, to increase the frequency of the beat; secondly, to diminish it: the brief application of cold acts as a stimulant, more prolonged application as a depressant to the heart: the output of the ventricle is probably at first increased, and afterwards lessened.

Respiration deepens: the output of carbonic acid is reduced and the intake of oxygen is augmented. Increased oxidation takes place chiefly in the muscles,[1] for if they be put under the influence of curare the tissue changes resulting from cold are reduced. The tonicity of muscle, both voluntary and involuntary, is increased, and unstriped muscle-fibre is stimulated to contraction. The effect of the cold bath on the capability of muscle for the performance of work has been strikingly shown by Vinaj and Maggiori[2] in a series of experiments on the fatigue curve of muscle. Using Mosso's ergograph, they found that after a bath of 10° C. (50° F.) for fifteen seconds the fatigue curve of muscle was greatly lengthened, and a similar result was obtained after a bath begun at 96° F. and cooled to 68° F. Further, the effect of cold upon a muscle already fatigued was to restore the contraction curve and to excite renewed power for work.

The body secretions, with the exception of the sweat, are increased, notably the urinary and intestinal secre-

[1] Röhrig and Zuntz, *Pflüger's Archiv.*, 1871.

[2] *Blätter für klin. Hydrotherapie*, 1892, vols. ii. and iii.

tions, probably as a result of the rise in blood pressure. On the nervous system the effect of the cold bath is tonic and invigorating.

Regarding the effect of the cold bath on *metabolism*, it has been shown by various observers that an increase in the excretion of urea, of uric acid, and of total nitrogen takes place. Formanek[1] found that the average excretion of nitrogen in the urine and fæces was 1·5 grm. more on bath days than on free days, and that the output exceeded the intake by ·59 grm., thus showing that the increased output was at the expense of the body albumin. Strasser[2] also found an increased excretion of total nitrogen in the urine and fæces as a result of the cold half-bath; and states that the nitrogen of the urine is increased, but that of the fæces is diminished, showing more complete absorption of food from the alimentary canal. The two sets of observations explain the increased appetite experienced, and emphasise the need for a generous diet in subjects taking cold baths.

According to Strasser,[2] the excretion of phosphoric acid is increased both absolutely and relatively to the total nitrogen; the increase affecting, however, only the alkaline, and not the earthy phosphates. He explains the *plus* phosphorus excretion as mainly due to greater absorption from the alimentary canal, and partly as derived from the lecithin of the red blood-cells, which are largely increased after exposure to cold.

The changes in metabolism resulting from the cold bath may be regarded in two phases—a primary metabolic change due to the reflex action of cold, which is said to cause no increase in proteid metabolism, but to affect

[1] Quoted by Strasser, *Fortschritte der Hydrotherapie*, Wien, 1897.
[2] *Ibid.*

only non-nitrogenous substances (Hagenbach, Röhrig and Zuntz, Voit); and a secondary metabolic change due to the abstraction of heat, which affects proteid as well as non-nitrogenous metabolism, and gives rise to a *plus* excretion of urea. It may also be followed by a rise in the body temperature, the result of an over-production of heat to compensate for the loss.

After the bath, or, in vigorous subjects, before leaving it, *reaction* takes place, with dilatation of the peripheral vessels and a sense of warmth throughout the body, a result which is aided by friction to the surface. The blood pressure falls, though not at once, down to, or below, its original level, and the pulse becomes full and soft. Winternitz calls attention to essential differences between the peripheral dilatation due to heat and the secondary dilatation during reaction from cold. The former he regards as "paralytic" in nature, the latter as possibly due to the action of inhibitory nerves on the blood-vessels, or possibly to an increase in calibre by contraction of the longitudinal fibres in the vessel wall, which has been shown by Exner[1] to be physically possible. In support of his contention he further points to the difference in character of the pulse to the touch in the two cases.

The difference in the hyperæmia following the application of cold and heat respectively is explained by Baruch[2] in the following way: The muscle and elastic fibres of the skin form a vicarious coat to the cutaneous arterioles and capillaries which aid in their support. This coat is very sensitive to changes of temperature, and by its contraction, together with the increased ventricular

[1] Academy of Science, Vienna, 1877.
[2] "International Clinics," vol. ii.

action called forth, supplies "tone" to the vessels dilated in the reaction after cold. Heat, on the other hand, relaxes the coat, and this, with diminished ventricular action, leads to relaxation of the vessels without "tone."

Among the remote effects of repeated cold bathing are increased tone of the nervous system, improved appetite, and augmented body weight.

Hydrostatic Pressure

This factor must be mentioned as one of those contributing to the effects produced by baths. The increase in pressure on the surface of the body immersed in water over the pressure of the atmosphere will depend on the specific gravity and depth of the water, and will tend to induce peripheral vaso-contraction, and to hinder respiration. It is estimated that the total additional pressure of an ordinary immersion bath of 50 gallons (230 litres) in an adult will amount to 1100–1320 lbs. (500–600 kilos). If the specific gravity of the bath be high, the depth of the body immersed will be less, so that the two causes of increased hydrostatic pressure to some extent neutralise each other. In any case, its influence on the net result is probably minimal.

Chemical Element

In the *Thermo-Chemical* group of baths, to the influence of temperature is added that of the chemical constituents of the water. These consist of salines, sulphide, and sulphuretted hydrogen gas in the case of the sulphur baths; of salines and carbonic acid gas in the case of the Nauheim baths; of iron salts and organic acids in the case of the peat baths, and so forth. The effect of these constituents must be viewed in two aspects with respect to the class of cases in which they are employed. The first of these is the effect on the circulatory system, and through it on the metabolic processes of the body generally; the second is the local effect on the skin, as in cases of skin disease, though here the larger and more widely reaching effects must by no means be overlooked. It is generally recognised that chemical constituents in waters used for bathing purposes are not absorbed to any appreciable extent through the skin. Water is certainly not absorbed. Gases, on the other hand, may be taken up—for example, sulphuretted hydrogen gas—though probably not in sufficient amount to produce any therapeutic effect. It is well known that water containing a moderate quantity of saline material in solution is distinctly more stimulating than plain water at the same temperature. This is no doubt to be accounted for by the action of the water in softening the outer layers of the skin, and thereby allowing the salines to penetrate to the fine nerve endings, by the stimulation of which reflex action is set up through the central nervous system. Thus it is possible with these baths to obtain the therapeutic effects of warm bathing at a lower temperature than with plain water alone, and to avoid the enervating and relaxing influence of heat. Especially is this so with the natural and strong saline-sulphur bath, less so with the mild. The chloride of sodium appears to be the chief stimulating ingredient, the carbonates being in relatively too small an amount to exert their sedative action. The action of the sulphide is somewhat obscure, although there is a distinct difference to be observed in the effects experienced on entering a bath containing sulphide in addition to salines and on entering one containing salines alone, the feeling of exhilaration and sense of warmth resulting from the bath being greater in the case of the former.

If observations be made on the blood pressure before and after the *saline-sulphur* baths, it is found that they lower the arterial and raise, either relatively or absolutely, the venous pressure to a greater extent than do plain water baths at the same temperatures.

Natural Sulphur Bath—20 Minutes, Temperature 98° F.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	72	175	125	22
After . . .	68	140	85	20

Strong Sulphur Bath—15 Minutes, Temperature 98° F.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	70	160	120	22
After . . .	70	150	110	15

They cause, in brief, a greater amount of peripheral dilatation, since the fall in pressure is mainly due to this cause, and there is no evidence of alteration in the output of the heart or other factors. The circulatory changes, as the examples show, are greater with the natural than with the strong sulphur bath, and are less marked with the mild, so that the effects produced become progressively greater as the amount of saline material in solution is increased.

In the observations previously alluded to[1] on the effect of baths on metabolism, the thermal sulphur bath was investigated, with the result that four baths (temperature 98° F., duration twenty minutes) on successive days produced no marked change in the blood or the urine beyond an increase in the quantity of the latter, the constituents examined remaining practically unaltered. Possibly a more prolonged series of baths would show a more distinctive effect.

The Nauheim Bath.—In the still Nauheim bath the same effect on the circulation is obtained, for at temperatures of from 94° to 88° F. a sense of warmth is experienced, with a fall in arterial[2] and rise in venous pressure, and slowing of the pulse, whereas with plain water the result is a slight rise of arterial pressure and quickening of the pulse rate. In the aerated Nauheim bath the mechanical action of the bubbles of gas impinging on the skin further increases the stimulating effect, and causes a greater fall

[1] Bain, Edgecombe, and Frankling, *loc. cit.*

[2] Hansen, in the *Deutch. Med. Woch.*, 1899, discusses the work done on CO_2 baths, and attributes the contrary results obtained on blood pressure by different observers to the use of unsatisfactory instruments for measuring it. He used the Riva-Rocci sphygmomanometer, and in a series of cases found that the blood pressure was always increased; that the rise was due to increased cardiac work (hence caution must be used in the prescribing of these baths); that the pulse varied, being sometimes slowed, sometimes accelerated; that the cardiac dulness varied; that the output of urine was always increased.

We suspect that the discordant results on blood pressure are probably due to the temperature of the baths employed. In the lower ranges—82°–86° F.—the constricting effect of cold is apt to overshadow the dilating effect of the salines and effervescence, and to cause a rise of blood pressure; in higher ranges—88°–94°—a fall of blood pressure will usually be found.

in arterial and a rise in venous pressure—that is, dilates the periphery to a greater extent than the still baths. This renders it possible to obtain the therapeutic effect at still lower temperatures without causing sensations of chill.

Still Nauheim Bath—20 Minutes, Temperature 93° F., 7 lbs., NaCl and 3 Ounces $CaCl_2$ to 30 Gallons of Water.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	54	190	115	5
After . . .	60	140	95	10
20 min. after .	60	155	110	7

Aerated Nauheim Bath—20 Minutes, at 93° F.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	88	165	125	12
After . . .	84	140	97	15
30 mins. after	84	145	105	20

Leith[1] found that plain water baths at 90° F. caused a slight lowering of the frequency of the pulse, which effect was not cumulative in a series of baths. The addition of sodium chloride to the bath produced a sense of exhilaration and further lowering of the pulse rate; the addition of calcium chloride, however, had no further effect, nor was any result obtained from its use alone without the sodium chloride. When the factor of effervescence was added, a further lowering of frequency

[1] *Lancet*, vol. i., 1896.

and increase of force of the pulse took place, but the effect of the aerated bath without the sodium chloride he found nearly equal to that obtained with the two combined.

Our observations tend to show that the aerated bath with salines exerts a greater effect in diminishing peripheral resistance than the saline bath alone, a larger fall of arterial and rise of venous pressure being obtained with the former than with the latter. Frequently as marked an effect is observed in this direction with the natural sulphur bath as with the Nauheim, though the quantity of saline matter in solution is much less in the former. Possibly the sulphide constituent present in the former may exert no inconsiderable stimulating effect.

Thus the effect of these saline baths on the circulatory system is to cause, in the first place, a marked peripheral vaso-dilation and a diminished resistance to the flow of blood, which affords relief to a labouring heart. Subjectively this is indicated by the relief of symptoms which is frequently experienced. Objectively it may be demonstrated by the diminution in the cardiac dulness which can be traced through successive baths. Although this may partly be explained as due to overlapping of the heart by the lungs distended by the deepened respiration excited, it has been shown by the use of the X-rays to be actually a fact; the size of the heart is in reality diminished by relief to the over-distension of its cavities. In the second place, a determination of blood to the surface takes place, leading to temporary relative anæmia of the central organs, whereby relief is afforded to such of these as may be congested, either actively or passively. In the third place, through these circulatory changes metabolism is accelerated, waste products carried off, and nutrition improved.

With respect to the aerated Nauheim bath, a further factor must be taken into consideration in attempting to arrive at the physiological action, viz. the inhalation of a definitely larger percentage of carbonic acid gas. This has the effect of deepening respiration, and so increasing the aspiratory force which aids in drawing the blood from the heart to the lungs, and so contributes to the relief of over-distension. Probably no other effect can be attributed to the carbonic acid, although it is said to increase actively the peristaltic action of unstriped muscle.

Woods-Hutchinson[1] endeavours to explain the action of the Nauheim baths by assuming the existence and functional activity of what he calls the "skin heart," by which he means a *rhythmic* contractility of the muscular walls of the arteries, arterioles, capillaries, veins, and lymphatics. He points to the existence of the skin heart in invertebrates and some vertebrates, such as frogs and fishes, and maintains that certain phenomena—for example, the rhythmic pulsation of the vessels in the rabbit's ear, the restoration of tone of the vessels after section of the vaso-motor nerves, the dicrotic wave of the pulse—are inexplicable except on the hypothesis of the persistence of a functionally active skin heart in the higher animals. The action of the Nauheim bath, he says, cannot be fully explained without assuming its existence. He considers the stimulation of the unstriped muscle fibre of the "skin heart" by the carbonic acid an important factor in the production of the circulatory changes observed.

[1] *Boston Med. and Surg. Journ.*, November 1897.

Viewing the action of the *sulphur baths* with respect to their local effect on the skin, the undoubted curative results they produce in various cases of skin disease, such as eczema, pruritus, psoriasis, must be referred partly to maceration of the outer layers of the epidermis by prolonged soaking in the water, and the consequent detaching of scales and crusts, and partly to a direct local, and probably parasiticidal, action of the sulphur constituents. In this connection it is perhaps useful to accentuate the difference previously pointed out between the saline-sulphur and the alkaline-sulphur baths. The former are mainly used for their action on the circulation, and for those cases of skin disease that require active stimulation. The latter, having salines insufficient in quantity to produce any marked circulatory disturbance, beyond that occasioned by the temperature, are used mainly for the treatment of cutaneous affections. Moreover, the salines consist chiefly of the soothing carbonates rather than the stimulating chlorides. The carbonates materially assist in the softening and detaching of exfoliated products, and enable the relatively large amount of sulphide present in the bath to penetrate to the seat of disease.

The Brine Baths.—The physiological action of Brine baths will depend mainly on the temperature and the quantity of salt in solution. Those of Droitwich, the strongest known, contain about 30 per cent. of salt, which is ten times the quantity contained in sea water, the average quantity present in the Atlantic Ocean being 3 per cent. The brine baths as given at Harrogate contain 16 per cent. of sodium chloride, and have a specific gravity of 1·104. Their action on the circulation is similar to that described under saline-sulphur baths. Whether they have any remote effect on metabolism is not known.

The action of the **Medicated Vapour Baths,** on the Berthe system, demands merely a passing reference, for it does not differ from that of the general vapour bath except in the special effect of the drug volatilised, which, as we have said, is probably minimal.

The **Peat Baths** combine the factors of temperature, of hydrostatic pressure, and of chemical constituents. Temperature is unquestionably the predominating one. The specific heat of the peat being less than that of water, a higher temperature can be borne without discomfort in the peat bath than in the water bath. The factor of hydrostatic pressure is greater here than in other baths, yet its effect is probably negligible. The chemical constituents consist of small quantities of the per-salts of iron, together with organic and inorganic acids, such as sulphuric and formic. They are said to have a stimulating action on the skin, but how far they contribute to the therapeutic effect of the bath is a matter of speculation. Doubtless the baths act as a huge warm poultice applied to the whole surface of the body, and produce similar derivative effects to a local poultice, though on a larger scale.

Their effect on metabolism, as judged by changes produced in the urine, is to cause a marked diminution in the quantity passed and in the amount of urea excreted, the other constituents showing no distinctive change.

The **Liver Pack,** which is merely a local poultice of mustard and bran applied over the liver area, is used to supplement the derivative action of the sulphur waters and baths in relieving an engorged liver. It is unquestionably an agent of great value, but only requires mention here as belonging to the group of Thermo-Chemical agents.

Mechanical Element

The mechanical factor of percussion as an aid to temperature is well exemplified by the action of the **needle douche.** The percussion of innumerable minute jets of water on the skin stimulates the nerve endings and excites a powerful reflex effect on the peripheral arterioles and on the action of the heart. When given cool or cold, the effect of percussion is to re-enforce that of the low temperature, and to cause a rise of arterial pressure greater than that obtained with cold alone. The venous pressure, however, though lowered, is reduced to a less extent proportionately than in the cold immersion bath, which tends to show that, though peripheral constriction occurs, the output of the heart is increased as the result of reflex stimulation.

Strong Needle Bath begun at 98° F. and rapidly cooled down to 60° F.; Time, 2 Minutes.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	64	115	85	15
After . . .	72	150	115	10

When given warm, a rise of arterial pressure still results, with a rise in venous pressure, which further tends to show that, though relaxation of the periphery may take place from heat, the output of the heart is increased to such an extent that the fall which would otherwise result from diminished resistance alone is more than counterbalanced.

Warm Needle at 100° *F.*, 3 *Minutes.*

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	72	140	115	15
After . . .	72	145	120	20

D. Müller,[1] from the results of two thousand blood pressure measurements after various baths, states that the influence of all still baths is due to thermic excitation, which either raises or lowers the blood pressure according to whether the temperature is below or above a certain indifferent point. If, however, the bath be in active motion, and particularly if a douche be employed, the mechanical excitation is paramount, and far exceeds that due to temperature, and consequently the blood pressure always rises.

Thus by these baths it becomes possible to get the tonic effect of cold bathing at warm temperatures, and without the shock incidental to the former, which is the converse of what obtains with the sulphur and the Nauheim baths, by which we get vaso-dilating effects at relatively low temperatures. The action of the needle bath in stimulating the heart suggests caution in its use where that organ is suspected to be weak. Given cold, it is too great a shock for any but the strongest; if given warm

[1] *Congress für innere Medicin*, 1902.

and gradually lowered in temperature in successive applications, a weak heart may be toned up by slow degrees to better contraction, as a voluntary muscle may be stimulated by graduated exercises. The effect obtained with the needle bath of plain water is so powerful that it becomes superfluous to give it with sulphur water, as is frequently done, little or nothing being gained by its use.

With the **Combined Needle and Douche Bath,** with its various douches, it is possible to apply, at pleasure, vaso-constricting or vaso-dilating agents to different parts of the body. The general needle bath may be directed, perhaps, to one object, the special douche to another; or alternate relaxation or constriction can be produced by means of the Scotch douche. By such measures the mobility of the vessel walls, and the functional activity of the vaso-motor nerve fibres can be stimulated, and the vaso-motor mechanism exercised in a manner possible with no other therapeutic agent. The result is to promote rapid changes in the relations between tissue lymph and blood plasma, and to modify the metabolic and nutritive processes.

The **Massage Douche** introduces the mechanical element of massage as a factor to be considered in addition to temperature in discussing the physiological effects of these baths. Lauder Brunton and Tunnicliffe have demonstrated by experiments on animals that massage of the muscles is followed by, firstly, an increased flow of blood through them; secondly, on cessation of massage an accumulation of blood takes place in the muscles, and is followed by a further additional flow through them; thirdly, an initial rise of blood pressure

[1] *Journal of Physiology*, vol. xvii., 1894.

occurs, and is succeeded by a considerable fall, which may amount to as much as one-fifth of the original pressure. Observation of the blood pressure in the human subject confirms these results, for an initial rise occurs on commencement of massage. If the latter takes the form of the lighter movements of stroking, percussion, or slapping, these changes persist; if the heavier movements of rolling and squeezing of the muscles be adopted, a fall in arterial and a rise in venous pressure takes place, showing some degree of peripheral relaxation. The fall occurs with this form of massage to the limbs and body, provided the abdomen be not massaged too vigorously; when this is done, the general arterial pressure rises, and a further increase in venous pressure takes place owing to dispersal into the systemic circulation of blood accumulated in the splanchnic veins.

Dry Massage; Heavy Movements—40 Minutes.

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	88	145	95	15
After forty minutes' vigorous massage to limbs and body (abdomen excluded) . .	88	135	85	17
After seven minutes' deep massage to abdomen . .	88	160	105	25

Massage probably acts primarily and chiefly on the peripheral circulation, and only secondarily alters the output of the heart. With the **Aix Douche,** in which the massage given is usually of the heavier type, a greater fall of arterial with rise of venous pressure occurs than with dry massage, the dilating effects of warm water being added to that of massage. This effect is cumulative as the result of a series of baths.

Aix Douche—Temperature 100°·*F.*

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before . . .	70	180	135	17
After . . .	64	150	115	25

Series of Aix Douches—Temperature 98°–100° *F.*

	Pulse-rate.	Arterial Pressure, mm. Hg.		Venous Pressure, mm. Hg.
		Maximum.	Mean.	
Before (sitting) .	100	240	155	15
After four baths (sitting) . .	96	215	130	25
After twelve baths (sitting) . .	86	180	110	30

On the other hand, with the **Vichy Douche** a rise in both pressures results, due, probably, in the first place, to the percussion of the needle douche tending, as previously stated, to raise the pressure by its reflex stimulation of the heart's action, and, in the second place, to the fact that the subject being in the recumbent posture, abdominal massage is more efficiently performed, which also tends to raise the pressure. This difference in physiological action furnishes a useful guide to the clinical indications for the employment of these two baths.

Vichy Douche—Temperature 100° *F.*

	Pulse-rate.	Arterial Pressure, mm. Hg. Maximum.	Arterial Pressure, mm. Hg. Mean.	Venous Pressure, mm. Hg.
Before . . .	64	117	85	15
After . . .	66	125	95	22

The effect of massage on the volume of the blood is strikingly shown by the following experiments. General dry massage of the limbs and body, with heavy movements, the abdomen being operated on last, causes a general rise of hæmoglobin and corpuscles, which attains its maximum in one to two hours, and which may not regain the normal until as much as five hours after massage.

	Hæmoglobin.	Corpuscle.	Value of Corpuscle.
	Per cent.	Per cent.	
Before massage . .	97	97	1·00
After forty minutes' heavy massage to limbs and body . .	102	102	1·00
One hour after . . .	102	102	1·00
Two hours after . .	104	104	1·00
Three hours after . .	100	100	1·00
Five hours after . .	98	98	1·00

Light massage has the same effect to a lesser degree.

	Hæmoglobin.	Corpuscles.	Value of Corpuscle.
	Per cent.	Per cent.	
Before massage . . .	101	101	1·00
After forty minutes' light massage to limbs and body . .	101	101	1·00
One hour after . . .	104	104	1·00
Two hours after . .	101	101	1·00

With local massage a similar result is obtained; in the experiment quoted the massage was of an exceptionally vigorous kind, and was sufficient to affect the general circulation to a certain extent:—

	Hæmoglobin.	Corpuscles.	Value of Corpuscle.
	Per cent.	Per cent.	
Before massage, blood from left finger . .	98	96	1·02
After five minutes' vigorous massage to left hand and forearm	106	104	1·02
One hour after . . .	106	104	1·02
Right finger one hour after	100	98	1·02
Left finger three hours after	98	96	1·02

The hæmoglobin value of the corpuscle remains unchanged throughout. The increase is therefore apparent, not real, and may be explained as partly due to a concentration of the blood, fluid passing out from the vessels to the tissues to supply the place of lymph driven on by the massage, the lymph finding its way back into the general circulation only after the lapse of some hours, and partly to the dislodgment into the general circulation of corpuscles stagnant in the less dilated capillaries. After successive administrations of massage the hæmoglobin may show an actual increase and the value of the corpuscle become raised. According to Ekgren,[1] massage, both general and abdominal, causes an increase in the number of leucocytes, the increase mainly affecting the polymorphonucleated cells.

That these baths modify the metabolic processes is demonstrated by the results obtained from the examina-

[1] *Deut. Med. Woch.*, July 17, 1902.

tion of the urine during a series. It has been shown that the Aix Douche causes an increase in the output of uric acid,[1] an increase in the urea, and a diminution in the quantity of urine.

Subject A.—Aix Douche.

Date.	Uric Acid, grms.	Quantity of Urine in c.c.	Remarks.
First Observation.			
September 24 . .	·739	1585	
„ 25 . .	·736	1385	
September 26 . .	·677	1465	Aix Douche
„ 27 . .	·715	1150	„ „
„ 28 . .	·835	1285	„ „
September 29 . .	·799	1120	
„ 30 . .	·810	1590	
October 1 . .	·846	1430	
Second Observation.			
October 6 . .	·640	1850	
October 7 . .	·687	1120	Aix Douche
„ 8 . .	·765	1230	„ „
„ 9 . .	·775	1460	„ „

The Vichy Douche causes an increase in urea, a slight increase in uric acid,[2] and a similar diminution in quantity; while a rise in hæmoglobin value was noted.

The increased elimination of uric acid resulting from these baths is probably due to the passive exercise occasioned by the massage, for it is known that active exercise is at first followed by an increased output of uric acid.

[1] Bain and Edgecombe, *Journal of Physiology*, vol. xxiii. No. 6.

[2] Bain, Edgecombe, and Frankling, *loc. cit.*

Same Subject.—Vichy Douche.

	Average of Three Preceding Days.	Average of Four Days and Vichy Douche.
Quantity	1141 c.c.	1087 c.c.
Urea	32·18 grm.	33·10 grm.
Sulphates	2·06 ,,	2·19 ,,
Uric Acid	·686 ,,	·695 ,,
Phosphates	2·46 ,,	2·37 ,,
Chlorides	6·76 ,,	7·80 ,,
Acidity	3·05 ,,	2·95 ,,
	Value of corpuscle 1·00	Value of corpuscle 1·02.

Ranglaret has shown, by injection into rabbits, that the specific toxicity of the urine of a subject undergoing Aix baths is greater during than before a series, thus proving that they increase the elimination of toxic material and waste products.

Such are the main changes produced by the massage douche, and they serve to show how active these baths are as therapeutic agents. The circulatory system is markedly disturbed, the changes that take place being more or less durable; interchange of fluid between the vessels and tissues is promoted, and metabolism is accelerated; all of which contribute to the clinical results obtained—viz. increased appetite and assimilation of food, gain in body weight, and general improvement in health, not only in definite morbid conditions, but also in cases suffering from no obvious disease.

Thermo-Electric Baths

The effect of the sinusoidal current, according to Jacoby,[1] depends on the number of alternations, the

[1] Cohen's "System of Physiologic Therapeutics," vol. ii.

electromotive force, and the quantity of the current flowing. With alternations of 2500–5000 per second, stimulation of muscle disappears and both pain and movement cease. Under the current an increased absorption of oxygen and augmented output of carbonic acid takes place, secondary, in all probability, to increased muscular activity. In the investigation alluded to, an attempt was made to ascertain if the electric immersion baths, with the constant and sinusoidal currents respectively, had any effect on the urinary excretion. The water used was the alkaline-sulphur water of the Beckwith Spring. It may be mentioned, as a point of interest, that this water requires to be diluted before the current can be made to pass through it. Dilution leads to the dissociation of the molecules of the dissolved salines into their respective ions, and so enables the current to be carried by the latter. The sinusoidal current (60 milliampères) was found to produce no marked change. The constant current (200 milliampères), on the other hand, determined a slight increase in the elimination of urea and of uric acid. The blood value was slightly reduced by both baths.

NORMAL SUBJECT.

	Average of Three Free Days.	Average of Three Sinusoidal.	Average of Four Constant Current.
Quantity . .	1047 c.c.	1178 c.c.	1102 c.c.
Urea . . .	34·96 grm.	34·73 grm.	35·95 grm.
Sulphates . .	2·23 „	2·27 „	2·35 „
Uric Acid . .	·519 „	·514 „	·541 „
Phosphates .	2·29 „	2·19 „	2·33 „
Chlorides . .	8·47 „	8·32 „	7·8 „
Acidity . .	2·87 „	2·78 „	2·78 „
	Value of corpuscle 1·02	Value ·99	Value 1·00

The effect of the current on the *blood pressure* appears to be an inhibition of the fall which usually results from a sulphur bath at a temperature of 98° F. The pressure after the bath, with both forms of current, remained at the same level as before it, instead of showing a fall, as is the case when the current is not employed.

Electric Baths

The D'Arsonval High Frequency Current. — The complete physiological action of these currents of high frequency and immense potential has not yet been fully worked out. D'Arsonval [1] first showed that the passage of the high frequency current through the body gave rise to a diminished excitability of the tissues to stimuli, that they lowered the general arterial tension, and that they increased respiratory combustion. He and other observers have continued to experiment with them, and from their work the following facts appear to be substantiated. The current has no appreciable action on motor and sensory nerves; it excites neither motion nor sensation, probably because the enormous frequency of the oscillations of the current is too great to evoke a stimulus. (Reasoning by analogy from the nerves of the eye and ear, it would seem that the nerves of motion and sensation are organised to respond only to stimuli within certain limits of periodicity.) There is local anæsthesia at the point of penetration of the current, and the response to other stimuli appears to be inhibited, for the sensibility of the skin to galvanism and faradism is greatly lessened

[1] D'Arsonval, "Action physiologique des courants alternatifs à grande fréquence," *Soc. française de Physique*, 1893.

during and after the passage of the current.[1] The respiratory processes are accelerated, and there is an increased intake of oxygen and excretion of carbonic acid, the latter amounting to 17–37 litres per hour. More active oxygenation of the blood takes place, and a *plus* heat production, which is said to vary from 79 to 127 calories per hour at a mean temperature of 17° C., the body temperature remaining normal.[2] Nutrition is modified, and a definite loss of weight has been shown to take place in animals subjected to the current.[3] In the human subject a loss varying from an ounce up to 2 lbs. may be observed even after a comparatively brief application of the current.[4] With regard to the effect on blood pressure observers appear to differ in their statements, some finding a rise in arterial tension, others a fall.

On the urinary constituents the following results have been obtained: Bordier and Lecomte,[5] experimenting with rabbits, found an increase in the urea, uric acid, and phosphoric acid excreted after auto-conduction. Vinaj and Vietti[6] used the method of auto-conduction on two healthy men, and noted an increase in urea, total nitrogen, and phosphates. A careful series of observations was undertaken by Denoyés, Martre, and Rouvière[7] on three adult subjects. Auto-conduction, 6–25 minutes daily on five successive days, produced in all three subjects a rise in the excretion of urea,

[1] Bordier, *Sensibilité electrique de la peau.*

[2] D'Arsonval, *Societé de Biologie*, 1894.

[3] D'Arsonval, *C. R. de l'Acad. des Sciences*, 1896. Querton, *Annales d'electrobiologie*, 1900.

[4] Nightingale, *Jour. Balneology and Climatology*, July 1904.

[5] *Congrès International de 1900.* Paris : Section d'Electricité Medicale.

[6] *Giornale di Elettricità Medica*, 1899.

[7] *Académie des Sciences*, 1901.

uric acid, total nitrogen, phosphates, sulphates, and chlorides; an increase in the specific toxicity of the urine, and an increase in the "total molecular diuresis." The last result was obtained by cryoscopy of the urine.

The action of the high frequency current on bacteria and their toxins has been partly investigated. D'Arsonval and Charrin[1] found that the toxin of diphtheria after being electrified by the current for fifteen minutes failed to produce the disease when injected into guinea-pigs. Dubois[2] found that a culture of the streptococcus is markedly attenuated by the current. Phisalix[3] observed a diminution in virulence of cobra venom after the passage of the current through it. Lagriffoul and Denoyés subjected tuberculous guinea-pigs to auto-condensation with the high frequency current, and found that the first effect was to cause inflammation of the tubercular foci; secondly, after abatement of the inflammation, the foci were found to contain fewer bacilli; finally, after repeated applications the lungs gradually became clear: other observers, however, working on similar lines, have not been able to confirm these results.

The effect of the current on low forms of plant life is not necessarily fatal. If it be passed through a drop of water containing vorticellæ the organisms immediately shrink on their stems, but presently emerge apparently none the worse.

In our investigations into the effect of the high frequency current on the blood, blood pressure, and

[1] *Societé de Biologie*, 1896.
[2] *Académie des Sciences*, 1897.
[3] *Societé de Biologie*, 1896.

metabolism,[1] the following results were obtained. They were found to vary according to the mode of application, whether by auto-condensation, by the effleuve, or by sparking, as in so-called electric massage. *On the blood,* both auto-condensation and the effleuve caused a slight reduction in the amount of hæmoglobin and red corpuscles, but with a definite increase in the value of the corpuscle—in one subject from 1·01 to 1·025 after six applications, in another from ·99 to 1·025 after nine applications. The effect on the *blood pressure* varied according to the mode of application. The method of auto-condensation produced a slight transient rise in the arterial pressure of 5–10 mm. Hg. immediately after the application of the current. It rapidly, however, fell to normal, and in a few minutes regained its original level. This result was repeatedly obtained.

Subject I.	
	Radial Pressure Recumbent. Mm. Hg.
Before current	95
30 minutes' auto-condensation, 350 to 450 milliampères—	
Immediately after	105
5 minutes after	95
Subject II.	
Before current	110
30 minutes' auto-condensation, 350 to 450 milliampères—	
Immediately after	118
5 minutes after	110

[1] Bain, Edgecombe, and Frankling, *loc. cit.*

	Radial Pressure.	Mm. Hg.	Weight.		
Subject I.					
			st.	lbs.	oz.
Before effleuve	Sitting	105	10	13	11
„ „	Semi-recumbent	98			
5 minutes' effleuve . .	„	95			
15 „ „ . .	„	90			
20 „ „ . .	„	85			
30 „ „ . .	„	85			
After effleuve	Sitting	90			
10 minutes after . . .	„	98	10	13	7
Subject II.					
Before effleuve	Semi-recumbent	112	13	2	9
After 7 minutes' effleuve	„	107			
After 20 „ „	„	105			
After 30 „ „	„	103	13	2	8
Subject I. *Effleuve to Abdomen.*					
Before effleuve	Semi-recumbent	100	10	13	12
After 15 minutes' effleuve	„	90			
After 20 „ „	„	85			
After 10 minutes' effleuve to abdomen	„	90			
5 minutes after . . .	„	90	10	13	10
Subject I. *Sparking—Electric Massage.*					
Before sparking . . .	Semi-recumbent	96			
After 15 minutes' auto-condensation (400 milliampères) and 15 minutes' sparking (150 milliampères) to limbs and body	„	88			

With the effleuve applied continuously for thirty minutes to the whole surface of the body in succession a distinct fall in blood pressure, amounting to 10–15 mm. Hg., was invariably observed. When, however, the effleuve was applied to the abdomen the pressure rose somewhat, though not to the original level. The duration of the fall in pressure after the current ceased was variable but in no instance long. Sparking (100-150 milliampères) applied in the form of electric massage caused active hyperæmia of the surface, and when vigorously done produced a papulo-erythematous rash, which endured for twenty-four to thirty-six hours. The effect of this form was to cause a more persistent reduction of arterial blood pressure. It would thus appear that the divergent results on arterial pressure previously obtained may be due to the different forms of current employed, auto-condensation causing a temporary rise and the effleuve a decided fall, both results having been obtained on all occasions of trial.

Investigating the effects on the urinary constituents, we used the methods of auto-condensation and the effleuve, instead of that adopted by the previous observers mentioned, who employed auto-conduction. The results obtained agree closely with those of Denoyés, and tend to show that *metabolism* is certainly affected by the passage of the current. Auto-condensation for thirty minutes daily on four successive days, with thirty minutes' effleuve on the two following days, caused in one case an increase in the excretion of urea (from 27 grms. to 33 grms. per diem) and of sulphates; a marked rise in uric acid eliminated (from ·656 grm. to ·769 per diem) and in phosphates, and a slight diminution in acidity. In another subject the changes were similar, though not so marked.

SUBJECT II.			
	Average of Five preceding Days.	Average of Four Days' Auto-condensation, 30 mins. each Day.	Average of Two Effleuve, 30 mins. each.
Quantity . . .	1167 c.c.	1197 c.c.	1355 c.c.
Urea	27·62 grm.	33·39 grm.	32·85 grm.
Sulphates . .	2·13 "	2·50 "	2·38 "
Uric Acid . .	·656 "	·718 "	·769 "
Phosphates . .	2·32 "	2·46 "	2·61 "
Chlorides . .	13·29 "	10·75 "	15·37 "
Acidity . . .	3·56 "	3·25 "	2·84 "

A loss of weight varying from one to four ounces occurred after each application, conformably with Nightingale's results. Crombie and Bokenham[1] have recorded striking observations on the effect of the effleuve in promoting contraction and diminution in size of the organ in cases of dilated stomach. In this connection we were struck by the fact that the effleuve to the abdomen excited marked peristaltic action leading to the active and notable passage of flatus for some hours after the current, and in one case to repeated diarrhœa. Further, the rise in blood pressure that results when the effleuve is applied to the abdomen is probably due to contraction excited in the splanchnic vessels.

The Electric Light and Ozone Bath.—As has been already said, the factors at work in this bath are multiple, viz. heat, electric light, ozone, and the high frequency current. The attempt, therefore, to apportion the results observed to one or other factor becomes a matter of difficulty. Kellogg,[2] who has worked extensively on the action

[1] *Lancet*, vol. i., 1902.

[2] Cohen's "System of Physiologic Therapeutics," vol. ix.

of electric light baths, states that sweating sets in earlier and is more profuse in the electric light bath than in any other form of hot bath, and that the elimination of carbonic acid is greater. He finds a rise in body temperature during the bath, and an increase in the blood count, especially of the red cells, of 10–20 per cent., which appears within half-an-hour and persists for a time. In cases of marked anæmia the increase is usually permanent if daily application be made. The blood pressure is at first raised, and then rapidly lowered. M. Cleaves[1] finds that in some cases the hæmoglobin and corpuscles are increased, but not in others. Klebs and Mayer[2] state that they cause a leucocytosis, mainly of polymorphonucleated cells. M. Roth[3] tested these baths exhaustively in cases of obesity, and found them to have no more effect than other forms of sweating baths.

In considering the results obtained by us[4] the presence of the two additional factors of ozone, and, during the latter half of the bath, of the high frequency current, must be borne in mind. The *blood pressure* always showed a great reduction, greater than would be obtained with exposure to a similar degree of heat in the Turkish bath, for instance. The fall, however, is of brief duration, disappearing soon after the bath.

[1] *New York Medical Journal*, 1899.
[2] *Loc. cit.*
[3] *Wien. Med. Woch.*, 1899.
[4] *Loc. cit.*

To give an example—

Normal Subject.	Mm. Hg.	Body Temperature.
		Deg. F.
Before the bath, radial pressure, sitting .	97	98
" " recumbent	87	
Bath, temp. of cabinet 100° F.; of surface of body exposed to the light 110° F.		
In bath 5 min., radial pressure, recumbent .	70	
" 10 " " " .	60	
" 15 " " " .	55	100
High frequency current passed through body.		
In bath 20 min. radial pressure, recumbent	50	100·2
5 min. after bath, recumbent	75	99·8
10 min. " "	80	
25 min. " sitting	95	99·0
40 min. " "	...	98·6

Examination of the blood showed an immediate diminution in the amount of hæmoglobin and number of the erythrocytes, with an increase about half-an-hour after the bath. Blood examined immediately on rising in the morning showed that a series of baths caused an increase in the amount of hæmoglobin and a decrease in the number of corpuscles, with a consequent striking rise in the value of the corpuscle—in one case from ·986 to 1·07 after four baths, in another from ·99 to 1·045.

Immediate Effect.	
	Per cent.
Before bath, volume of red corpuscles	98
Immediately after bath, " "	95
30 minutes after bath, " "	104

Remote Effect.		
Subject I.	Average of Four Free Days.	Average of Four Light and Ozone Baths.
	Per cent.	Per cent.
Hæmoglobin . . .	107·8	105·3
Red corpuscles . . .	109·2	98·3
Value	·98	1·07
Subject II.		
Hæmoglobin . . .	97	95·2
Red corpuscles . . .	98	90·7
Value	·99	1·045

Now, as has been pointed out previously (p. 100), the Dowsing bath, which is essentially an incandescent electric light bath, causes a fall in the worth of the corpuscle. Hence the rise obtained must be attributable to some other factor, probably to the presence of ozone, for with the high frequency current alone a slight but not marked rise in value is obtained. To determine this point exposure to the ozonised atmosphere within the cabinet for thirty minutes daily was undergone on three successive days, without either the electric light or the high frequency current, and the blood was examined each morning and for three days previously. The result showed a rise in value from ·986 to 1·043, thus clearly proving ozone to be the factor concerned. The blood examined immediately before and after the inhalation of the ozone showed a rise in value in one case of 7 per cent. after thirty-five minutes in the cabinet, in another of 4 per cent. after twenty-five minutes.

Remote Effect.			
SUBJECT III.			Value of Corpuscle.
Average of three morning observations prior to ozone			·986
Average of three days, ozone inhaled 30 minutes each day			1·043
Immediate Effect.			
SUBJECT III.	Red Corpuscles.	Hæmoglobin.	Value.
	Per cent.	Per cent.	
Before exposure to ozone .	100	98	·98
Immediately after 35 minutes ozone . . .	100	105	1·05
SUBJECT I.			
Before exposure . . .	98	95	·97
After 25 minutes ozone .	98	99	1·01

The suggestiveness of these results in the treatment of anæmia by exposure to ozone is obvious.

The remarks made on the effect of the light rays in the Dowsing bath apply equally here, though their effect on the blood is more than counterbalanced by that of the ozone.

The effect of these baths on metabolism appears to be but slight. The body temperature is raised about 2° F. during the bath. Four baths on successive days produced in two normal subjects a diminution in the quantity of urine excreted, a slight fall in the excretion of urea—doubtless due to the perspiration excited—and a slight rise in the excretion of uric acid and phosphates, the sulphates being unchanged, results which are comparable to those of Garratt on the Turkish bath.

In the foregoing résumé of the physiological action of the various bathing procedures, stress has been laid on their influence on the vaso-motor system, for that is of prime importance. On its integrity and on the perfect performance of its functions the maintenance of health largely depends, and through its agency the secondary metabolic changes are brought about. The vaso-motor mechanism, by which the ebb and flow of vaso-constriction and vaso-dilation are controlled, enables the circulation to become adapted to the rapid succession of changes that take place in the environment of the organism—changes due to gravity, posture, exercise, or digestion—and to ensure a full and adequate supply of blood to the various parts as occasion demands. On it largely depends, secondarily, the ebb and flow of tissue fluid through the capillary wall by means of which nourishment is conveyed to, and waste products removed from, the tissues. The state of nutrition of the capillary wall is also a factor to be taken into consideration in this connection. The physiological changes that take place would seem to show that where the vaso-motor mechanism is impaired, the various baths, intelligently used, can restore the normal mobility of the vessels, when this is functionally in abeyance, or if arterial disease be not too far advanced; and where the free transudation of fluid through the capillary wall is interfered with, the constantly changing relations between blood plasma and tissue fluid, which the preceding observations show to be a prominent physiological effect of bathing, serve to "exercise" the function, to stimulate the interchange, and to modify nutrition, until finally the normal equilibrium of health is restored.

A purely mechanical explanation of the changes which take place in the body as the result of balneological procedures is not possible, however, in the present state of our knowledge. Though attempts have been made to measure these changes definitely in so far as they are capable of measurement—as is shown by the epitome given above of work done on the subject—yet the results are not sufficiently extensive to cover the whole ground, or to furnish adequate material for a final pronouncement on the exact way in which the changes are brought about. The factors sharing in their production are too many and too complex to admit of a simple explanation. Even were the data complete, which are procurable from measurement of those factors capable of measurement, we should still be far from a complete understanding of the processes involved; for there yet remain certain other factors which are quite insusceptible of definite measurement, the importance of which may be equally great. Nerve influences, for example, come into play other than those by which reflex changes are induced. Psychical impulses, subjective sensations, and "vital" changes of an obscure nature are called forth, and unquestionably exert a powerful influence on the physiological processes of the body. Of the nature of such influences we are in almost complete ignorance. A knowledge of these phenomena, combined with a thorough understanding of the objective mechanical phenomena, is requisite before a completely satisfying account can be given of the manifold effects of balneology.

THERAPEUTIC USES OF THE BATHS

An appreciation of the preceding physiological facts will indicate many of the directions in which the baths may be employed with advantage. The more special indications for their use will be dealt with in the chapter on the treatment of diseases by waters and baths. Here a few of the general indications need only be mentioned. It is undesirable to enter fully into the particular course of baths to be adopted in any given case, or into detailed points of administration, such as the temperature at which they should be given, the length of time the patient should remain in, the promotion or otherwise of sweating, and the after-treatment on leaving the bath. These belong to the Spa practitioner, and demand his close attention and careful supervision. It is impossible to lay down rules which are applicable to all cases. Each patient must be specially studied, and his individual requirements met on rational lines as far as this may be possible. Any attempt on the part of the resident physician to prescribe a uniform course of bath treatment to any class of cases, as being the treatment special to Harrogate, is strongly to be deprecated as contrary to scientific therapeutics.

Thermal Baths

The Turkish and Russian Baths are taken very largely for purposes of cleanliness or refreshment by those in perfect health. Therapeutically they are used chiefly in cases in which it is desirable to promote rapid alterations in the fluid content of the body, for the replacement by the mouth of considerable quantities of water lost through the skin must lead to a more rapid renewal of the fluid bathing the tissues and to a process of "washing out" which results in the carrying away of additional quantities of waste material. Hence their employment in a few cases of obesity, in cases of perverted nutrition from over-indulgence or lack of exercise, and in certain cases of kidney disease, provided that the state of the circulation is such as to admit of exposure to a high temperature without undue risk.

It should be noted that the immediate loss of weight resulting from the Turkish bath, in cases of obesity, for example, is not an actual loss of weight in the sense of reduction of tissue, but a spurious loss due to the quantity of water excreted by the skin, and is rapidly regained by the ingestion of fluid. To secure permanent loss of weight other measures, such as dieting and exercise, must be enforced; without them a series of Turkish baths may result in actual gain of weight.

The Turkish bath is also prescribed for cases of chronic rheumatism, in which it is often efficacious, and in local rheumatic affections as sciatica, myalgia, lumbago, and brachial neuritis. In certain skin diseases it is useful, notably in acne and seborrhœa.

The Berthollet Vapour Bath is much used in cases of local affections of the joints or periarticular tissues having a gouty, rheumatic, or traumatic origin. The high temperature acts as a sedative and relieves pain, while the active vascular dilatation induced by the play of the hot steam flushes the part with blood, and leads to the more rapid absorption of inflammatory exudation. In cases where tenderness is not too great to preclude their employment this result is materially aided by massage and passive movement subsequently performed. Exudation into the fibrous tissues of joints tends to disappear rapidly under these measures. The limitations of movement resulting from arthritis of a gonorrhœal origin, or from adhesions following a recent injury, show rapid improvement as absorption of the newly formed tissue proceeds.

The Dowsing and Greville Baths are each used for much the same class of cases and may be conveniently considered together. Touching their general application to the whole body for the cure of diseases other than those affecting the joints, more is claimed for them than we think can be substantiated. Thus they have been advocated for the cure of chronic phthisis, bronchitis, asthma, chronic kidney disease, heart disease, anæmia. dyspepsia, obesity, chronic alcoholism, and skin diseases, in each of which good results are said to have been obtained by one or other system. In some of the above, as, for instance, chronic kidney disease, the indications for their use as sudatory baths are clear, and they are of distinct value. In others, though a few cases are recorded as having derived benefit, the evidence is not sufficiently strong to warrant the supersession by these baths of better known and longer tried methods.

In the chronic general diseases of which the prominent manifestation is arthritis they are of most service, and especially in local affections of the joints, fibrous tissues, or nerves, such as chronic arthritis (gouty, rheumatic, traumatic), sprains, lumbago, sciatica, and neuritis. In these conditions the results obtained are strikingly good, better indeed in many cases than can be achieved by any other known method, and are referable to the alteration in nutrition which results from the rapid changes that take place in the volume of the blood, and is evidenced in part by the variations observed in the excretion of urea and uric acid. In arthritis deformans, however, the benefit derived from superheated air baths, employed alone and without auxiliary measures directed to the general health, is too often of a merely temporary nature. Permanent relief is sometimes procured by them; more often, however, this occurs when they are combined with dieting and tonic treatment by drugs. Nevertheless the Greville and Dowsing systems of using hot air at temperatures hitherto unavailable in the treatment of disease have come to occupy an assured place among the resources of mechanical therapeutics.

Thermo-Chemical Baths

The Sulphur Baths are, so to speak, the staple baths at Harrogate. Most of the other bathing procedures described are to be obtained elsewhere at well-equipped bathing establishments, either at home or abroad. These can only be obtained on the spot, and, together with the sulphur waters, are the basis on which the reputation of Harrogate has been built up.

The existence of two varieties—saline-sulphur and alkaline-sulphur water—leads to their employment respectively in two different types of case. The former is used chiefly in gout, rheumatism, and hepatic disorder, though it is also of great service in diseases of the skin, while the latter is chiefly employed in cases of skin trouble.

Full-length immersion baths of the saline-sulphur water, natural, strong, or mild, reduce high arterial tension, open up the peripheral circulation, and lessen engorgement of the deeper organs, such as the liver, and by their soothing anodyne influence diminish the pain and relieve the stiffness of joints affected with chronic arthritis. Such effects vary in intensity with the strength of the bath. Having different strengths of water available is obviously of no little value, for the course can be gradually adjusted from the weakest up to the strongest bath without overtaxing the powers of the patient.

The sulphur baths are also used as a preliminary to the inunction of mercury in the treatment of syphilis. No doubt they act by preparing the skin for the more ready penetration of the medium in which the metal may be conveyed.

The Alkaline-Sulphur Baths are used mainly in cases of skin disease, supplemented, if need be, by the more stimulating saline-sulphur baths. They are given in cases of eczema, more especially the chronic forms, and particularly those of a gouty nature; in all forms of psoriasis, excepting those in an acutely hyperæmic condition; in pityriasis, unless very acute; in all forms of pruriginous eruptions; in parasitic affections, especially scabies; in urticaria, acne, lichen-planus, erythema, and many other disorders. The wide range of waters available, from the mild and sedative alkaline waters of the Beckwith and Harlow Car Springs, upwards through the successive stages of the Starbeck water, mild and strong saline-sulphur water, to the stimulating natural sulphur bath, renders it possible to adjust the treatment to the requirements of any particular case with a delicate nicety. Few cases are so sensitive as to be unable to bear the more soothing baths, and few so indolent as to have no impression made upon them by the more stimulating.

It is necessary to insist on the great care required in watching the effect of these baths, as they may do harm if incautiously administered. The length of time the patient should remain in the bath should be rigidly prescribed and cautiously extended, and the temperature should be adjusted with care. Want of caution may light up a quiescent affection into a state of active recrudescence.

The Nauheim Baths.—So much has been written during recent years on the use and action of these baths in cases of heart disease that it is superfluous to discuss the matter in detail here. Suffice it to say that it has been abundantly proved that this extension of previously known methods of treating heart disease by means of saline baths can be applied equally well in this country as abroad, and a fatiguing journey avoided which might in many cases prove prejudicial. That certain cases of failing heart derive benefit from artificial Nauheim baths, with or without graduated exercises, there can be no doubt, but the cases must be carefully selected, and the indiscriminate application of the methods to all forms of heart disease rigorously avoided. The most suitable cases are those of failing heart due to valvular disease: early myocarditis following rheumatic fever or other acute disease: dilated heart without valvular mischief, such as may occur in anæmia or following exhausting illnesses: dilated heart resulting from contracted peripheral circulation: fatty heart: tobacco heart, and angina pectoris of neurotic origin—that have resisted ordinary treatment. The initial cause of the trouble is, however, of little moment; the important point is the condition of the heart muscle, and whether it is capable of response to any form of treatment. Unsuitable cases are those with degeneration of the myocardium, aneurism, and advanced arterio-sclerosis.

How far the benefit obtained is likely to remain permanent will depend, of course, on the nature of the disease, whether functional or organic. In the latter, if cure is impossible, the temporary relief afforded by the baths is sometimes very marked, and may be prolonged to a greater or less extent by successive courses at suitable intervals. In the former, the tone of the heart may be completely restored, and permanent results accrue. While due allowance must be made for its limited value, it is unquestionable that the treatment of heart disease by baths, either Nauheim or others, forms a useful addition to our therapeutic methods.

It may be helpful to accentuate a further application of the Nauheim baths to which sufficient attention has not been drawn, namely, their employment in cases of chronic rheumatism. After having ordered a course for patients with heart disease, suffering at the same time from chronic rheumatic pains, we have frequently been struck by the marked relief afforded to the latter, and in consequence have been led to prescribe the baths for rheumatism alone, with gratifying results. The same effect has been observed at Nauheim, which has become almost as much a resort for sufferers from chronic rheumatism as for patients afflicted with heart disease.

The Peat Baths are largely used in cases of chronic pelvic disorder of an inflammatory nature. The action of the peat bath resembles that of a widespread poultice, and materially aids in the absorption of the effused products. They are also used for cases of intractable articular rheumatism, muscular rheumatism, local neuritis, lumbago, and sciatica.

The Brine Baths have been recently added to the resources of Harrogate, but in the presence of such a wide choice of other balneological procedures are not much used. They may be given generally in cases of widely distributed rheumatic affections of the body, or locally to individual joints in the form of hot saline compresses or douches.

Pine Baths.—The indications for the use of these baths are not clearly defined, and the writers have no experience of them.

The Schwalbach Bath, as artificially given, is claimed to be of service in the treatment of anæmia, though how the iron present in the water can be absorbed and exert any curative effect is a mystery. The factor of effervescence exerts a similar influence to that of the Nauheim bath. The Schwalbach bath is also said to be of value in uterine cases.

The Liver Pack.—Combined with the administration of the sulphur waters internally, the active counter-irritation induced by the liver pack is of great service in the treatment of functional disorders of the liver and stomach. Cases of catarrhal jaundice recover more rapidly with the aid of the liver pack than without it, and the jaundice of obstruction tends towards improvement by reason of the lessening of the accompanying catarrh of the bile ducts. It has also a very soothing influence in cases of distended and painful gall-bladder. Passive congestion of the liver from back pressure is diminished by the opening up of the collateral circulation between the visceral and parietal veins which results from the warmth and counter-irritation. Organic disease of the liver is obviously less amenable, but it would appear that the enlarged liver of certain forms of cirrhosis may be reduced in size in this way, and the circulation through a small cirrhotic liver much improved.

Thermo-Mechanical Baths

The Needle Bath is largely used either alone as a tonic and invigorating agent in cases suffering from general slackness and want of tone, without obvious disease; or as a terminal bath to other procedures, such as the Aix douche and the liver pack. In the latter instances its object is to raise the blood pressure after it has been lowered by the massage or warmth of these baths, and to prevent the relaxation and enervation that would otherwise follow. The advantage of being able to get the tonic effect of cold bathing at warm temperatures, which, owing to the factor of percussion, can be obtained by the needle bath, is manifest in the complete absence of shock or discomfort experienced after the douche.

The Combined Needle and Douche Bath is used in cases where, in addition to the effects of the general needle bath, it is desired to produce an effect on some local part by means of a special douche directed upon it—as in cases of sciatica and lumbago, when a douche of any or alternating temperature may be played on the leg or back; cases of neurasthenia, where the Scotch douche to the spine may be desirable; cases of local joint trouble, and so forth.

The Plombières Bath and Douche is used in cases of simple colitis, muco-membranous colitis, chronic appendicitis, chronic peritonitis, or dilatation of the colon.

The cases comprised under the term of muco-membranous colitis are notoriously difficult to cure, and any methods likely to be of service in this direction are especially welcome. The success obtained at Plombières in the treatment of this disorder is remarkable. There the methods adopted include careful dieting, the regulation of the bowels by the Plombières water taken by the mouth, together with Carlsbad salts or other aperients, the use of the bath with the sub-massive abdominal douche, and the repeated washing out of the bowel by douching with the Plombières water. It is claimed that this water has a specific action on the intestinal mucous membrane, but it is probable that the effect is mainly to be attributed to the mechanical washing away of effete material. The question naturally arose as to whether similar methods could not be carried out at Harrogate. The saline-sulphur waters, containing, as they do, considerable quantities of sodium chloride, are probably unsuited for the purpose. The nature of the alkaline-sulphur waters which contain a relatively high proportion of carbonates, rendered it probable that success would attend a trial of them, and this anticipation has been realised. Since the introduction of the methods in 1904 they have been largely employed and with success in the treatment of muco-membranous colitis and chronic appendicitis.

The Massage Douches.—The Aix douche and the Vichy douche are among the most valuable of the balneological agents at our disposal. Combining the factors of massage and warm temperature, acting vigorously on the circulation and stimulating metabolism, they are useful in a variety of affections. The chief of these is that known as the "gouty state," which may be characterised by a condition of high arterial tension, sluggish or perverted action of the alimentary functions, physical torpor and mental depression, and occurs in subjects who may or may not have had previous attacks of gout. They are also given in cases of toxæmia, from high living with sedentary habits: in cases of brain fag from too assiduous work: in obesity: in chronic rheumatism: in arthritis deformans: in heart disease of peripheral origin, or where relief is required to a heart labouring from excessive peripheral resistance: in long-standing sciatica and lumbago, and in many other disorders. General diathetic diseases, such as gout and rheumatism, with local manifestations, may be dealt with effectively by these baths, for while the massage douche will modify the constitutional condition, especial attention can be directed to the particular part involved and the local effect be obtained at the same time.

The active circulatory changes excited by these baths lead to the removal by the blood stream of waste products from the tissues and to their subsequent elimination. This results in comparative freedom from the toxic effects of imperfectly oxidised material and a consequent sense of freshness and vigour which is unattainable in the same space of time by any other form of bathing. The energetic effect of the massage douche incautiously prescribed in cases of gout is sometimes unpleasantly demonstrated by the precipitation of an acute attack during the course, which renders it advisable to proceed in a tentative fashion in dealing with cases prone to acute manifestations. The opposite effect of the Aix and Vichy douche on the blood pressure may be emphasised here. The former lowers it, the latter raises it, and this furnishes a useful guide to the employment of the two forms. The Aix is more useful where high arterial pressure exists and reducing measures are indicated; the Vichy when the aim is to stimulate metabolism and at the same time to tone up the vascular system. Further, the recumbent position adopted in the Vichy douche enables massage of the abdomen to be more effectually performed, and points to its use in states of abdominal plethora, with an atonic condition of the hollow viscera.

The complete séance comprised in the full Vichy bath includes a preliminary exposure to steam heat in the Berthe apparatus, and the sweating induced by this measure leads to the further elimination of waste products. It unduly prolongs the bath however, and imposes a considerable strain on the powers of the patient, which precludes its frequent use.

Thermo-Electric Baths

The Immersion Electric Baths, with the constant, interrupted, or sinusoidal currents respectively, are used to induce restoration of contractile power in cases of muscular weakness or atrophy resulting from nerve lesions or essential muscular dystrophy; for example, atrophy following neuritis, lead poisoning, injury to nerve, disease of joints; loss of power from slight hemiplegia; progressive muscular atrophy; tabes dorsalis. Certain cases of neurasthenia, the latent forms of hysteria, and local manifestations of this disease, such as hysterical paralysis, derive great benefit from these baths. They are also useful as a general tonic measure in cases presenting no definite disease, but suffering from general debility and want of tone. It is believed that the constant current exercises a favourable influence in cases of chronic gout.

Electric Baths

The precise indications for the use of the **D'Arsonval High Frequency Current** are not as yet clearly formulated. Since the introduction of the methods they have been used in a great variety of affections, both local and general, with varying success. Among the general may be mentioned gout, chronic rheumatism, obesity, diabetes, neurasthenia and hysteria, anæmia and chlorosis, phthisis pulmonalis, atonic dilatation of the stomach, and chronic colitis. Among the local affections, skin diseases are the most prominent, and include lupus, lupus erythematosus, psoriasis, chronic eczema, acne rosacea, rodent ulcer, chronic callous ulcers, and pruritus ani or vulvæ. Local affections of the nerves rank next in frequency, such as sciatica, local neuritis, neuralgia, &c. Lastly, good results are obtained in some cases of hæmorrhoids.

Reasoning from the physiological action of the current, its general application might be assumed to be of service in cases of gout, rheumatism, and obesity, by reason of the reduction in blood pressure produced, the stimulus given to metabolism as shown by the *plus* heat production, the *plus* excretion of urea, of uric acid, and of carbonic acid, and the loss of weight; in cases of anæmia from the rise produced in the hæmoglobin value of the corpuscle; in cases of dilated stomach from the distinct contraction of unstriped muscle fibre it excites. To this cause must be attributed the shrinking and disappearance of hæmorrhoids which frequently occurs after repeated local application of the effleuve or vacuum electrode. The evidence for its real value in cases of diabetes and phthisis does not appear to rest upon a sufficiently large number of cases to carry conviction as to its superiority over other methods of treatment.

In our opinion, after considerable experience of the methods, the results obtained from the local application are superior to those from the general application. In rheumatism and anæmia no advantage is presented by the methods over those in more general use. On the other hand, in the treatment of atonic forms of gout, and in obesity, associated with feeble action of the heart, it offers distinct advantages, as it may be given without risk when more active balneological procedures might be attended by danger. In neurasthenia the trials have been disappointing; in the milder incipient forms good results have been observed; in the more severe, failure or even positive harm is more frequently met with. In the latent forms of hysteria marked improvement has been seen in not a few cases; the more overt forms do not appear to be benefited. The striking effects obtained by Crombie and Bokenham should lead to the more frequent use of the current in cases of atony of the stomach.

With regard to local affections, our experience has been more favourable, especially in cases of local neuritis, sciatica, and neuralgia, in which excellent results have been obtained. In skin affections the results have been unequal, some cases doing well, others showing no improvement; especially does this apply to pruritus, anal or vulval, and to hæmorrhoids.

Finally, one of the most prominent features of the high frequency current as a therapeutic agent is the uncertainty of its effect. In one case it may be of great service, while in another of apparently the same nature it is entirely inert or even harmful. It appears to be impossible to differentiate between the two and to predict in a given case whether the result will be favourable or unfavourable. A more complete knowledge of the physiological action of the current and further clinical experience will give the method its proper value and render clearer the indications for its employment.

The Light and Ozone Bath.—The presence of the factors of ozone and the high frequency current distinguishes this bath from the ordinary electric light bath, but their therapeutic uses are somewhat similar. The experimental results obtained on the hæmoglobin of the blood point especially to its use in cases such as arthritis deformans, rheumatic arthritis, renal disease, in which anæmia is a prominent symptom. The cure of chlorosis and secondary anæmia may be accelerated by daily exposure to an atmosphere highly charged with ozone, in conjunction with treatment by the chalybeate waters.

The X-rays.—In a work of this character no account of the therapeutic uses of the X-rays is needed. It is sufficient to state that they are available for purposes of diagnosis or treatment.

SECTION III

CLIMATE

THE FACTORS WHICH DETERMINE CLIMATE

Before entering upon a description of the climate of Harrogate in particular a few remarks are necessary on the subject of climate in general and the factors by which it is governed. In the first place, climate must be distinguished from weather. By weather is understood the succession of ephemeral changes that take place in the meteorological conditions of a given locality, the sum total of which changes, recurring in a more or less regular order, year after year, make up the climate of that locality.

Meteorology is the science which attempts to define the factors which combine to constitute climate, and which "seeks to explain the various atmospheric phenomena by known physical laws and to discover the causes underlying the succession of atmospheric processes."[1]

Climate has been defined by Humboldt in the following sentence: "The term climate, in its broadest sense, implies all the changes in the atmosphere which sensibly affect one's physical condition," a definition which accentuates the most important aspect of climate in a medical sense, and that is, the manner in which

[1] Hann, "Handbook of Climatology," part i. p. 2.

it affects our personal well-being. For climate may be considered from two standpoints; on the one hand, that of the meteorologist and physicist, to whom will appeal the practical aspect of definite measurement and the theoretical exercise of endeavouring to correlate observed data with known physical laws; and on the other, that of the physician, whose interest is centred chiefly in the biological aspect of how climate affects physiological or pathological processes in the human organism. The former method involves the treatment of climate objectively; the latter demands in addition an exhaustive study of subjective phenomena, to which as yet too little attention has been paid.

The chief factors which govern climate in general are *Temperature, Humidity, Rainfall, Sunshine and Cloudiness, Fog and Dew, Winds, Evaporation, and Barometrical Pressure*, all of which are to some extent mutually interdependent, though in the present state of our knowledge it is impossible accurately to apportion to each its relative value. The climate of any particular locality is governed by conditions geographical, topographical, and geological, which modify these factors in an extremely complex way, and often render their correct analysis a matter of impossibility.

Temperature

This is unquestionably the most important of the climatic factors. Meteorologically it means simply the measurement of the air temperature at a given station; climatologically it means the total amount of the warmth of the air, and the amount of radiation. It depends on a variety of factors—latitude, amount of sunshine and heat of the sun, humidity, evaporation, prevailing winds, and so forth.

According to Hann,[1] the following data are needed to get a correct presentation of the temperature of any given locality:—

(1) The mean monthly and mean annual temperature of the air.

(2) The mean diurnal range of temperature for each month.

(3) The mean temperature at the different observation hours for each month.

(4) The extreme limits of the mean temperature of the individual months.

(5) The mean monthly and mean annual extreme temperature, as well as the mean minimum and mean maximum temperature for the year.

(6) The absolute maximum and minimum temperature observed within a given interval of time.

(7) The mean variability of temperature.

(8) The average limits or dates of frost in spring and autumn, and the number of days free from frost.

Now to procure all these data in the case of any one locality is a matter of difficulty under the present system of meteorological observation, while to obtain them for comparative purposes from a number of different places is practically impossible. Hence only a partial, but often sufficiently accurate, presentation of this leading climatic factor is rendered possible.

Radiant Heat is an important climatological factor in modifying the temperature of the air. Unfortunately there is no reliable method of measuring it, that most in use being the black bulb thermometer in vacuo.

[1] *Loc. cit.*, p. 28.

Actinometers of this kind are much affected by local conditions, and give results which are wanting in accuracy.

In a medical aspect the significance of temperature lies not so much in meteorological data of the temperature of the air as in the sensations it calls forth in the body. The temperature as felt is of greater moment to the physician than the temperature as recorded by the dry-bulb thermometer. The so-called "sensible" temperatures depend not only on air temperature, but on other factors, notably the amount and direction of wind, exposure to the sun, humidity of the atmosphere, and rate of evaporation. A degree of cold which is tolerated in comfort on a dry, still day may become unpleasant on the advent of a slight breeze, though the air temperature may remain the same. In hot weather the amount of perspiration and rapidity of its evaporation will depend on the humidity and the movement of the air; hence the toleration of extreme heat depends to some extent on these conditions. Very high temperatures, which would be intolerable if the air were moist and still, may be well borne if the atmosphere be dry and there be active movement of the air. Humidity is indicated by the readings of the wet-bulb thermometer, and as the evaporation of perspiration causes a considerable degree of cooling, the surface of the skin has been aptly compared to a wet-bulb thermometer, the readings of which instrument correspond to the temperature as actually experienced.

Humidity

The amount of water vapour in the air, or of water in the form of rain, snow, and clouds, is the climatic factor next in importance to temperature. The vapour pressure, or actual weight of water vapour in the atmosphere, is known as the absolute humidity; the ratio of the observed vapour pressure to the pressure at saturation point under the conditions of temperature obtaining at the time is known as the relative humidity. Absolute humidity may be expressed either as vapour pressure in mm. Hg., or as weight of water in grams per cubic metre, or grains per cubic foot, as in English tables. For climatological purposes the most convenient mode of expression of the amount of water vapour in the air is undoubtedly through the relative humidity. From the medical point of view, as an expression of the effect of humidity of the organism, there is some difference of opinion as to whether this is more accurately indicated by the absolute or by the relative humidity. According to Weber,[1] the degree of absolute humidity is of greater value, especially in relation to respiration, since air inspired becomes saturated with moisture at the temperature of the body, and the amount of water vapour it can take up from the lungs will depend on the absolute weight of water it contained before inspiration, irrespective of its temperature. Air of high absolute humidity can remove less water vapour from the lungs than air of low absolute humidity, and consequently can abstract less heat. Hann,[2] on the contrary, regards relative humidity as the truer indication of the effect of moisture on the body, and says in this connection: "Since air breathed into the body is warmed by the lungs to the temperature of the body, and is breathed out again filled with water vapour, it has been maintained by some that absolute

[1] Von Ziemssen's "Handbook of General Therapeutics," 1885, vol. iv.
[2] "Handbook of Climatology," 1903, part i. p. 51.

humidity plays a more important part as a climatic factor than relative humidity. When the air is perfectly dry the body loses more than 430 grams of water through the process of respiration every day. This corresponds to saturation at 37° and ten cubic metres of air per day. Yet air of this degree of dryness is breathed out of doors all winter long in Eastern Siberia and in Arctic districts; for even in saturated air the vapour pressure at $-30°$, $-40°$, and $-50°$ is only 0·4, 0·1, 0·04 respectively. The air is almost absolutely dry, and yet no complaints are heard about the dryness of the air, and there is no mention of its effects. . . . The case appears to be different when the air which is breathed in already contains so much water vapour that the loss of water from the lungs is checked. This seems to affect the body much more acutely, but there is nowhere under natural conditions in the atmosphere relatively dry air which contains so large an amount of water vapour. When air with the same absolute humidity is nearly saturated (that is, when the relative humidity is also high) then evaporation from the surface of the skin is also checked, and the air seems extremely muggy. It is impossible, under these conditions, to tell how much of the effect is due to the reduced loss of water from the lungs, and how much to the reduced loss from the skin. . . . For purely climatological purposes the relative humidity is unquestionably the most convenient expression for the amount of water vapour in the air. When we describe the air as very damp or very dry, we are usually speaking quite unconsciously of the relative humidity. The air is moist in our climate in winter, notwithstanding the small amount of water vapour which it then contains; while the air is dry in summer, although it then contains two or three times as much vapour as in winter. The relative humidity, next to the temperature, determines the need which is felt by organisms for water, and also controls evaporation."

In winter, though the absolute humidity is lower, the relative humidity is higher than in summer, which corresponds with sensations as felt. Further, the daily variations in the former are not sufficiently abrupt to have much influence on respiratory processes over a short space of time; seasonal variations, however, have a greater effect.

Rainfall

Climatically, rainfall is a factor of great importance, determining to a large extent the productiveness of a country, and itself giving rise to conditions which in their turn modify meteorological phenomena. Medically, however, it has not that importance which might be inferred from the wealth of statistics usually adorning the pages of books on health resorts. Apart from its purifying influence on the atmosphere, which is unquestionably of paramount importance, its main claim to our consideration, provided there is sufficient subsoil drainage to prevent the collection of retained surface water in large quantities, lies in the extent to which it permits or hinders open-air exercise. The amount of rainfall has little or no effect on atmospheric humidity; it certainly does not increase it; according to Weber, it tends to diminish the relative humidity.

A correct presentation of the rainfall of a given locality is obtained from the following data (Hann):—

1. The monthly and annual amounts of rainfall,

including precipitation from all sources, rain, hail, snow, dew, and frost.

2. The maximum rainfall per day or per hour.

3. The number of rainy days, *i.e.* on which at least $\frac{1}{100}$ inch is recorded.

Sunshine and Cloudiness

In a climatological aspect the importance of sunshine cannot be over-estimated, as the main cause determining the prime factor of temperature, and secondarily as affecting humidity. Evaporation, which is one of the factors determining humidity, is largely dependent upon sunshine, and, conversely, sunlight is in its turn affected by humidity, for air holding water vapour is less diathermic than dry air. Further, water vapour is less diathermic to heat rays than to light rays; hence a greater number of the heat rays, both as transmitted through the air and as reflected from the earth, are retained than is the case with the light rays. This helps to explain the well-known fact that moist climates of a high degree of absolute humidity are more relaxing than dry climates of low absolute humidity, the water vapour in the air retaining more heat in the former case. In a medical aspect, with a climate such as ours, and especially in relation to a health resort, the value of sunshine is sufficiently obvious, if only for its cheering and enlivening influence. In recent years systematic registration of the duration of sunshine has been carried out at many meteorological stations, the instruments most in use being the Campbell-Stokes pyrometric sunshine recorder and the Jordan photographic recorder. These instruments give somewhat different results, the Jordan registering rather longer periods than the Campbell-Stokes, and it is important in making comparisons between different places to insure that the same method has been adopted in each, otherwise the results are not strictly comparable. Much depends, too, on whether the local situation of the recorder enables it to command a free horizon.

Cloudiness may be recorded in terms of tenths of the whole sky, a cloudiness of 7·5 denoting that 75 per cent. was covered by clouds. This is not a method in general use, and records are unobtainable except from a few stations.

Fog and Dew

The measurement of *fog* by the precipitation it causes is impracticable; it can only be recorded in the form of the number of foggy days. It is of importance climatologically as a source of atmospheric humidity, in that it checks radiation, diminishes insolation, and modifies temperature. Medically it is of great moment, owing to its depressing influences and its effects on respiratory troubles. *Dew* also is not yet satisfactorily measurable by the instruments available. Climatologically it is important, because in certain climates where it is exceptionally heavy it may take the place of rainfall. Medically it is of small import.

Wind

Active movement of air increases evaporation and influences the dryness of the soil, and is therefore of much importance as a climatic factor. Medically it is of equal importance through its effect on the "sensible temperature," both the degree of force and the direction of the wind being of moment in this respect. A rapid movement of air about the surface of the body induces active evaporation and subsequent loss of heat, and has also a stimulating effect. The rate of evaporation has been shown by Schierbech[1] to be proportional to the square root of the wind velocity, and this independently of its direction. The loss of heat from this source is therefore considerable. Every day experience will furnish numerous examples of cold weather which is pleasant when the air is still, but which becomes intolerable in the presence of a breeze; and, conversely, of hot weather unendurable in a calm but tolerable in a wind if the latter be not too moist. In a medical aspect wind must also be looked upon as the great ventilator, preventing stagnation of air, and consequent enervation and unhealthiness. The objective measurement of wind velocity by the anemometer has little more than a scientific interest. Of greater interest is the subjective estimation of the effects of wind on the personal well-being, and of winds from different quarters. Owing to many disturbing factors and to the wide variation of the personal equation, an immense number of co-ordinated observations would be necessary to ensure uniform results from which trustworthy inductions could be made.

Barometric Pressure

In considering the climate of any one locality, variations in pressure, occurring, as they do, within comparatively narrow limits, may be neglected. The difference in pressure at the top storey of a building of

[1] *Ueber die Geschwindigkeit der Verdampfung von speziellen Gesichtspunkt der physiologischen Beziehungen.*

moderate height may amount to 2–3 mm. Hg., while differences of level in different parts of the same town will cause wider variations in pressure, and yet these variations are without observable influence on the climate of the locality. Meteorologically speaking, however, variations in pressure are of the utmost importance. From the point of view of general climatology, which embraces the climatic features of areas of widely different altitudes, barometric pressure is a factor of great value, chiefly because of its influence on evaporation, the rarified air of low atmospheric pressure increasing evaporation, when temperature, movement of air, and relative humidity remain the same.

Evaporation

The combined effect of air temperature, relative humidity, and wind velocity determine evaporation. Its measurement would be of great use could it be done with accuracy. Unfortunately, owing to a variety of circumstances, absolute values that are strictly comparable cannot be obtained. Relative values for evaporation in the same locality, under the same conditions, are more serviceable.

THE OBJECTIVE AND SUBJECTIVE ESTIMATION OF CLIMATE

Hitherto the study of climate on the medical side has been largely based on meteorological data obtained objectively from prolonged observations, and on these data climates have been classified as dry or moist, hot or cold, according to objective phenomena alone. A far more rational basis for the study of climate clinically, so to speak, would be derived from a series of subjective observations as to the personal effects of the climate of different localities on a large number of trained observers over a long period of time, provided that a satisfactory scheme for the correlation and co-ordination of the results could be adopted. Such a scheme has been suggested by Tyler[1] in an interesting paper giving the result of the subjective impressions of a body of twelve observers, each of whom recorded at noon every day during the month of August 1902 at Shanghai, where they resided, his opinion of the climate at that hour, expressing his sensations by means of a scale in which 10 represented the very worst day the observer remembered to have experienced in Shanghai, while 0 represented an ideal summer day—warm of course, but bright, brisk and bracing, when, suitably dressed, no discomfort was felt from temperature and humidity. Parallel readings of the temperature and humidity were taken, and a comparison made between the figures obtained and the tabulated impressions of the various observers. The mean of the latter was found to agree closely with Tyler's own personal sensations. From a study of the results he believed a clear relation to exist between the temperature and humidity records and the weather, as estimated on the sensation scale by his collaborators. He recognises, of course, that the observations are too few in number and the period of time covered is too short for more than suggested inferences to be drawn from them. Yet the scheme is highly original and instructive, and, if it were possible to make use of it on a large scale,

[1] W. F. Tyler, "A Scheme for the Comparison of Climates," *Journal of Balneology and Climatology*, January 1904.

could not fail to yield valuable results which would further our knowledge of climate from a medical standpoint. The obvious objections to it are the difficulty of organising a sufficiently large number of observers and, when organised, of ensuring that they shall be under conditions as nearly as possible alike; and the difficulty encountered in the personal equation, which must be reduced to a minimum by the employment only of trained individuals. Further, the many disturbing factors that come into play, influencing unconsciously the appreciation of climate at given times, would necessitate the continuance of the observations over a long period of time before results could be obtained from which trustworthy inductions could be made. Tyler concludes his paper with a remark on the value of a sensation scale from a medical point of view. "It cannot, of course," he says, "be assumed that the physiological effects of climate will vary exactly with the subjective effects, but it is certain that they will march much closer to them than to the effects indicated on existing instruments measuring physical quantities," a statement which it must be admitted is probably true.

PHYSIOLOGICAL EFFECTS OF THE CLIMATIC FACTORS

As indicated in the foregoing remarks, the climatic factors most potent in inducing physiological changes are temperature and humidity, each being made up of a combination of other factors.

TEMPERATURE

Above and below an indifferent point, which probably varies in different individuals in different localities, and in the same individual at different times, temperature has an irritant effect on the nerve endings of the skin, and excites reflex changes similar to those fully dealt with in the chapter on the physiological effects of temperature in bathing. A temperature much above the indifferent point excites dilatation of the vessels of the skin and results in enlargement of the vascular area exposed to the air, and thus enables an increased loss of heat to take place by conduction and radiation in the endeavour to maintain the balance between heat production and heat loss. The relative hyperæmia of the skin induced leads to increased activity of the sweat glands, with consequent further loss of heat by evaporation of perspiration, that is, if the relative humidity of the atmosphere be not too high. (In tropical climates, if the temperature is above that of the body, and the amount of water vapour in the air approaches saturation, the loss of heat by conduction and radiation becomes negative, and that by evaporation is dangerously curtailed. The condition known as heat-apoplexy is then apt to supervene.) The blood pressure is lowered, but in health contraction of the splanchnic area takes place to prevent undue reduction. The respiration is increased, by which additional loss of heat takes place. On the nervous system the effect of high temperature is distinctly sedative and relaxant, one result of which is to induce disinclination for active exertion, so that undue production of heat from this source is avoided. Thus the main results of exposure to high temperature all tend in the direction of facilitating heat loss, while limiting heat production. It is probable that the balance is further regulated by direct stimulation of the thermotaxic centres, but of this we know very little.

The effects of low temperatures are practically the converse of the above, and lie in the direction of conservation of heat to the body, together with increased production. Contraction of the superficial vessels is reflexly induced, so that the amount of blood exposed to the surface is less. Excretion of sweat and heat loss by evaporation are reduced to a minimum. The blood pressure rises, but is prevented from undue elevation by dilatation of the splanchnic area, to which the chilled surface blood in course of circulation passes to be warmed again. The heart is stimulated to stronger contraction, which in itself becomes a source of heat production. The nervous system is invigorated and the disposition to exercise is excited, so that a *plus* heat production may result from active muscular exertion. If exercise be impracticable and the degree of cold be great, Nature provides a source of heat supply in the muscular contraction of shivering. The respiratory movements are slowed and at first deepened. Later, however, they become more shallow, so that less heat is lost from this source. Metabolism is accelerated owing to the increase of tissue activity necessary to furnish an increased heat production. An indication of increased metabolic activity is afforded by the excess of carbonic acid which has been shown to be eliminated under the influence of cold over that under normal atmospheric temperature (Leibermeister, Gildemeister, Lehmann).

The reaction after sudden exposure to unwonted great heat or cold may be imperfect and their respective effects be badly borne at first. Toleration is, however, soon established, and in health the marvellous physiological mechanism of the body ensures the maintenance of heat equilibrium over long periods of time under the most extreme conditions of temperature. It is probable that with exposure to cold the factor of heat production exerts a greater influence than reduction of heat loss, while conversely with exposure to high temperature the more prominent of the two factors is increased heat loss.

Humidity

The physiological effects of humidity are of importance, for on the amount of aqueous vapour in the atmosphere largely depends the rate of evaporation, and the loss of water from the body through the medium of expired air. According to Pettenkofer, the daily elimination of water from the skin and lungs of a healthy man amounts to 900 grams, of which 540 grams, or 60 per cent., are excreted by the skin alone and 40 per cent., or 360 grams, by the lungs. The absolute humidity, or actual weight of water vapour in the atmosphere, determines the amount of water lost during each respiration *viâ* the lungs, while the relative humidity is of more importance in influencing the amount lost in evaporation *viâ* the skin. As the former loss is considerably less in amount on the average than the latter, the relative humidity is probably a more important indication of atmospheric moisture from a medical point of view (*cp.* p. 160).

Sudden marked changes in humidity acting on a subject whose adaptability is impaired by ill-health may be very harmful owing to the changes excited in the blood pressure and the strain consequently thrown upon the kidneys. Even a slight variation in relative humidity of one per cent. may induce changes which may be detected in the amount of evaporation from the skin. The difference in effects of a high temperature saturated with aqueous vapour and an equally high or higher temperature in which the amount of aqueous vapour, though relatively great, is much below saturation point, is well exemplified in the Russian and Turkish baths respectively. In the former, loss of water, and therefore of heat, is prevented by the inability of the already saturated atmosphere to take up more moisture. In the latter, evaporation can take place more freely. These facts afford an explanation why a high temperature can be more readily borne in the Turkish bath than in the Russian. The humidity of the atmosphere has therefore an important influence in modifying the physiological effects produced by changes of temperature, these effects being different in different climates. A fall of temperature when the relative humidity is high will produce much more marked effects than when the air is dry. From this it follows that sudden changes of temperature are tolerated in a dry climate with much less discomfort than in a moist climate.

THE CLIMATE OF HARROGATE

Features, Geographical and Topographical, modifying the Climatic Factors

The distinguishing features of the climate of Harrogate are as follows: with respect to temperature, the freedom from extremes of heat and cold, considering the altitude and situation; the abundance of sunshine; and with respect to humidity, the dryness and peculiarly invigorating quality of the air.

Situation.—Harrogate is situated in the West Riding of Yorkshire, midway between the Irish Channel and the North Sea. It lies on the 54th parallel of north latitude, its longitude being 1° 31′ 53″ west of Greenwich. The town stands on an elevated moorland plateau varying from 400 to 600 feet in height, which is in fact the highest tableland in England. In the immediate neighbourhood there are no abrupt elevations. To the eastward (from N.E. to S.E.) this plateau shades off by a gradual slope to the level of the plain of York and thence to the sea coast, a feature which permits the free passage of winds from the sea to mingle with the moorland air. Winds from the east, however, are not prevalent, except for a few weeks in the spring months, and are robbed of much of their harshness by passing over the flat tract of land intervening between Harrogate and the North Sea. That some of the qualities of sea air are conveyed to Harrogate, either from the east or the west coast, or both, would seem to be proved by the fact that a deposition of salt is frequently observed upon the instruments at the meteorological station after a stiff breeze from either quarter. This intermingling of sea air with moorland air may account to some extent for the peculiar but indefinable quality of freshness which is so notable a feature, and which at once arrests the attention of the visitor. To the westward (from N.W. to S.W.) the moorland plateau rises within a radius of 15 miles to elevations varying from 800 to 1600 feet, and beyond that, within a radius of 25–35 miles, to greater elevations, which culminate in the mountainous tract of the Pennine Range, varying from 1800 to 2400 feet in height. The effect of this chain of hills and mountains is to form a natural barrier in the shape of a huge amphitheatre extending from N.W. to S.W., protecting Harrogate from the rain-laden winds of the west. Westerly winds are the most prevalent in the locality for two-thirds of the year, and in passing over these elevated tracts deposit much of their moisture before reaching Harrogate. The following table of the annual rainfall for one typically dry year (1901) and one wet year (1903) at various stations from N.W. to S.W. of Harrogate illustrates this :—

Rainfall for One Dry Year (1901) and One Wet Year (1903) at Stations N.W. to S.W. of Harrogate.

	Direction from Harrogate.	Distance from Harrogate in Miles.	Elevation in Feet.	Rainfall in Inches. 1901.	Number of Rainy Days. 1901.	Rainfall in Inches. 1903.	Number of Rainy Days. 1903.
Masham	N.N.W.	17	1412	36·40	172	67·78	...
Aysgarth	N.W.	28	643	31·95	188	53·86	225
Ramsgill	N.W.	15	925	34·62	167	69·92	215
Arncliffe	W.N.W.	26	734	56·95	195	81·92	232
Malham Tarn	W. by N.	27	1296	51·34	206	73·01	258
Settle	W. by N.	30	525	36·86	191	60·28	236
Barden	W.	17	746	35·48	221	56·80	272
Slaidburn	W. by S.	37	540	62·90	...	87·15	235
Skipton	W. by S.	19	730	32·21	195	44·09	...
Clitheroe	W.S.W.	36	464	35·21	...	57·12	...
Ilkley	S.W. by W.	12	395	29·60	...	49·60	238
Keighley	S.W.	18	385	30·87	196	49·71	229
Average				39·53	192	62·60	238
Harrogate (altitude, 480 feet) .				24·33	164	39·55	226
Difference				15·20	28	23·00	12

It will be seen that in an exceptionally dry year like 1901 the average rainfall of these stations, situated at various points on the western barrier, at varying distances from Harrogate, amounts to no less than 15 inches more than that recorded at Harrogate itself, while in an exceptionally wet year the difference amounts to as much as 23 inches. Also the number of rainy days was less at Harrogate than the average of these stations by 28 in 1901 and 12 in 1903. Thus the presence of the natural barrier shields Harrogate from much of the rainfall that would otherwise fall to its lot, having regard to the prevalence of rain-laden westerly winds.

Rivers.—Arising in the mountainous country to the west and flowing eastward along valleys radiating thence are the rivers Nidd and Wharfe, the former to the north of Harrogate, distant 2–3 miles, the latter to the south, distant about 6 miles.

One consequence of this absence of close proximity to the river beds is frequently to be observed in a very striking manner in the way in which rain storms or thunder storms, gathering in the hilly districts of the west and travelling eastward, divide and follow the course of either or both rivers, leaving Harrogate comparatively dry. Another consequence is the freedom from dense foliage in the immediate vicinity which so often marks the course of river beds and is an undoubted factor in contributing to the amount of atmospheric humidity. Further, though the town lies on the outskirts of what was once the dense forest of Knaresborough, at the present time it is by no means encumbered with trees, although there is sufficient foliage to render the district attractive. The number and distribution of the trees in the neighbourhood is probably not such as to have any appreciable effect on the climate. The influence of forests on the climate of a district is of course considerable, various factors being disturbed by their presence. Thus the mean temperature of the air tends to be lower in forest areas than in open country, a result brought about by the shading of the ground, by the increase of radiation and of radiating surface supplied by the leaves, and by the increased evaporation and consequent reduction of temperature. Humidity is modified in the direction of an increase in relative humidity owing to decrease in evaporation from the ground and to the retention of moisture in the soil, and, further, to the limitation of free movement of the air.

The effect of forests upon rainfall is a somewhat disputed point. They are commonly supposed to increase markedly the amount of precipitation. This is doubtless true for tropical zones, but the evidence that the same holds good for temperate climates is not so convincing. Hann states[1] that "in general the rainfall is to be looked upon as the cause, and the condition of the cover of vegetation as the effect," and he goes on to say: "Extended forests, even in middle and higher latitudes, certainly have some influence in increasing the frequency of rainfalls, but it is naturally almost impossible to determine the extent of this influence by observation and measurement. It must nevertheless be admitted that it was formerly the habit very greatly to over-estimate the effect of forests in increasing rainfall, and the natural reaction has led to the present tendency altogether to deny such an influence. A surface which keeps the air moist and cool, and from which there is as great an evaporation as takes place from extended forests,

[1] *Loc. cit.*, pp. 194–195.

must have a tendency to increase the amount and frequency of precipitation, as contrasted with an open country which is dry, but over which conditions are otherwise similar. Small and scattering groves of trees will naturally not have this influence."

Thus it is probable that formerly when the dense forest of Knaresborough was in existence the climate of Harrogate was distinctly colder and more humid than at the present time. The absence of forest is a contributory factor towards the maintenance of the dry quality of the atmosphere.

The local conformation of the district and of the plateau on which the town stands is peculiarly favourable to the free play of air, and thus prevents stagnation of the atmosphere. The absence of abrupt elevations which would act as sheltering barriers and the absence of dense forest ensures active circulation and constant renewal of the air, and contributes to the production of the peculiar quality of "freshness." The enervating and relaxing effects of a stagnant atmosphere are well known, and the freedom from this source of depression is of great value to the jaded town-dweller who seeks relief at a health resort.

Winds.—There are thus no obstructions to impede the free sweep of winds with their purifying, invigorating influences. As has been said, the prevailing winds for two-thirds of the year come from the west, south-west, and north-west, bereft, however, of much of their moisture and much of their force by their passage over the mountain barrier. This prevalence of westerly winds, which in this country are warmer than those from the east, is a factor of some moment, influencing the air temperature. Were winds from the east more prevalent the mean annual temperature would undoubtedly be lowered. From this quarter they are common during the spring months, but are usually associated with fine dry weather, with abundance of sunshine, which renders them far less searching than would otherwise be the case.

Although Harrogate has its fair share of wind, it is not an exceptionally windy place. One noticeable feature, however, is the comparative absence of dead calms. Rarely even on the hottest and most still days is the air absolutely motionless, and gentle breezes almost invariably spring up which render the heat less oppressive.

The geological formation of the district is such as to favour the production and maintenance of a low degree of humidity of the atmosphere; it affords facilities for natural drainage, and is unfavourable to the retention of undue moisture in the ground. A detailed account of the geology of Harrogate would obviously be out of place in a work of this description: sufficient only will be said to indicate its general bearing on the climate.

Harrogate stands on the eastern end of the great anticlinal axis which extends across the country from Clitheroe in Lancashire, to the west, and passes eastward across Yorkshire to the north of Skipton, to end in a great fault where the axis is broken and the strata are tilted to the surface at varying angles. From between the strata so inclined issue the various medicinal springs. The rock formation underlying the district belongs to the Carboniferous series, and the plateau of Harrogate consists of alternate beds of millstone grit and shale, originally deposited horizontally. By subsequent upheaval the strata have been broken and tilted at high angles to form two massive flanking walls sloping away northward and southward, while between them appears a mass of shale and deeper beds of rock, also inclined at irregular angles. Wherever the strata are exposed in the neighbourhood, in quarries, cuttings, and excavations, they are seen to slope in one direction or the other.

Natural drainage is eminently favoured by such a formation, and takes place in a gradual, steady manner, for the elevation of the plateau is not so great, nor the inclination of the strata so abrupt, as to cause too rapid flow of water, with consequent denudation and aridity of surface soil. The effect of this natural drainage is apparent on the humidity of the district.

The Climatic Factors in relation to Harrogate Meteorological Data [1]

Temperature.—The distinguishing features of the temperature are, first, that the monthly and annual means are not as low as might be expected considering the latitude (54° N.) and the elevation (400–600 feet); and, secondly, that the extremes of heat and cold in winter and summer are not excessive. The mean monthly and mean yearly temperatures at the observation hour of 9 A.M. are given in the table below. The 9 A.M. observation hour is used conformably with the practice at English meteorological stations. From the medical point of view it is to be regretted that no figures are

[1] The meteorological data have been kindly supplied by Mr. G. Paul, F.R.Met.Soc., meteorologist to the Harrogate Corporation.

obtainable for observations taken nearer the middle of the day, at a time more suitable for invalids to be out of doors. The mean of such observations would, of course, show a much higher range of temperature.

Mean Monthly Temperature—Average of Ten Years, 1895–1904.

Degrees Fahrenheit.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
37·0	37·0	40·1	44·2	48·9	55·7	59·4	58·2	54·6	47·1	42·9	38·2

Mean Annual Temperature—Ten Years, 1895–1904.

Degrees Fahrenheit.

1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
45·9	46·9	46·6	47·8	47·6	47·5	46·9	46·2	46·8	46·7

Mean of ten years, 46·9.

The mean temperature of the winter months, December, January, February, is about 20° F. below that of the summer months, June, July, and August—a difference which does not appear to be excessive considering the geographical and topographical conditions. The mean annual temperature of 46·9°, compared with that of towns on nearly the same latitude, such as Liverpool and Dublin, though lower by 2° and 3° respectively, is not as much lower as would be expected considering that both these places are on the coast, and both of somewhat lower latitude, viz. 53° 20′.

In the following table the mean annual temperature of a few of the larger towns for the past five years is compared with that of Harrogate :—

Mean Annual Temperature.

	London, Regent's Park.	Dublin.	Liverpool.	Birmingham.	Glasgow.	Harrogate.
1899	51·3	51·5	49·7	49·4	47·2	47·6
1900	50·9	50·5	49·3	48·9	47·0	47·5
1901	49·6	49·9	49·0	48·1	47·1	47·0
1902	49·4	50·0	48·2	47·7	45·7	46·1
1903	50·4	50·2	49·0	48·3	45·7	46·8
Mean of 5 years	50·3	50·4	49·05	48·48	46·5	47·0

If the range of variation between the mean of the maximum and the mean of the minimum yearly temperatures be compared with that of London, for example, it will be seen that although Harrogate lies so much farther north, the range of variation for the past five years is nearly the same in the two places. This supports the statement that the extremes of heat and cold are not excessive.

Mean Maximum and Mean Minimum Temperature for London and Harrogate for Five Years, 1899–1903.

	London.			Harrogate.		
	Max.	Min.	Difference.	Max.	Min.	Difference.
1899	58·3	44·3	14·0	54·6	40·6	14·0
1900	57·7	44·0	13·7	53·9	41·1	12·8
1901	56·7	42·4	14·3	53·9	40·0	13·9
1902	55·6	43·1	12·5	52·3	39·9	12·4
1903	56·4	44·3	12·1	52·9	40·7	12·2
Mean of Difference	...	...	13·3	...	...	13·06

The data for Harrogate during the past year, 1904, are as follows:—

Maximum, Minimum, and Mean Monthly Shade Temperature for Harrogate in 1904, *with Seasonal Averages.*

	Max.	Min.	Mean.	
March . .	43·7	32·5	38·1	44·8 Spring average of mean temps.
April . . .	53·2	39·5	46·3	
May . . .	56·3	43·4	50·1	
June . . .	62·4	46·5	54·4	57·0 Summer average of mean temps.
July . . .	67·3	51·4	59·3	
August . .	65·0	49·8	57·4	
September .	61·2	46·1	53·6	47·9 Autumn average of mean temps.
October . .	55·0	42·1	48·5	
November .	46·7	37·0	41·8	
December .	43·0	32·0	37·5	37·4 Winter average of mean temps.
January . .	42·9	33·4	38·1	
February .	40·4	31·8	36·1	

Results which conform closely to the ten years' average given previously, notably in the difference (19·6°) between the summer and winter average temperature.

The mean diurnal range of temperature for each month, on the average of the past ten years, is shown in the following table, together with the mean diurnal range for each year:—

Mean Monthly Diurnal Range of Temperature for Harrogate, 1895–1904.

Degrees Fahrenheit.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
8·4	9·7	11·1	14·3	15·9	16·7	16·2	14·6	14·4	11·1	9·2	8·5

Mean Annual Diurnal Range of Temperature for Harrogate, 1895–1904.

Degrees Fahrenheit.

1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
12·8	11·6	12·1	12·6	12·3	12·8	13·8	12·2	12·2	12·7

Mean of ten years, 12·5.

As is the case with the seasonal variations, the mean diurnal variation is also by no means excessive, and affords further evidence of the comparative absence of extremes.

Frost.—The following table of the earliest and latest dates upon which frosts were observed during the last ten years is of interest:—

Dates of Earliest and Latest Observed Frosts, from 1895–1904.

	Earliest Observed.	Latest Observed.
1895	October 3	...
1896	...	May 25
"	October 19	...
1897	...	May 27
"	September 8	...
1898	...	July 30
"	August 29	...
1899	...	June 15
"	September 28	...
1900	...	May 25
"	September 3	...
1901	...	May 24
"	October 8	...
1902	...	June 10
"	October 4	...
1903	...	July 8
"	September 27	...
1904	...	May 20
"	September 20	...

The usual time for the appearance of occasional frosts is thus late in September or early in October. They may occur in a sporadic manner as late as May, June, or July; and in one remarkable year, 1898, frosts occurred on 30th July and 29th August.

The data given above bear out, in the main, the statement that the mean temperature of Harrogate is relatively high for its latitude and situation, and that the variations experienced are comparatively moderate in extent.

Humidity.—As has been already said, a prominent feature of the climate is its dryness, a condition attributable in part to the amount of sunshine, with which, as will be seen, Harrogate is exceptionally favoured, and in part to the facilities for rapid evaporation and thorough drainage afforded by the conformation of the country. The average monthly humidity, both relative and absolute, for the past six years, is as follows :—

	Relative Humidity.	Absolute Humidity.
	Per cent.	Grs. per Cubic Foot.
1899	76	3·1
1900	82	3·2
1901	82	3·2
1902	76	3·1
1903	68	2·9
1904	75	3·0
Mean of six years . .	76·5	3·08

A comparison may be made of the mean monthly relative humidity with that of a few other places for which the figures are obtainable :—

Relative Humidity, 1899 *to* 1903, *for*

	London.	Dublin.	Liverpool.	Llandudno.	Southport.	Harrogate.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1899	77	81	81·3	82	80	76
1900	77	82	82·4	78	83	82
1901	77	80·6	83·1	76	82	82
1902	78·9	81·3	84·0	82	...	76
1903	78·1	83·1	82·0	80	...	68
Mean of 5 years	78·0	81·6	82·5	79·6	(3 yrs.) 81·6	76·8

The table shows Harrogate to be drier than London, and, as would naturally be expected, drier than the coast towns mentioned.

The absolute and relative humidity for the four seasons of the year appear as follows :—

	Mean Monthly Relative Humidity.		Mean Monthly Absolute Humidity.	
	Per cent.		Grains per Cubic Foot.	
Spring	77·60	76·07	2·76	3·62
Summer . . .	74·54		4·49	
Autumn . . .	88·94	87·92	3·55	2·90
Winter . . .	86·90		2·26	

Thus relative humidity is much higher in winter than in summer, while the reverse is the case with the absolute humidity. This certainly corresponds much more closely to the subjective sensations of climate, as experienced by the individual, than if attention be paid to the absolute humidity alone as the better indication of the effect of moisture. Again, the extremes of daily variation that take place in relative humidity are proportionately greater than those of the absolute, which affords a further reason for regarding relative humidity as the more important datum medically. For example :—

	Relative Humidity.	Absolute Humidity.
	Per cent.	Grains per Cubic Foot.
Maximum monthly variation	15·57	2·20
„ daily „	61·0	1·8
Mean monthly „	10·09	·476
„ daily „	10·14	·469

It is of interest to note from the above table that in 1901, which was the year of least rainfall in Harrogate for many years, the mean monthly relative humidity was high, viz. 82 per cent., while in 1903, the year of greatest rainfall, the relative humidity was very low, viz. 68 per cent. Corroborative evidence is thus afforded of the statement of Weber, that a high rainfall tends to lower the relative humidity.

Of further interest is a comparison between the mean humidity for the months of April and October in these two years respectively, April being on the average the driest, and October the wettest month of the year in Harrogate.

	Relative Humidity.	Absolute Humidity.
	Per cent.	Grains per Cubic Foot.
April 1901. Dry year .	74·7	2·7
April 1903. Wet year .	69·5	2·38
October 1901. Dry year .	91·3	3·5
October 1903. Wet year .	83·6	3·33

The comparison shows that in the driest month of the driest year with respect to rainfall, the humidity, both relative and absolute, is greater than in the same month of the wettest year; while in the wettest month of a wet year the humidity, both relative and absolute, is less than in the same month of a dry year.

Sunshine.—The amount of sunshine recorded is a noteworthy feature. The following table shows a comparison in this respect between Harrogate and certain other inland and coast towns from which records are obtainable. The data procurable extend over four years, and are obtained by means of Jordan's photographic recorder. The figures for 1904 are not yet available for all these places:—

	Hours of Sunshine.				
	1900.	1901.	1902.	1903.	Average.
Buxton . . .	1236·0	1345·9	1146·0	1117·1	1211·2
Bowness . .	1406·8	1662·4	1224·2	1238·0	1382·8
Cheltenham . .	1525·0	1590·1	?	1454·0	1523·0 (3 years)
Falmouth . .	1932·9	1975·4	1731·7	1712·3	1838·1
Folkestone . .	1752·0	2271·8	1535·0	1687·7	1811·6
Grange . . .	1618·5	1749·9	1414·5	1477·8	1565·2
Southport . .	1660·3	1801·6	1477·7	1539·4	1619·7
Torquay. . .	1858·0	1777·3	1572·8	1645·4	1713·4
Tunbridge Wells .	1840·0	1920·5	1631·7	1693·7	1771·5
Harrogate . .	1995·5	2172·2	1655·1	1641·6	1856·1

With the single exception of Folkestone, the maximum amount of sunshine observed in any one of the four years was recorded by Harrogate, viz. 2172 hours in 1901; and the average amount during the whole period was greatest at Harrogate, exceeding even the records obtained at south coast watering-places, such as Falmouth and Folkestone. Considering the difference in latitude, this result is as remarkable as it is unexpected.

The figures so far obtainable for 1904 are given in the following table, into which those from certain large towns are introduced for comparative purposes:—

	1904.	
	Hours of Sunshine.	Sunless Days.
Bowness	1282	93
Falmouth	1637	71
Grange	1611	57
Southport	1626	73
Bradford	958	136
Leeds	1458	91
Sheffield	1325	87
Harrogate	1606	67

It will be seen that in 1904 Harrogate was slightly exceeded in the total amount of sunshine by Falmouth, Southport, and Grange, but recorded fewer sunless days than any, with the single exception of Grange.

The large amount of sunshine enjoyed contributes largely to the maintenance of a dry atmosphere, and towards raising the average air temperature to a level higher than might be expected from the latitude and elevation of the town. Its influence upon invalids can hardly be overestimated.

Rainfall.—The mean annual rainfall of Harrogate for ten years is compared in the following table with that of certain inland and coast watering-places and with that of the three capitals of the United Kingdom. The table also shows the altitude in feet of the meteorological stations at the places mentioned, and the number of "rain days"—that is, days on which at least ·01 inch fell—in the dry and wet years 1901 and 1903 respectively.

Average Annual Rainfall for Ten Years, 1894–1903.

	Altitude in Feet.	Rainfall in Inches.	Rainy Days, Dry Year, 1901.	Rainy Days, Wet Year, 1903.
INLAND WATERING-PLACES.				
Bath . . .	520	30·8	144	202
Buxton . . .	1600	50·5	225	258
Cheltenham . .	500	27·3	145	203
Ilkley . . .	395	35·9	163	238
Leamington . .	300	22·9	141	179
Moffat . . .	500	55·4	222	254
Malvern . . .	1006	27·6	161	164
Strathpeffer . .	210	29·5	...	235
Tunbridge Wells .	416	29·3	127	172
Harrogate . .	**480**	**31·6**	**164**	**226**
COAST WATERING-PLACES.				
Bournemouth . .	41	30·7	173	209
Brighton . . .	35	27·6	141	185
Blackpool . .	59	33·7	195	236
Eastbourne . .	70	28·8	138	196
Falmouth . .	169	42·4	185	247
Folkestone . .	230	27·8	144	206
Grange-over-Sands .	180	45·5 (last 7 years)	184	248
Hastings . . .	301	27·8	132	174
Llandudno . .	72	30·9	200	206
Lowestoft . .	86	23·6	145	174
Margate . . .	55	21·7	160	182
Morecambe . .	24	25·1 (last 7 years)	136	227
Nairn . . .	82	25·4	207	250
Scarborough . .	63	26·5	185	226
Southport . .	38	30·4	163	220
Torquay . . .	12	34·0	154	198
Ventnor . . .	70	29·4	144	192
Weston-super-Mare .	23	31·6	155	206
CAPITALS.				
London . . .	111	24·0	128	179
Edinburgh . .	349	27·8	140	223
Dublin . . .	514	30·2	198	243

It would appear then that the average annual rainfall at Harrogate is somewhat in excess of that of the majority of the places quoted, being greater than is recorded by 22 out of the 30 for which the figures are given.

Inasmuch as the local conditions obtaining at such widely different localities are so varied no strict comparison can be made, and the table is merely given as a matter of interest and according to custom. From the invalids' point of view a more important question than the total amount of annual rainfall is the number of days on which rain fell, for on this will depend to some extent his possibilities of taking open-air exercise. The number of "rain days" at Harrogate for the past ten years was as follows:—

1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
213	174	185	204	198	173	203	164	178	226

These figures give an average number of 191 "rain days" per year, which is also somewhat excessive. The average annual rainfall being 31·6 inches, it is a matter of simple calculation to show that the average amount of rain that falls on each "rain day" is ·11 inch, which would indicate that frequent light rainfalls are the rule.

An examination of the number of heavy rainfalls (that is, of 1 inch or more during the twenty-four hours) which have occurred within the last ten years, will show, however, that these are by no means infrequent. A considerable proportion of the total rainfall occurs, therefore, in sharp outbursts during short periods—generally from clouds that have been too heavily laden to deposit all their moisture in passing over the mountain barrier in the west, which has been previously described. Thus the number of days sufficiently rainy to prevent the enjoyment by invalids of the open air are not as great as would appear from the average number of meteorological "rain days."

Days during ten years, 1895–1904, *on which* 1 *inch or more fell within twenty-four hours.*

		Ins.		Ins.		Ins.
1895.	Oct. 3	1·15.				
1896.						
1897.	June 28	1·03.				
1898.						
1899.	May 11	1·10;	Sept. 29	1·05;	Oct. 1	1·74.
1900.	Feb. 10	1·02;	Feb. 16	1·30;	June 12	1·03;
	July 12	1·20;	Aug. 2	1·50;	Aug. 23	1·03.
1901.	Nov. 11	1·07;	Nov. 12	2·05.		
1902.	Oct. 9	1·04.				
1903.	Sept. 10	1·30;	Oct. 8	1·28;	Oct. 27	1·02.
1904.	July 24	1·39;	Aug. 14	1·11;	Nov. 21	1·85.

As previously pointed out, the mean annual rainfall has but a slight influence on humidity, and is therefore not a prominent factor in determining the amount of moisture present in the atmosphere.

The importance of rainfall lies chiefly in its fructifying influence, in its effect on the purity of the atmosphere and the soil, and, consequently, on the amount of sickness in the locality, and in the degree to which it curtails or hinders open-air exercise.

Fog and Dew.—It is impossible to give more than a general indication of the amount of fog and dew, inasmuch as there are no satisfactory methods of measuring them. Formerly, fogs were said to be unknown in Harrogate, but this is probably an exaggeration. They are by no means uncommon now, possibly owing to the increased size of the town, but they occur at the time when fog is liable to be most prevalent in this country, viz. in November, and are seldom experienced at other times of the year.

Atmospheric Pressure.—As a climatic factor in relation to Harrogate this is of minimal importance, and may be excluded from consideration here.

The Climate in its Medical Aspects

Before remarking on the climate and its bearing on the health of residents and invalid visitors, the considerations mentioned under the physiological effects of the climatic factors in general may be briefly applied to the climate of Harrogate in particular.

The prime factor of temperature being relatively though not extremely low in winter, and equable in summer, tends to promote heat loss, and secondarily to increase heat production. The second factor of humidity, which is comparatively low at all seasons of the year, favours the loss of water, and consequently of heat, from the lungs, and further involves an increase of heat production. The subsidiary factor of active movement, and "freshness" of the atmosphere, leading to free play of air on the body surface, encourages evaporation—which in turn is permitted by the low degree of humidity—and thus further increases heat loss; while the increase in frequency and depth of respiration excited leads to more active oxygenation, a *plus* excretion of carbonic acid, and acceleration of respiratory combustion. Further, the accompanying stimulation of the cutaneous nerve endings gives rise to sensations of buoyancy and exhilaration, which find expression in active exercise, whereby a fertile source of heat production is rendered available. The net effect, therefore, of the climate is to cause an increase in tissue metabolism. To those reacting satisfactorily to the stimulus, this cannot fail to be beneficial by the setting up of a more rapid tissue metamorphosis. In them elimination keeps pace with the liberation of waste products; a demand is created for further intake of food to make good the loss, and is satisfied by the increased appetite provoked; anabolism balances katabolism, and physical regeneration more rapidly ensues than under less stimulating climatic conditions. On the other hand, with such as are too feeble to respond to the excitation caused by the climate, or in whom a condition of nerve irritability exists, katabolism will tend to outrun anabolism, and the result in the long run will be failure to maintain the normal equilibrium of health.

Climate of Harrogate with respect to Permanent Residence

As a place for permanent residence Harrogate has many attractive features, not the least of these being the nature of its climate. The dry, bracing quality of the latter, and particularly its "freshness," render it peculiarly invigorating, especially to those accustomed to dwell in towns, in whom want of fresh air and enforced sedentary habits have brought about a condition of lowered vitality. To such, migration to more stimulating surroundings is often attended by immediate improvement in health. Many have been led to reside in Harrogate by their experience of the climate gained during one or more visits to the town for pleasure or for treatment. Children, especially, do exceptionally well there. It is common to see delicate, town-bred children when transferred to Harrogate develop in a few months into vigorous individuals without the aid of any further treatment.

A common misapprehension is that the winters in Harrogate are very keen, and such as to try severely any but the strongest. In our experience, covering ten years, this is only partly true. Up to February the climate is not more trying than that of the north of England generally. The months of February and March are the worst, and for those whose means and occupation permit, are the months of election for a sojourn away when possible. It has also appeared to us that a too prolonged residence in Harrogate without a change may lead to an irritable condition of the nerve centres, as though frequent repeated stimulation led to a failure of response and fatigue of the nerve tissues—a state, however, which rapidly subsides with a change to less exhilarating surroundings.

The Climate with respect to Invalids

A.—*Diseases to which the Climate is suited*

The types of cases which are likely to benefit from the climate alone, apart from treatment by waters and baths, appear to be as follows:—

1. **Conditions of Perverted or Poor Nutrition** from causes other than definite organic disease, which are not too far advanced to be beyond the power of reaction to stimulation. Such are the physical and mental depression resulting from town life and sedentary occupation; that

state of "brain fag" which is the outcome of too prolonged and assiduous mental work without a break; conditions of physical and mental torpor resulting from over-indulgence in food and drink, combined with insufficient exercise; the exhaustion of prolonged convalescence, and so forth. In the same category may be included the defective nutrition of children which results from hereditary tendencies, unhygienic surroundings, or improper feeding. As has been previously mentioned, and may be here emphasised, such cases show rapid improvement. Rickets is a disease in which specially striking results are obtained.

2. **Tubercular Diseases,** more especially those manifestations which fall within the domain of surgery, such as tubercular glands, tubercular disease of bones or joints, tabes mesenterica, improve in such a climate. The stimulus to nutrition given by the climatic conditions develops the resistive powers of the patient and favours recovery. Tubercular disease of the lungs in its chronic forms is also favourably influenced, especially during the summer months. Among the resident population phthisis is uncommon, and such cases as have been observed have been chiefly of the slowly progressing type, as though the climate exercised a retarding influence on the tubercular process. Cases of chronic phthisis are frequently sent here, and generally do well. More acute cases, with marked febrile reaction, as a rule do badly.

3. **Affections of the Respiratory Tract.**—In cases of chronic bronchitis and bronchial catarrh the climate is decidedly beneficial in the summer months, but not in winter time. Patients with catarrhal, relaxed conditions of the nose and throat derive benefit from the low degree of moisture in the air.

4. **Cases of Anæmia**, whether chlorotic or secondary, find in the increased oxygenation excited by the operation of the climatic factors a useful aid to the action of the iron waters in the cure of these diseases.

5. **Diseases of the Nervous System.**— On most organic diseases of the nervous system the climate of course can have no beneficial effect. Functional diseases, such as neurasthenia, when dependent upon defective nutrition of the nerve centres, are amenable to climatic influences. Those cases characterised by debility in contradistinction to irritability, and attended by loss of flesh, do well. To the latter type, more especially if insomnia be a prominent symptom, the climate is unsuited. Cases of hysteria respond to the stimulating effect of the climate on the nervous system.

6. Cases of **Skin Disease**, especially forms of eczema that are irritated by residence at the seaside, improve under the drier climatic conditions that obtain at an inland health resort, an improvement which, apart from specific treatment, is aided by the favourable character of the domestic water supply hereafter to be mentioned.

7. In cases of **Chronic Gout**, the accelerated metabolism induced by the climate is an adjunct of value to their treatment by a course of baths and waters.

8. **Rheumatism.**—The dryness of the climate is apparently inimical to the rheumatic process. It is rare to meet with rheumatic fever among the residents, and the chronic forms of rheumatism also are uncommon. We have, moreover, repeatedly observed an abatement, after continued residence here, of the rheumatic manifestations of patients sent from elsewhere, with or without a history of previous attacks of rheumatic fever; and this apart from any treatment by waters or baths. Hence

the climate would appear to be a valuable aid in the treatment of cases sent for limited periods.

B.—*Diseases to which the Climate is unsuited*

A brief allusion must be made to certain classes of cases in which the climate of Harrogate is manifestly contra-indicated. Such are—

1. **The irritable Neurotic Type of Functional Nervous Disease,** associated with restlessness and insomnia. In cases of this kind stimulating influences provoke nerve discharges which are already in excess from loss of inhibitory control, and do harm by prolonging the condition. For these a more sedative climate is required.

2. **Catarrhal Affections of the Respiratory Tract.**—In winter, when the ill-effects of cold may more than counterbalance the advantages of a dry atmosphere, these cases should not be sent here for treatment.

3. **Chronic Affections of the Kidney.**—The climate is unsuited to these conditions, in winter especially, when the strain thrown upon these organs by undue contraction of the peripheral circulation may affect them prejudicially.

4. **Organic Disease.**—In cases of progressive organic disease, in which demands greater than can be met are already made upon the processes of assimilation and nutrition, to add to those demands the further strain imposed by a stimulating climate would be unscientific, and could only result in accelerating the progress of the disease.

Descriptive Features of the Town

That portion of the elevated plateau, on which Harrogate stands, lying to the north and east, is called High Harrogate, in contradistinction to the western portion, which is intersected by a valley passing through it, and is consequently termed Low Harrogate. The central district, roughly quadrangular in shape, is surrounded on three sides by the "Stray," a broad level expanse of turf unobstructed by trees. This open space, about two hundred acres in area, is one of the distinctive features of the town, and is secured in perpetuity to the public use. It is bordered by a broad road which is much used as a promenade by visitors. The valley running through Low Harrogate is laid out as public gardens, and reaches to the foot of Harlow Hill, which forms the western boundary of the town, and is a commanding feature. The valley terminates in an open space known as the Bogs field, in which arise most of the mineral springs. Other springs arise in various parts of the town, notably the Old Sulphur Spring, which emerges immediately beneath the Pump Room, and is delivered to water drinkers direct from its source. In the neighbourhood of the Pump Room are most of the public buildings—the Royal Baths, Victoria Baths, Royal Spa, and Kursaal, while many of the chief hotels are close at hand. The town is well laid out, and the handsome stone houses and fine streets give the Spa an impressive appearance.

In a work addressed to the medical profession, any lengthy reference to Harrogate as a pleasure resort would be out of place. Nevertheless a hint as to its resources will be of service, since the question as to whether the recreation available may suit a given patient must often have weight in the selection of a Spa. For indoor amusement abundant provision is made; an excellent band is to be heard morning and evening at the Kursaal. The conditions as a whole, however, greatly encourage an outdoor life, and the requirements of patients are met in this respect by the accessibility of the picturesque "Stray" from almost every part of the residential portion of the town; and for those able to go farther afield, by the variety of attractive circular walks in the immediate neighbourhood, and the excursions through varied scenery to places of interest within reach by cycling or driving.

For those able to take more active exercise facilities are afforded for croquet, bowls, tennis, and golf. For the elderly and those more disposed to sedentary recreation, the Social Club will prove more attractive.

Public Health and Sanitary Conditions

The public health of Harrogate is exceptionally good. The *annual death-rate* among residents is low, the figures for the past ten years being as follows:—

Year.	Death-rate per 1000.	
	Resident Population.	Including Visitors.
1895	12·6	14·7
1896	10·3	12·6
1897	11·5	13·6
1898	12·8	14·8
1899	12·7	14·0
1900	10·6	11·8
1901	13·2	14·9
1902	11·8	13·0
1903	12·2	13·7
1904	12·5	13·5
Average	12·02	13·6

The first column in the table does not include deaths among the visitors to the town, for the number of visitors varies within such wide limits at any given time that it is difficult accurately to estimate the mortality per thousand if they be included. Moreover, since the majority of these are more or less ailing, and come for treatment, the death-rate among them would tend to be higher than among the residents alone. Even if they be included, as shown in the second column, the death-rate compares more than favourably with that of other towns.

Amount of Sickness.—Among the resident population the incidence of disease cannot be gauged with absolute definiteness, but is undoubtedly below the average. Phthisis is uncommon, and respiratory diseases generally are infrequent, considering the nature of the climate. Rheumatic fever is seldom seen. Zymotic diseases, in particular, are rare. This is somewhat remarkable when we consider that Harrogate is a prominent educational centre, and contains a large number of schools. Epidemics do, of course, occur here as elsewhere, but their number and severity are less than might be expected.

The Water Supply.—The waterworks undertaking, formerly the property of a company, was acquired by the Corporation in 1897. The characteristic features of the domestic water supply are its purity and freedom from contamination, its low degree of hardness, and its abundance at all times of the year. The sources of supply are the moorland areas to the west and north-west of Harrogate, the most distant reservoir being situated near Masham, some thirty miles away. With gathering grounds remote from habitations the possibility of contamination by sewage or from other sources is reduced to a minimum. Recent extension on a large scale of the area of supply and the provision of new reservoirs has ensured a practically unlimited quantity of water for many years to come.

Derived from moorland, the water is exceptionally soft, having only 2·9 to 3·0 degrees of hardness—a characteristic which is particularly advantageous in view of the large number of cases of skin disease that are sent here, and to whom a hard water would be undoubtedly prejudicial.

Sewerage.—The system of sewerage adopted is on the irrigation principle combined with bacterial treatment. Formerly small separate sewage farms sufficed, but latterly the rapid growth of the population has necessitated the adoption of a comprehensive scheme by which the sewage is conveyed to two large tracts of land to the north and south of the town, and distant some miles from it. The scheme is rapidly nearing completion, and is sufficiently extensive to meet the requirements of the future.

SECTION IV

THE TREATMENT OF CHRONIC DISEASE BY THE WATERS, BATHS, AND CLIMATE

In the remarks that follow on the treatment of the various conditions for which a course at Harrogate may be found beneficial, it is not intended to go fully into details of the treatment of particular cases. To do so would be of little use unless we were to give, in addition, the clinical history of individual ailments, which in a work of this kind would be out of place. Such details, moreover, fall within the province of the local practitioner, by whom a careful study is made of each individual patient and his requirements fulfilled, not on a common plan for any given disease, but according to such special indications and idiosyncrasies as may be found to exist. Our object then is merely to give a general outline of the management of different types of disease and to suggest where possible the reasons for the mode of treatment recommended.

The following classification of 1500 consecutive cases sent to Harrogate for Spa treatment will give some idea of the variety of disease with which we have to deal, and will show the affections which are, as a matter of experience, most likely to be benefited. The classification is not put forward as scientific; it is purely clinical, and is based upon what appeared to be the chief feature of each case.

Analysis of 1500 Cases sent to Harrogate for Spa Treatment, in order of Frequency

		Number of Cases.
Gout and Goutiness		205
Skin Diseases		189
Rheumatism, chronic and sub-acute		134
Diseases of the Liver		109
Neurasthenia		108
Diseases of the Stomach		103
,, ,, Heart		67
Anæmia and Chlorosis		62
Arthritis deformans		54
Sciatica		49
Diseases of the Intestine		45
Neuritis (other than Sciatic)		35
Diseases of the Kidney		33
,, ,, Respiratory System		26
,, ,, Uterus and Ovaries		25
,, Throat		22
Alcoholism		21
Lumbago		19
Diabetes and Glycosuria		17
Hysteria		16
Nervous symptoms associated with errors of refraction		16
Migraine		15
Syphilis		15
Organic and other Nervous Diseases—		
Epilepsy	3	
Hemiplegia	2	
Tabes dorsalis	2	
G.P.I.	1	12
Chronic anterior Polio-myelitis	1	
Cerebral Tumour	1	
Paralysis agitans	1	
Vertigo, Auditory	1	
Arthritis, Traumatic, Gonorrhœal		10
Obesity		9
Melancholia		8
Diseases of the Ear		8
Malignant Disease		7
Varicose Veins		7
Diseases of Bladder		6
,, Nose		6

Analysis of 1500 Cases sent to Harrogate for Spa Treatment, in order of Frequency—(*continued*)

	Number of Cases.
Pernicious Anæmia	6
Neuralgia	4
Enlarged Prostate	4
Phlebitis	4
Diseases of the Testicle	3
Post-Influenza weakness	3
Malaria	3
Gonorrhœa	2
Insomnia	2
Lead Poisoning	2
Addison's Disease	2
Graves' ,,	2
Leucocythemia	1
Raynaud's Disease	1
Tongue, Chronic Ulcers of	1
	1500

For convenience the diseases will be dealt with as far as possible in the order in which they appear in the table—that is, in their order of frequency. Allied conditions will be discussed together. Some diseases appearing in small numbers were sent merely for change of air and scene. They need no further mention in this work.

Although what follows has to do mainly with treatment by baths and waters, the local practitioner does not necessarily limit himself to these therapeutic agents. He ought to be allowed a free hand to do the best he can for his patient, and if in his judgment drugs are required in addition to Spa treatment, he should make use of them or any other measures he thinks necessary. Many cases of chronic disease have exhausted the resources of the pharmacopœia without benefit before seeking therapeutic methods of a different kind such as are to be obtained at a well-equipped health resort. Hence drugs are seldom required.

Chronic Gout

Factors in the causation of this disease are: (1) heredity, (2) a too liberal diet, (3) alcohol, (4) sedentary habits, (5) worry or mental stress, (6) lead poisoning.

The pathology is obscured by the many hypotheses which have been advanced. The following reference to them is quoted from Bain's "Text-book of Medical Practice":—

"The enigmatical nature of gout is strikingly illustrated by the number of theories advanced regarding its causation. The facts upon which most of them are based are: (1) that there is a deposit of biurate in the tissues of the gouty which is the characteristic feature of the disease, (2) that there is in some gouty cases a marked nitrogen retention which cannot be accounted for by the slight diminution in the excretion of uric acid, (3) that there is an excess of uric acid in the blood of gouty subjects. In this connection it may be pointed out that uric acid is present in the blood in other diseases, notably leucocythæmia, in larger amount than in gout. Sir William Roberts considered that uric acid circulated in the blood as quadriurate only and was excreted in the urine as such. When the blood, either through excessive production or defective elimination of uric acid, became surcharged with sodium quadriurate the latter was converted into biurate, this metamorphosis being accomplished by sodium carbonate. He ascribed the gouty manifestations to mechanical irritation by the crystalline deposit, and held that this deposition takes place in tissues where the circulation is sluggish and where the lymph contains relatively a high percentage of sodium salts; in his opinion the inflammatory phenomena in joints were the expression of the tissue response to the action of the irritant. Luff believes that uric acid is formed exclusively in the kidney, probably by the union of urea with glycocine, and that a functional or organic disorder of the kidney is a necessary antecedent to the development of gout. This assumption is chiefly based upon the statement that uric acid has not been detected in normal blood; the inference must be accepted with caution because of the extreme difficulty of separating small quantities of uric acid from proteid-containing fluids. Kolisch and Crofton believe that the *materies morbi* in gout are the purine bases. The latter holds that, normally, all the nuclein is transformed into uric acid, which is harmless, and that a perversion of metabolism leads to the formation of the toxic bases. Ebstein considers that the primary factor is a special degenerative change in the tissues leading to necrotic areas in which the urates are deposited. According to Balfour, there is no local inflammatory change, the acute attacks being due to a stasis in the capillaries of the affected joint. Duckworth attributes gout to perverted innervation, and believes the affected tract to be localised somewhere in the medulla. Functional inactivity of the liver is held responsible by Murchison and others. Garrod supposed that the alkalinity of the blood was diminished in gout, but this has been disproved. Other theories are mere modifications of those quoted.

"I regard the uric acid phenomena as an important incident in the pathology of gout, but consider that the real or essential factor has so far eluded detection. It is probable that the disease originates in the alimentary tract, and is due either to the excessive formation there of a purely physiological substance, or more probably to the production of an abnormal substance. This latter may arise either from deranged digestive processes, or through the action of micro-organisms. This supposition is strengthened by the fact that impairment of the digestive or assimilative processes generally precedes a gouty attack, and that amelioration of symptoms follows even partial correction of the gastro-intestinal derangement. The prejudicial effect of constipation on gouty subjects and the characteristic odour of the evacuations during a seizure may be mentioned in this relation.

"We know that careful adjustment of the diet to the needs of the organism, combined with the necessary amount of exercise which favours the more active oxidation of the ingesta, will prevent or delay further attacks. Carbohydrates cannot directly give rise to uric acid during their metabolism, nor have we any evidence that they can influence its rate of formation, yet excess of these ingredients in the diet will in many gouty subjects precipitate a paroxysm. If uric acid be the paramount agent in the gouty condition, why does not its presence in the blood of leucocythæmia and other diseases result in an acute attack of gout?"

There are several points in this affection to which attention may be directed: (1) every tissue in the body is liable to be implicated—the clinical manifestations are therefore manifold and diverse; (2) it is frequently associated with a rise in arterial pressure without the presence of albumin in the urine; and (3) some impairment of digestion is almost a constant accompaniment of the gouty state.

A patient who has had an attack of gout may after recovery remain in apparently perfect health and have no recognisable signs of the disease providing he exercises some self-denial. The important fact, in our opinion, is that some disturbance of digestion is always associated with the gouty manifestations.

The improvement observed in gouty patients when taking the Old Sulphur water must be ascribed to the cleansing of the gastro-intestinal tract, and possibly to its stimulating effect on the liver. Probably the former is the more important effect, as in this way is secured the removal of one or more substances which may be responsible for the train of symptoms designated as gouty. The supporters of the hepatic inadequacy theory argue that the liver renders innocuous many toxic substances brought to it from the alimentary canal by synthetising them into harmless products, and if this organ be inactive, these compounds will be absorbed into the blood.

The literature dealing with the association of uric acid and gout is endless, and in this connection it may be pointed out that the difficulty in extracting uric acid from blood is probably due to the fact that uric acid exists in the blood in a state of dissociation and not as a quadriurate. Schmoll's hypothesis that uric acid circulates in the blood in combination with thymic acid has been emphasised by Fenner,[1] and he states that the administration of this substance in gout is attended with gratifying results.

In some cases the only treatment required in addition to the sulphur water is careful dieting and a sufficiency of regulated exercise. If patients can take a fair

[1] *Lancet*, 1905.

amount of outdoor exercise—preferably some agreeable form—special baths are not as a rule necessary. If the weather, however, be inclement, or if other circumstances render active exercise inadvisable, then massage douches, sulphur or electric baths are useful adjuncts to treatment. For the reduction of blood pressure it is more scientific and rational to remove irritating material from the bowels, which if absorbed would tend to accentuate the condition, than to resort to temporary expedients for its reduction, such as hot baths or d'Arsonval applications. Some baths, such as the high frequency current and Aix douches, are useful in cases of high blood pressure, but too much is made of transient measures and too little attention is paid to the removal of the cause. The Old Sulphur water diminishes the excretion of uric acid, and yet cases of gout, especially of the asthenic type, derive the most marked benefit from its use. This fact is mentioned because some writers attach the greatest importance to an augmented excretion of uric acid in the urine as a necessary concomitant of successful treatment. This we firmly believe to be an erroneous view.

Gout presenting, as it does, a great variety of clinical manifestations, offers a choice of remedial measures. In every case, however, a daily evacuation of the bowels should be secured, and the diet should be less than proportional to the digestive activity. Some delicate patients cannot take a strong sulphur water. For these one of the Mild Sulphur waters or an alkaline-sulphur water may be prescribed with one or other of the baths mentioned. In painful affections of the joints the Berthollet bath generally gives relief, and when there is considerable tumefaction the Greville or Dowsing are perhaps more suitable. Gouty sciatica, eczema, and other skin complications are discussed elsewhere.

Great relief is often obtained from the effleuve in cases of gouty neuritis, and the beneficial effect may be supplemented on alternate days by hot packs to the affected part followed by a thermal sulphur bath. Uratic deposits do not appear to be influenced by any drug or mineral water so far as its chemical constituents are concerned, but massage and superheated air baths have a slight effect upon the smaller concretions. Presumably the larger deposits are also reduced by these agents, but the effect is so slight that it is difficult to detect. In gouty albuminuria the Magnesia water should be given twice daily in addition to the Old Sulphur or some other morning water. It has a marked effect in reducing the absolute amount of albumin in the urine (see p. 46). If the specific gravity of the urine be low in a case of albuminuria, some iron water is indicated, with, if necessary, an added aperient in the morning draught.

For glycosuria the combination of Old Sulphur and Magnesia waters is the most effective. Under this treatment, with slight modification of the diet, the quantity of sugar in the urine becomes diminished. If glycosuria and albuminuria co-exist, discrimination is required in prescribing, and the sulphur waters may be tried tentatively, as the specific gravity does not help us in these cases. When in doubt it is safer to give an iron water and trust to diet and baths for a diminution in the excretion of these substances.

The vexed question of the most suitable diet in gout may be briefly discussed. The most diverse opinions exist as to what gouty subjects may or may not eat and drink. Haig and others advocate a purin-free diet, which of course reduces the number of palatable dishes. The success of this dietary depends upon a diminished intake, the non-appetising character of the food acting as a deterrent to over-indulgence. The secretion of gastric juice being to some extent a psychological effect, it follows that digestive activity is increased by delectable viands. Apart from alcohol, whatever promotes digestion should be encouraged, and anything that is likely to produce indigestion should be discouraged. Instead of withholding or markedly reducing the intake of uric acid antecedents, our aim should be to prevent digestive disturbance. In this connection individual idiosyncrasies should be studied. Some cases improve more rapidly on a purin-free diet, others on a diet in which the carbohydrate intake is diminished and the nitrogenous element relatively increased, while others again do better on a mixed diet. The personal experience of the patient generally proves a useful guide in this respect. Whichever plan be adopted, the most important consideration is moderation in diet; it is, in fact, the keynote of success in the prevention of gouty manifestations.

Chronic Articular Rheumatism

After excluding the joint affections of gout, arthritis deformans, gonorrhœa, and traumatism, there remains an arthritis to which the name chronic articular rheumatism is applied. It is generally admitted that acute rheumatism is of microbic origin, but the pathology of the chronic variety is rather obscure. Various writers state that it frequently follows an acute attack, but Osler and Burney Yeo do not support this statement, their experience being that the sequence is rare. Our opinion is that the cases which develop independently of an acute attack and those occurring in subjects who have had acute rheumatism are about evenly balanced numerically.

The predisposing causes are a cold damp climate, and residence in damp houses. In many cases the exciting cause appears to be the prolonged exposure to cold or wet.

The indications for treatment are: (1) to relieve pain, (2) to promote freedom of circulation in the affected joints in order to remove inflammatory exudations and thus to restore free movement, (3) to prevent muscular atrophy consequent on restricted movement, and (4) to improve the general nutrition.

Although some of these patients are anæmic, it is generally advisable to begin treatment with the administration of one of the Strong Sulphur waters; subsequently the Alexandra, Kissingen, or other Iron water may be given. The cases associated with gastro-intestinal derangement generally improve more or less rapidly, while others show little or no improvement while taking the waters.

As regards bathing, the Berthollet and superheated air baths generally relieve the pain and diminish the swelling of the affected joints. Before their introduction hot douches to the affected joints were much in vogue, and in a certain proportion of cases did good. In others good results are obtained with the thermal sulphur, peat, or brine baths. When the pain is relieved and the swelling subsides (which usually takes some time) more stimulating baths may be employed, such as the electric immersion bath or the Vichy douche, the massage of the affected joints in the latter bath being confined to effleurage.

General dry massage is very beneficial. Special attention should be paid to diet and digestion.

Chronic Muscular Rheumatism

This painful affection of the voluntary muscles or of their fasciæ has received various names according to the region affected, for example stiff neck, lumbago, and pleurodynia. The etiological factors appear to be the same as in chronic articular rheumatism, but the condition is frequently associated with gastric derangement, and may be the outcome of dietetic indiscretion.

These cases respond quickly to the Old Sulphur water, and generally no further treatment is necessary. If baths are required to relieve pain there is a considerable choice, since almost any of the hot baths will answer the purpose. In chronic cases, and particularly in those with rheumatic nodules or thickening in the fibrous aponeurosis covering the lumbar or other muscles, massage is required, and must be persevered with until the nodules are dispelled and all sensations of pain due to them have disappeared.

Sub-acute Rheumatism

Cases of sub-acute rheumatism are not as a rule suitable for Spa treatment. They are not infrequently sent, however, for the purpose, and it is sometimes necessary to send them to bed at once on account of a rise in temperature. Thus no Spa treatment is possible, and they resent the enforced inactivity. Some cases without febrile reaction may undergo a course, but in our experience seldom derive benefit.

Arthritis Deformans

Until the pathology of the different forms of joint affection connoted by the term rheumatoid arthritis, or better, arthritis deformans, is thoroughly worked out, the treatment of the disease must be mainly symptomatic. It is probable that two or more distinct affections, having distinct causes, are included under the name. Excluding the disease described by Still, which is probably infective, and of a different nature, at least four different types may be recognised clinically: the acute or sub-acute polyarticular form, with fusiform swelling of the joints and involvement of the extra-articular tissues; the more slowly progressing form, characterised mainly by destruction of bone, without much swelling, and tending towards fixation of the joints; the senile form; and the form in which Heberden's nodes are the prominent feature. The evidence so far available points to the probability of the first form being due to microbic infection, and the others to some disturbance of nutrition of an obscure nature, or to a dystrophy resulting from a lesion of the nervous system. However this may be, the indications for treatment lie in the direction of improving the nutrition of the patient and maintaining it at the highest possible level, while at the same time endeavouring to stay the progress of destruction of the joints by local means. The association of arthritis deformans with disturbance of the digestive functions is too frequent to be regarded otherwise than as a prominent factor in the causation and maintenance of the disease, and the correction of this disturbance is often the first step towards recovery.

Spa treatment offers great facilities for the relief of these troublesome cases. Digestive disturbances and the auto-toxæmia resulting from them may be efficiently dealt with by the Strong and Mild Sulphur waters, followed by a course of Kissingen water to promote tone, or the Chalybeate waters to combat anæmia. The improved appetite and stimulus to nutrition occasioned by the invigorating climate are useful auxiliaries in developing resistance against microbic invasion.

Various forms of baths may be used according to the variety or stage of the affection. In the early stages of the fusiform type, if not too acute, the massage douche or dry massage gives good results. It must be tentatively used however, for many cases do not bear massage well. To the more acute, with febrile reaction, it is wholly unsuited. In well-chosen cases the joint swelling rapidly diminishes, pain is relieved, mobility improved, and a gain in body weight and general health ensues. Other cases which do not tolerate massage will do better with a course of peat baths. In the later stages, when swelling has largely subsided, and in the slowly progressive cases belonging to the second group, attended by destruction and fixation of the joints, the "superheated" air baths, Greville or Dowsing, are much used, and sometimes give astonishingly good results in the relief of pain and apparent arrest of the morbid process. Frequently however they are disappointing, and the relief, if any, proves merely temporary. The monarticular forms in elderly subjects, with much distortion and loss of bone substance, are little amenable to treatment of any kind. Nothing can restore the loss of tissue, and the remission of pain sometimes effected by local radiant heat may coincide with the natural tendency to arrest which occurs in this condition.

It cannot be too strongly insisted upon that whatever may be done locally for the individual joints, unless the general measures directed to improvement of nutrition are attended by success, the relief afforded to the arthritis will as a rule be either slight or merely transitory.

Arthritis: Traumatic and Infective

Arthritis following traumatism, in the later stages of adhesions and fixation of the joint, is best treated by exposure to great heat—either dry, as in the Greville and Dowsing baths, or moist, as in the Berthollet bath—followed by massage and passive movements. If pain is set up by the latter, it should be allayed by hot moist packs. The amount of blood passing through the tissues is locally increased, and the removal of inflammatory products is favoured both by the heat and massage. Passive movements, and active movements if they can be performed, should be persevered with until all trace of limited range of action of the joint has disappeared. In long-standing cases it may be necessary to break down adhesions under an anæsthetic before applying the baths.

In cases of recent injury to joints or tendons—for example sprains, and the after-effects of dislocation, or fracture in the neighbourhood of joints—great relief of pain is obtained from the hot air baths; absorption of effusion is materially hastened by their use.

Arthritis of infective origin, such as that following gonorrhœa or some local source of infection often difficult to discover may be treated by measures similar to those mentioned under arthritis deformans. The first essential, however, is the discovery and effective treatment of the local source of infection, whether it be a gleet, an ulcer of the rectum, a septic endometritis, or other cause. Even after this has been done the joint troubles often prove intractable, and demand great patience and perseverance on the part of both patient and doctor. This is especially the case in gonorrhœal rheumatism.

DISEASES OF THE SKIN

Skin affections have a high place in the table of diseases, numbering 189 out of 1500, or 12·6 per cent.

Eczema

In its various forms eczema is by far the commonest skin disease seen by us; the majority of cases occur in gouty subjects. Though eczema is looked upon by many, led by Hebra and the Vienna school of dermatologists, as a purely local disease, in which the causal relationship of an underlying constitutional condition is denied, yet we are forced to conclude from extensive observation of these cases that the question still remains open; and this opinion is shared by many others. It is certain that eczema occurs with undue frequency in gouty subjects—a fact which may be due to the general tendency of the gouty to catarrhal affections, but more probably depends on some causal connection between the two diseases. If most forms of eczema are due solely to the invasion of the skin by micro-organisms, the only possible explanation of their frequent association lies in the supposition that the diathetic condition has the effect of so modifying the nutrition of the tissues as to diminish their resistive powers. Other conditions of chronic auto-toxæmia from absorption of poisons generated in the alimentary canal and inefficiently eliminated by the kidneys appear to act as predisposing causes in a similar way.

The first indication, then, in the Spa treatment of these cases is to improve the general nutrition by the removal from the alimentary canal of the products of imperfect or perverted digestion, by the stimulation of a functionally inactive liver, and by the promotion of more perfect elimination of waste products through the kidneys. These requirements are best fulfilled by a course of the Old Sulphur water in purgative doses, with the Magnesia or other diuretic water as an adjunct. In subjects who are anæmic, or with distinct want of tone, the Kissingen water should be prescribed. The Mild Sulphur and the No. 36 waters are of service in maintaining a copious kidney secretion when the necessity for free action on the alimentary canal is no longer present. It is a common experience to see gouty persons suffering from eczema, recover from their skin trouble under a course of waters alone—that is, without any local application.

In other forms of eczema not associated with diathetic conditions such as gout and rheumatism, the indications are not so clear. When any obvious underlying source of ill-health exists, such as is often found in the so-called "neurotic" eczema, or in the digestive disturbances which frequently accompany seborrhœic eczema, it must be dealt with on general principles, and the waters, tonic or eliminatory, be used as auxiliary measures. The excretion of sulphur by the skin, which occurs while the sulphur waters are being taken (see p. 42), may be a factor of no little moment in the cure of skin affections. Most cases of gouty eczema derive benefit from taking the sulphur baths concurrently with a course of the waters, and improve more rapidly with waters and baths in combination, than with waters alone.

Sweating baths are also of service in certain instances. It is necessary to exercise caution in their use, for a chronic quiescent eczema may sometimes pass into an acute inflammatory state through injudicious or too severe measures. It is, therefore, occasionally advisable to postpone the prescription of baths until the waters have been taken for a week or more.

In eczema not associated with diathetic conditions the baths are also freely made use of, more especially the alkaline-sulphur baths of the Beckwith, Starbeck, or Harlow Car waters, or the Crescent saline bath. These are prescribed for the more recent forms in which soothing measures are required; for the more chronic forms the mild, strong, or natural sulphur baths will be found more stimulating. The action of both varieties of baths is partly mechanical, in that they aid in the softening and removal of scales, crusts, and discharges, and so admit of the penetration to the seat of disease of remedies subsequently applied; partly parasiticide, owing to the sulphur constituents; and partly nutritive, owing to the changes excited in the circulation through the skin. The direct action, if any, of the sulphur water on the eczematous process is merely subsidiary.

In **seborrhœic eczema**, which is certainly parasitic in origin, the parasiticidal effect of the strong sulphur baths is beneficial. The rapid removal from the skin of infected material, consisting of epidermal scales and sebum, may be brought about by the use of the massage bath, or by shampooing after free perspiration. In eczema associated with neurotic states tonic baths, such as the Vichy douche or the combined needle and douche bath, are useful in restoring the tone of the nervous system and indirectly aiding in the cure of the skin affection.

Great care is required in prescribing baths of any kind for sensitive cases of eczema, because much harm may be done by the use of too stimulating a bath; discrimination is also necessary with respect to details of temperature and length of immersion. A sub-acute or chronic case may become more active when injudiciously managed. A certain degree of exacerbation may not be harmful; it is, in fact, in many cases a necessary prelude to the cure of a chronic condition. It should, however, be kept within bounds and watched closely, lest by its depressing influence on the general health the way be opened for fresh encroachment of the disease. Cases of eczema in an acutely hyperæmic condition are quite unsuitable for any form of bath treatment.

Very chronic forms of eczema, attended by infiltration and thickening of the skin which do not yield to treatment by bath and waters, may often be favourably influenced by the reaction excited by local measures, among which may be mentioned the high frequency current (effleuve or vacuum tube), the X-rays, and the Dowsing or Greville superheated air baths.

The first of these we have seen do good, particularly in chronic intractable eczema of the anus and surrounding parts, though its mode of action is somewhat obscure. The second we have no experience of, and should hesitate to use. The third is of service in promoting active circulation of blood through the affected part and so assisting in the removal of the infiltrated products of long-standing inflammation.

Psoriasis

In the treatment of psoriasis the waters occupy a secondary place. Where some manifest source of ill-health exists, which, however, is frequently not the case, and its correction is possible by the waters, they will of course be prescribed; the sulphur group, for example, in cases of defective nutrition, or chronic auto-intoxication; the iron group, when anæmia is a prominent symptom. Further, if it be maintained that gout is a factor of importance in the production of psoriasis, or that a definite type of gouty psoriasis exists, the sulphur waters may be given to modify the underlying condition. If nervous symptoms predominate, as in the neurotic type of psoriasis, the iron waters will be found useful as a general tonic.

The sulphur baths are of undoubted value in this disease. Cases have frequently been observed of widespread recent psoriasis which completely recovered under a course of baths alone. Making due allowance for the well-known capriciousness of the eruption and its tendency to disappear spontaneously, especially at certain seasons of the year, it seems impossible to deny some curative influence to the sulphur baths, though of what nature beyond the parasiticide and nutritive effects already mentioned, it is difficult to say.

Cases of psoriasis in an acutely hyperæmic state should not be treated by these baths. In the more chronic cases they should be freely given. The maceration and removal of scales is a necessary preliminary to the inunction of remedies, and may be efficiently done by the sulphur baths. For this purpose prolonged soaking for an hour or more is sometimes necessary. The more stimulating baths excite an inflammatory reaction of the skin, which aids in the cure of the psoriasis in a manner analogous to the effect of chrysarobin in setting up a dermatitis, on recovery from which the original eruption will often be found to have disappeared. In the very chronic cases of local psoriasis, with much hyperplasia, the high frequency current or the X-rays may be tried.

In cases of **Pityriasis rubra**, supervening upon eczema or psoriasis, the alkaline baths are of service. The association of this condition with the gouty and rheumatic diatheses, regarded as probable by some dermatologists, calls for the administration of the waters in addition.

In **Pityriasis rosea** the alkaline-sulphur baths will be found useful.

Erythema

The frequent association of erythema in various forms with a diathetic state—for example, erythema nodosum with a pronounced rheumatic history, or erythema multiforme with a toxic state of the blood of unexplained nature—leads to the use of the sulphur waters in the treatment of these troublesome conditions and of the iron waters subsequently to counteract the depressing effects of the disease. In cases accompanied by vasomotor irritability, as in erythema simplex, the tonic effect of needle baths on the circulation may be utilised to restore the normal control over the vessels. As a preventive measure in cases subject to erythema pernio the massage douches are helpful.

Chronic Urticaria

In this disease both waters and baths may be employed with advantage. When dependent upon chronic disturbance of the alimentary tract, or upon the gouty state, and accompanied by albuminuria or glycosuria, it is amenable to treatment by waters appropriate to the underlying condition. If neurosis be the prominent factor in the causation, the tonic waters should be prescribed. For the relief of irritation the sulphur baths are useful. The vasomotor instability which characterises the disease may be modified by other forms of bathing, notably the Vichy douche and the needle bath.

Acne Vulgaris

Cases of acne come in considerable numbers to Harrogate for treatment. Associated as they frequently are with constipation, a sluggish state of nutrition, muddy complexion, phlegmatic temperament, or, in the female, with amenorrhœa and anæmia, the sulphur and iron waters respectively are useful in the treatment of these conditions. It has appeared to us that these patients benefit by the consumption of large quantities of fluid, whether of plain or mineralised water, the skin becoming clearer and acting more freely. The present tendency is to regard the products of the sebaceous glands as the outcome of a process of exfoliation rather than as a true secretion, and the free action of the skin excited by copious libations of hot sulphur water tends to promote the shedding of exfoliated material and to liberate the orifices of the glands from retained sebum, which affords such a fertile soil for the growth of micro-organisms and may lead to the development of the acne eruption. This end is furthered by the use of the hot sulphur baths, which help to soften and remove the plugs blocking the gland-orifices. The sulphur constituents are thus enabled to penetrate and exert their antiseptic action. Sudatory baths aid in the maceration of the outer layers of the epidermis, and the removal of the exfoliated products teeming with micro-organisms is effected by vigorous shampooing such as follows the Turkish bath. The massage douches, Aix and Vichy, are useful for the same purpose. By these means infective material is diminished, while at the same time the resistive powers of the tissues are improved, and the nutrition of the skin promoted.

Furunculosis

Much the same considerations apply to cases of furunculosis, with this difference, that it is wiser not to make use of methods including massage and shampooing, even if they are not precluded by the presence of tenderness and inflammation, for the virulence of the infection being greater or the resistance of the tissues less—or both—a considerable risk may be run of disseminating the infection to other parts of the skin as yet unaffected. Otherwise the same methods may be applied, along with vigorous antiseptic treatment of each boil.

When a definite cause can be traced, such as exposure to sewer gas poisoning, the removal of the patient from the primary source of infection and the washing out of the tissues by a course of waters are important elements in the treatment. Furunculosis occurring in the course of kidney disease, or diabetes, may be improved by the use of baths and waters directed to the relief of the primary disease.

Parasitic Diseases

Scabies is frequently found among patients sent to Harrogate and erroneously supposed to be suffering from eczema. When it occurs in well-to-do cleanly individuals the disease is often mistaken for eczema on casual examination. The Thermal or Strong Sulphur baths combined with subsequent inunction of parasiticide remedies usually suffice to effect a cure.

Tinea versicolor, Erythrasma, Tinea circinata, and **Impetigo contagiosa** are also amenable to treatment by sulphur baths.

Pruritus

In **Pruritus universalis,** dependant upon some constitutional derangement of the liver, "lithæmia," oxaluria, jaundice, much good may be done by the use of the sulphur waters internally. Externally the alkaline-sulphur baths or one of the many forms of sweating baths will afford relief to the irritation. **In Pruritus senilis** some improvement may be made in the nutrition of the skin by the massage douches and other baths, but from the nature of these cases it is difficult to effect much.

Pruritus ani and **vulvæ,** accompanied by derangement of the alimentary canal, congested liver, or alimentary glycosuria, may be relieved by the unloading of the portal system which results from ingestion of the Old Sulphur water. If dependent upon some local condition, such as hæmorrhoids, fissure, spasm of the sphincter, baths are sometimes helpful as an accessory to local surgical measures.

In these varieties the high frequency current applied round the anus in the form of the effleuve, or to the interior of the bowel by means of the glass vacuum electrode, is sometimes effective, and may lead to shrinking of the hæmorrhoids if not too large, and to permanent relief of the itching.

In the troublesome form of long-standing pruritus occurring in neurotic subjects, without obvious cause beyond the general neurosis, the high frequency current may give temporary relief, which, however, is seldom of long duration.

Prurigo though practically incurable may be relieved for the time being by treatment similar to that recommended for pruritus.

Seborrhœa

The seborrhœic skin so commonly met with may be favourably influenced by frequent courses of baths. Though no disorder of the general health may exist, and no eruption may be present, these subjects are more prone to skin diseases than others not affected with seborrhœa. What is said under seborrhœic eczema and acne as to the removal by baths of exfoliated material, and the improvement in nutrition of the skin, applies equally here. As a preventive measure repeated courses of baths are valuable in maintaining a more healthy condition of skin and in warding off possible attacks of inflammatory or parasitic disease.

Syphilides

The many skin eruptions due to syphilis may be effectually treated at Harrogate. There are facilities for treatment by inunction which along with the sulphur waters and baths can be more thoroughly carried out than at home. Further reference to the subject will be made under the Spa treatment of syphilis.

DISEASES OF THE STOMACH

In discussing the treatment of gastric disease, the following classification will be adopted :—

- Gastric Irritation—
  - Acute.
  - Chronic.
- Gastric Insufficiency.
- Neuroses of the Stomach (nervous dyspepsia)—
  1. Secretory Neuroses.
  2. Motor Neuroses.
  3. Sensory Neuroses.
- Dilatation of the Stomach.
- Acute Gastritis (acute gastric catarrh, acute dyspepsia)—
  - Acute Catarrhal.
  - Acute Toxic.
  - Acute Infective.
- Chronic Gastritis (chronic catarrh of the stomach)
- Gastric and Duodenal Ulcer.
- Cancer of the Stomach.
- Pyloric Stenosis.

Diseases such as cancer of the stomach and subphrenic abscess are obviously unsuitable for Spa treatment, and gastric ulcer can be treated quite as well at home. The affections which will be considered here are functional disorders of the organ, chronic gastritis and gastric dilatation. In connection with their treatment it is desirable to recall briefly the salient facts concerning the physiology of digestion; subsequently the chemical pathology of gastric disorders will be cursorily dealt with under the respective diseases. The inclusion of such data may appear beyond the scope of this book, but their insertion is helpful in discussing indications for treatment, as some degree of indigestion accompanies many nutritional and other disorders.

Digestion and Absorption of Carbohydrates.—Granulose is acted upon by ptyalin, being converted first into dextrin and then into maltose. For about half-an-hour after digestion has begun ptyalin will act more vigorously in the stomach than in the mouth, being favoured by the weak acid reaction due to lactic and traces of butyric acids. The starch and dextrin which have escaped the action of ptyalin are converted into maltose by the amylopsin of the pancreatic juice. The carbohydrates are mainly absorbed as dextrose or levulose, as these are the only two forms found in the blood, and they are also the final sugars formed in the intestinal canal. The conversion of maltose into dextrose is brought about by the invertin of the succus entericus or by the cells of the intestinal villi. If an excess of dextrose be introduced into the intestine some of it appears in the lymph and urine, but an excessive quantity of starch given in a similar way is completely assimilated, the explanation being that dextrose is absorbed so rapidly that the liver and intestinal cells have not sufficient time to deal with it adequately. If the intake of carbohydrate be excessive the portion that is not required for the immediate needs of the organism is partly stored as glycogen and the remainder deposited as fat, and this conversion takes place in the liver and connective tissues.

Absorption of Fats.—The whole of the fats pass into the duodenum chemically unchanged. Previous to absorption, fats are melted, emulsified, and broken up into fatty acids and glycerine by the fat-splitting ferment steapsin. The acids form soaps with the alkali of the pancreatic juice, and fat is absorbed either as fatty acids or soaps. The path of absorption is the lymph stream. If the total quantity passing into the lymph be measured, there is a marked deficiency contrasted with the quantity absorbed from the alimentary canal. The amount found in the portal blood is not greater than that in the general circulation; therefore a portion must be utilised by the cells in the formation of non-fatty products.

Digestion and Absorption of Proteids.—Although Pawlow has shown that the activity of the glands is reflexly inhibited by painful stimuli and that secretion can be induced psychologically by sham feeding, yet stimulation of the vagi is without effect on the secretion. He further observed that the amount of secretion was considerably modified by the character of the food given. The glands of the stomach are of two kinds, the pyloric and cardiac; the former are relatively few in number, the latter contain two kinds of cells, small central cells secreting pepsin, and large parietal or oxyntic cells secreting hydrochloric acid. The pyloric glands secrete pepsin only. The gastric juice consists of hydrochloric acid, two ferments, rennin and pepsin, a small quantity of mucus, inorganic salts, and water. The amount secreted in the twenty-four hours varies from 1000 c.c. to 1500 c.c.

Three conditions are necessary for the formation of the normal amount of hydrochloric acid required for digestive purposes; (*a*) an adequate supply of chlorine, (*b*) the integrity of the oxyntic cells, and (*c*) the stability of the nervous mechanism. It has been shown experimentally that if the food chlorides be diminished there is a corresponding decrease in the secretion of hydrochloric acid.

The action of the gastric juice is practically restricted to proteids, which it converts into acid-albumin, proteoses, and peptone in the order mentioned. The process is one of hydration, the resulting products being simpler in chemical composition than the original ones. The disintegration of animal food is speedily brought about by the activity of the gastric juice in dissolving collagen, the chief constituent of white fibrous tissue. The hydrochloric acid in addition to combining with proteids destroys any bacteria that may be present in the stomach, and brings into solution the calcium and magnesium salts of the food. The movements of the stomach materially assist in the subdivision of the food masses.

It is important to remember that the highest point of the base of the stomach lies at a level above and behind the apex of the heart. The organ may be divided anatomically and physiologically into two portions, a large portion comprising the cardiac end and fundus, and a smaller portion with thicker walls, the pyloric region or antrum. At the junction of the fundus and antrum the circular muscular coat is thickened into a ring called the sphincter of the antrum. Shortly after food is taken contractions begin at the ring involving the adjacent portion of the fundus and travel towards the pylorus. These movements churn the food, and as digestion proceeds they become progressively stronger, until the stomach contents are gradually expelled.

The proteoses are often spoken of as albumoses, and are divided into two varieties, the primary and secondary, but these subdivisions are of little or no importance to the physician. The peptones consist chiefly of amido-acids and nitrogenous bases, such as lysin and arginin. As trypsin only acts on the surface of the proteid particles, the more finely divided these are, the more quickly is the peptone stage reached; therefore thorough mastication of the food assists proteolytic action. The rennin of the gastric juice acts upon the caseinogen of milk by converting it into the coagulated proteid casein which is the most easily digested of all proteids. Vegetable proteids are not so readily digested as animal. In man probably a large portion of the food proteids passes through the duodenum chemically unchanged, or having undergone only the first steps in hydrolysis. Some of the peptone may be absorbed from the stomach, but the great absorbing surface is the intestinal mucosa. If a nutrient enema be administered, the proteid is absorbed without peptonisation. It is probably first converted into albumose, which is changed by the ferment erepsin into simpler products, for albumose is toxic to the blood, and even the liver is unable to assimilate it directly, although it is a powerful stimulant to that organ.

When the acid chyme gushes through the pylorus, the muscular fibres of the gall-bladder contract, and a sudden rush of bile takes place. As the bile and pancreatic juice continue to be poured out the reaction of the chyme becomes less acid, and may be weakly alkaline, but it soon becomes acid again. In the lower part of the small intestine it may be neutral or weakly alkaline. To phenol-phthalien the reaction is acid throughout. The bile aids absorption, dissolves fats, and excites the muscular walls of the intestine. Although the acid chyme reflexly stimulates the pancreas, the real excitant is secretin formed in the upper part of the small intestine, and conveyed by the blood to this organ. Two kinds of movements are to be observed in the intestine during digestion: (1) so-called pendulum movements—localised constrictions of the gut, which recur rhythmically—and (2) true peristaltic movements, which travel slowly down the tube at the rate of about 2 cm. per second.

TREATMENT OF FUNCTIONAL DISEASE OF THE STOMACH

General Considerations.—In treating a case of functional disease of the stomach it is necessary to take into consideration the condition of the intestinal tract, for if the stomachic affection has existed even for a short period, there is almost certain to be some impairment of intestinal digestion. As these cases present great variation in their symptomatology it is hardly possible to lay down precise rules of treatment for each and all; the following commonplace directions are, however, worth mentioning: (*a*) moderation in diet; (*b*) food should be thoroughly masticated; (*c*) fluids should be taken after meals; (*d*) for fifteen minutes after a meal exercise, physical or mental, should be avoided. A point of importance is that indigestion may be merely a symptom of some serious affection, such as organic disease of the nervous system or renal trouble; therefore a careful examination of every patient should be made.

Chronic Gastric Irritation

This common affection includes the majority of functional diseases of the stomach. The chief factors in its production are over-indulgence in food and its accessories, mental worry, irregular hours, and sedentary habits.

The symptoms referable to the stomach are fulness, weight and oppression in the epigastrium, which generally occur from twenty minutes to two hours after a meal, and exceptionally persist until the next meal. The tongue is usually coated, and flatulence is a frequent symptom; it is not due to excessive fermentation, but either to the liberation of carbonic acid or to air entering during deglutition. Vomiting is not a very common symptom, and is due either to irritating food or to a hyper-secretion of hydrochloric acid. It is a moot point as to what constitutes an excess of free hydrochloric acid in the stomach. The normal percentage is about 0·2, but if the gastric juice contains over 0·3 per cent. an hour after Ewald's test-meal, the condition is probably pathological; if the quantity be more than 0·4 per cent., epigastric tenderness and pain will most likely be experienced. Herter noticed a decided retraction of the gums from the teeth in cases of hyperchlorhydria.

A hyper-secretion of acid generally leads to a more rapid digestion of proteids and to an increased motility of the stomach.

The treatment of most cases of gastric irritation consists in clearing out the alimentary tract every morning with a large dose of the Old Sulphur water; combined with a moderate amount of exercise and careful dieting. In cases associated with hyperchlorhydria the Beckwith water with an added aperient should be substituted for it, as the supply of sodium chloride should be restricted, at least temporarily. In patients who have not been accustomed to exercise, it is advisable to begin with the massage douche, but after the first week some form of exercise should be encouraged. For more delicate patients it may be necessary to prescribe a milder water than the Old Sulphur Well, but in these also the removal of irritating material from the alimentary canal is essential.

Gastric Insufficiency

In this condition the functions of the stomach, both secretory and motor, are depressed. Defective activity is generally observed during or after the middle period of life, and occurs in those who lead sedentary lives with much mental work, and also follows acute or prolonged illnesses. It may be associated with organic diseases, such as cancer of the stomach, but only the uncomplicated cases are here considered.

When gastric insufficiency is the sequel of an acute illness it is usually more amenable to treatment than when it follows continued gastric irritation or occurs in old people. Similarly, irregularities of secretion respond more readily to treatment than defects of motility. The free hydrochloric acid is usually diminished (hypochlorhydria) after a test meal, and it may occasionally be absent (achylia gastrica). When the acid is much diminished carbohydrate fermentation generally occurs. Flatulence is a constant symptom, and the over-distension produced by it leads to atony of the stomach.

The treatment of these cases differs considerably from that of gastric irritation; the indications are to stimulate the secretory apparatus, to improve the motility of the organ, and to promote the general nutrition, which is generally impaired. The diet should be easily digestible, and at the same time nourishing. Pawlow found that in dogs the nature and amount of gastric juice was considerably modified by the food-stuffs presented to them; that the dextrins were the most active agents in evoking a secretion of pepsin, and next to them the meat extracts.

An effective evacuation of the bowels should be secured daily. This may be accomplished by the Strong Sulphur water or, in debilitated subjects, by the Mild Sulphur or Starbeck water before breakfast, with a laxative the previous night. The digestion of food may be hastened by the administration of dilute hydrochloric acid combined with pepsin immediately after meals. The movements of the stomach can be influenced by abdominal massage, preferably in the form of the Vichy douche, and by the high frequency current, the most effective modification of the latter being the effleuve, for ten minutes daily to the epigastric region.

Neuroses of the Stomach

The treatment of neuroses of the stomach should be directed to the immediate relief of distressing symptoms and to the rehabilitation of the controlling nervous mechanism.

The cause of the nervous break-down should be diligently sought for, and if possible removed; any likely determining factor however trivial must not be overlooked; even very slight errors of refraction should be corrected. The manifestations of this disorder are numerous, and the condition of the stomach presents considerable variability, but in most cases the chemical processes of digestion are good. For the general treatment of these cases, which is by far the most important, see under Neurasthenia and Hysteria.

In considering the alleviation of symptoms or conditions, only those amenable to Spa influences will be discussed. With this reservation the various derangements will be considered.

Neuroses of Secretion — Hyper-acidity, Subacidity, and **Gastroxynsis.**—When the symptoms resemble those of gastric irritation, the same line of treatment should be adopted; again, if the symptoms be similar to those of gastric insufficiency, the treatment mentioned under that affection should be carried out.

Physiologists have yet to explain why apparently the same depressing influences should produce in one case an increase in the secretion of hydrochloric acid and in another a diminution. The other constituents of the gastric juice are not generally reduced in the same proportion as the acid, the secretion of the latter being more liable to fluctuation than that of pepsin; and this fact may account for the observation that the amount of free acid may be much below the normal without any recognisable signs of disordered digestion. In connection with the absence of *free* hydrochloric acid from the gastric contents, it is essential to distinguish between that condition and its total absence; for if there be a sufficient amount to combine with the proteid present digestion may proceed in a normal manner, whereas if no acid be secreted it is a strong indication of serious structural alteration in the glandular mechanism.

Gastroxynsis, or periodical flow of gastric juice, generally comes on when the stomach is empty, and is associated with great gastric distress and vomiting of a highly acid fluid mixed with mucus. The treatment of this condition consists in (*a*) systematic exercises, such as golfing, riding, or bicycling; (*b*) avoidance of mental work; (*c*) abstinence from alcohol and strong tea or coffee; (*d*) the administration of Beckwith or Harlow Car water; (*e*) a course of galvanic or sinusoidal baths; and (*f*) lavage if the condition does not yield to the other remedies.

It may be remarked here that it is highly undesirable to teach neurotic patients to wash out their stomachs.

Motor Neuroses—Gastric Hyperperistalsis (*peristaltic unrest*), **Nervous Vomiting,** and **Atony of the Stomach** (*myasthenia gastrica*).

For peristaltic unrest the following measures may be adopted: (*a*) avoidance of worry, excitement, or excesses; (*b*) the administration of the Beckwith or Starbeck water before breakfast; (*c*) hot packs to the epigastric region; (*d*) peat baths or thermal sulphur baths; combined with the most careful feeding, the essential point being rest to the stomach. Nervous vomiting should be treated by the Weir Mitchell method. Myasthenia gastrica will be discussed under Dilatation of the Stomach.

Sensory Neuroses—Hyperæsthesia and Gastralgia.—The differentiation of these sensory disturbances lies in their relation to meals, hyperæsthesia being due to the stimulation of the gastric mucous membrane by food, while gastralgia does not appear to be produced by digestive irritation. For both conditions, alkaline carbonate waters may be taken, moderately hot, an hour before breakfast, and the diet should be easily digestible. Pleasurable exercise should be taken without fatigue, and galvanic baths with subsequent local application are useful, the anode being applied to the epigastrium and the cathode to the spine, the strength of the current varying from 15 to 25 milliampères; or sulphur baths with the sub-aqueous douche may be prescribed. An attack of gastralgia necessitates the use of some anodyne.

Chronic Catarrhal Gastritis

This affection is due to organic changes in the gastric mucosa, and sometimes follows attacks of acute or sub-acute gastritis. Among other causes may be mentioned prolonged gastric irritation due to persistence in dietetic indiscretions, and the abuse of stimulants and irritants such as alcohol, tea, strong condiments and spices.

Ewald recognises three varieties: (1) *simple gastritis,* in which the free hydrochloric acid is somewhat diminished; (2) *mucous gastritis,* which is distinguished by the large amount of mucus present in addition to the diminution of free hydrochloric acid; and (3) *atrophic gastritis*, in which both the hydrochloric acid and ferments are absent: in the last only palliative measures are of service.

As the course of the disease depends upon the degree of histological alteration in the mucous membrane, so do the symptoms which are protean in character.

In *mucous gastritis* nausea is a prominent feature, and it is an interesting fact that an excess of mucus is nearly always associated with a diminution in the hydrochloric acid. When there is excessive fermentation, the vomit generally is very acid from the presence of organic acids. The most important element in treatment is the removal of the cause, whether it be alcoholic excess, injudicious dieting, or some other indiscretion. Cases associated with cardiac disease or organic disease of the liver are here excluded from consideration.

It has been stated under the physiology of digestion that the secretion of hydrochloric acid is considerably modified by the conditions of innervation and the state of the glandular apparatus. It is advisable to begin treatment by mechanically emptying the stomach of its contents, using a dilute solution of sodium bi-carbonate, as lavage tends to restore the glandular cells to their normal activity by removing mucus and undigested fragments of food which act as mechanical irritants. Many patients express feelings of the greatest repugnance to having their stomachs washed out, and decline to submit to the process. Fortunately other methods may be adopted. An emetic may be given in the early morning and shortly afterwards a pint of Beckwith water, or—what is more pleasant and almost as effective—a large dose of Beckwith or Harlow Car water to which has been added a sufficient quantity of Carlsbad salts. On account of the excessive intestinal putrefaction which generally accompanies the gastric affection, it is very necessary that the bowels should be satisfactorily evacuated daily. The re-establishment of normal innervation may be favoured by the patient leading an outdoor existence without fatigue. As the stomach is unable to cope with meals of average quantity, the diet should be carefully restricted. Both the massage douche and the galvanic baths promote metabolic functions, and may aid the other therapeutic measures; if motility is affected, the effleuve is distinctly serviceable.

Dilatation of the Stomach

The normal size of the stomach naturally varies in different individuals, but on an average it holds about thirty-five ounces; when the organ is dilated the capacity ranges between two and eight pints. Dilatation may be acute or chronic; the former is very rare, and need not be considered.

Sidney Martin[1] classifies the causes of chronic dilatation as follows:—

Obstructive dilatation is caused by (1) stenosis of the pylorus from cancer or fibroid contraction, as in ulcer; and congenital stenosis; (2) pressure on the duodenum by malignant growth or constriction occurring after a duodenal ulcer; (3) contraction of the pylorus by constriction in chronic peritonitis; (4) contraction of the cardiac end of the stomach by adhesions usually resulting from a severe and chronic left-sided pleurisy.

[1] Bain's "Text-book of Medical Practice."

Non-obstructive dilatation is a sequel of (1) gastric irritation, (2) of gastric insufficiency, (3) of subacute and chronic catarrh.

The importance of even lesser degrees of dilatation (atony of the stomach) is due to the fact that the diminished motor function of the stomach leads to delay in emptying the viscus. Fermentative changes are very apt to be set up in the retained food, especially if the free hydrochloric acid is below the normal amount. There are four recognised varieties of fermentation: (1) the alcoholic, (2) the lactic, (3) the butyric, and (4) the acetic. The last probably takes place in the upper part of the intestine. The significance of excessive fermentation lies in the fact that the gases thus generated accentuate its already impaired motility by distending the stomach.

The indications for treatment are: (1) to cleanse the stomach by removing mucus and fermenting food, (2) to promote digestion by suitable dieting and by relieving constipation, (3) to improve the tone of the muscular walls of the stomach.

For minor degrees of dilatation, the following plan is generally effective: (1) a pint of strong sulphur water hot an hour before breakfast; (2) three small, easily digested meals a day without any liquid; (3) fluid to be taken an hour before meals and at bed-time; (4) galvanic current baths every second day with subsequent local application, the cathode to the epigastrium and the effleuve daily to the same region; (5) abdominal massage; and (6) a very moderate amount of daily exercise in the fresh air. For the more severe forms, lavage is unquestionably the best remedy, but it can be supplemented by the therapeutic measures already suggested.

CHRONIC DISEASES OF THE INTESTINES

The affections under this head which will be discussed are—

Intestinal Neuroses.
„ Indigestion.
„ Colic.
Constipation.
Diarrhœa.
Intestinal Catarrh.
Membranous and Mucous Colitis.
Hæmorrhoids.

Intestinal Neuroses

Painful sensations are not so common in the intestine as in the stomach, and the pain in ulceration of the two respectively is quite different as regards severity. Muscular spasms (enteralgia) occur in neurasthenia, hysteria, and hypochondriasis, and are similar in character to those produced by mechanical stimuli. Burning or scalding sensations in the abdomen are frequently complained of by neurotic patients.

Regarding motor neuroses, diminished peristalsis may occur in hysteria and other nervous affections from a general loss of muscular tone, and as a result the onward movement of the intestinal contents is retarded, giving rise to constipation; or there may be an increased excitability of the neuro-muscular mechanism and frequent action of the bowels.

With respect to the secretory neuroses, the secretion of the succus entericus may be diminished, and this diminution in the fluid content of the fæces is a cause of constipation; or the amount may be increased, producing watery evacuations generally associated with the passage of mucus.

For the general treatment of these conditions, the reader is referred to neurasthenia, and for the alleviation of symptoms, to the paragraphs on intestinal indigestion, constipation, and diarrhœa.

Intestinal Indigestion

It is necessary to indicate exactly what is meant by the term, as the text-books do not mention it, although the symptoms must be familiar to every medical man. It is used here to denote cases of intestinal disturbance without any histological alteration of the mucosæ, the symptoms depending primarily upon abnormal changes in the digestion of the food-stuffs.

It may arise from a variety of causes—

(1) In cases of hyperchlorhydria the acid chyme may completely neutralise the pancreatic secretion and thus impair the digestive energy of the latter.

(2) A deficient secretion of gastric juice favours fermentative changes in the ingesta, and this will prejudicially affect intestinal digestion.

(3) Defective motility of the stomach predisposes to fermentation of the food by the delay occasioned in expelling its contents.

(4) A diminution in the secretion of the pancreatic juice.

(5) A deficiency in the quantity of bile.

(6) Indigestible articles of diet.

The symptoms being largely due to putrefactive processes which take place in the intestine, proteid putrefaction will be briefly considered. It occurs almost entirely in the large intestine, and is caused by anærobic bacteria which are taken in with the food. Those bacteria which escape the lethal action of hydrochloric acid are in normal circumstances destroyed by the bacillus *coli communis* and the bacillus *lactis ærogenes*, natural inhabitants of the intestine, but if the latter be diminished in number and unable to antagonise the former, proteid decomposition will result.

The amount of ethereal sulphates in the urine affords a general index of the degree of proteid putrefaction. These sulphates arise from the union of sulphuric acid with aromatic bodies formed in the intestine. The four principal aromatic products of intestinal putrefaction are phenol, kresol, skatol, and indol, indican being derived from the last. In health the proportion of the combined or ethereal sulphates to the preformed sulphates is roughly about 1 to 10. In putrefactive processes, whether occurring in the intestine or elsewhere, the proportion of ethereal sulphates is increased. It must be remembered that their excretion may be augmented by the administration of aromatic bodies, such as salol and creasote.

The compounds of the fatty acid series, which are also formed by the action of bacteria, have been referred to under diseases of the stomach. The gases resulting from the decomposition of proteids are carbonic acid, marsh gas, hydrogen sulphide, and ethyl mercaptan (C_2H_5S). Other bodies are formed, such as phenyl acetic acid and phenyl propionic acid, and the aromatic hydroxy acids, the latter being found in the urine.

The important point to the physician is that the formation in large amounts of these aromatic bodies must be injurious to the organism on account of their toxic properties; hence the advisability of preventing intestinal putrefaction by diet and other means.

Treatment.—It is almost unnecessary to mention that the first indication is to clear out daily the putrefactive material by a suitable aperient so as to diminish if not prevent the absorption of these toxic substances. The second and most essential indication is to construct a dietary that is within the limits of the patient's digestive capability. This will necessitate a knowledge of the chemistry of the different food-stuffs, their relative value as nutritive agents, and the time normally required for the conversion of proteid and carbohydrate into peptone and dextrose respectively. In addition to this, the digestive power of the patient has to be gauged, and this can only be done approximately by careful observation.

For clearing out the bowels the Old Sulphur water answers the purpose admirably. It is frequently advisable to give a small dose of calomel the previous night. No other mineral water should be given during the day in these cases, as too much fluid in the intestine favours the activity of the putrefactive bacteria. Massage douches, especially the Vichy, during which the abdomen can be more effectually massaged than in the Aix douche, not only give tone to the muscular system and soothe the nervous system, but they also benefit the local condition by relieving flatulence.

The importance of eating slowly and resting after meals should be emphasised. The question of suitable exercise requires discrimination, and no rules can be formulated applicable to all cases.

Intestinal Colic

Under this heading is included all cases of severe paroxysmal intestinal pain not dependent on organic changes in any portion of the bowels—biliary and renal colic being excluded. The condition is analogous to gastralgia, and is due to contraction of the unstriped muscle fibres of the intestine provoked by the effort to propel some mechanical irritant; or it may be neuralgic in character, and traceable to a chill or to some diathesis.

Among the irritants which act reflexly are indigestible articles of food and hard fæcal concretions, the passage of a gallstone along the intestine—the stone in transit increasing in size by accretion—the distension of the bowels by retained gas, intestinal worms in children, and the absorption of lead.

Treatment.—As colic is frequently associated with constipation, the primary indication is to give an aperient which will act on the whole intestinal tract, removing thereby any source of irritation. If the patient be delicate, a mild laxative should be administered, but it must be effective. In addition, any irregularities in diet should be corrected. Abdominal packs, followed by the needle douche alternating with one of the massage douches, will in most cases be all that is necessary. If the colic be due to lead, small doses of iodide of potassium should be given, as well as a sulphur water. During an attack it will generally be found necessary to administer some anodyne, either hypodermically or otherwise.

Constipation

One of the most common causes of constipation is the disregard of the natural impulse to defæcation. Among the other causes may be cited the following: (1) irregularities in meals and mode of life; (2) inefficient peristalsis; (3) an insufficient supply of liquids, either from a diminished intake or from excessive perspiration due to muscular exercise or other causes, if the loss of fluid be not compensated for by the quantity imbibed; (4) a diet consisting of easily digested material, and leaving little residue to stimulate the nerves of the intestinal mucosa; and (5) spasmodic contraction of the sphincter ani without fissure. Constipation due to organic affections is not considered.

Treatment. — Before resorting to aperients other measures should first be adopted, such as (1) the enforcement of regular habits as regards the calls of nature; (2) the improvement of the tone of the abdominal muscles by massage, electricity, and suitable exercises; and (3) the alteration of the diet, so that it may contain a residue which will be sufficiently stimulating to increase peristalsis. In addition to these the Strong Sulphur or Kissingen waters should be given according to circumstances which will be sufficiently apparent. Massage may be given in the form of the Vichy douche, and this may be supplemented by a general tonic bath, such as the Scotch douche or the galvanic current bath, with local application to the abdomen. If these fail, the effleuve along the course of the colon may be tried.

Non-Inflammatory Diarrhœa

The exciting causes of diarrhœa may be thus classified :—

(1) Irritating food.—The meals may be too large or very indigestible, containing a large amount of cellulose. An excess of carbohydrate in the diet causes diarrhœa by favouring fermentation.

(2) Irritability of the intestine.—Any stimulus which increases peristaltic action will produce frequent evacuations. Thus the fatty acids formed during fermentation, or indol resulting from proteid putrefaction, sometimes set up diarrhœa. Emotion, worry, or anxiety will in some subjects give rise to frequent movements. In neurotic patients it is often a troublesome symptom.

The *treatment* consists of small doses of the Mild Sulphur or Mild Montpellier waters three times a day before meals, along with either hot packs or sulphur baths to soothe the irritable intestines. Before commencing this treatment it is sometimes advisable to clear out the bowels by a mild laxative, such as castor oil, especially if it be suspected that there are any undigested fragments of food keeping up the irritation. After a time, when the motions regain their normal consistence, more stimulating baths may be used, such as the needle or Scotch douche and the electric baths (weak current); in neurotic cases the latter are especially necessary, otherwise a relapse may occur. Faulty dietetics should of course be corrected.

Chronic Catarrhal Enteritis

In this affection there are definite pathological changes in the intestine. It may remain after repeated attacks of the acute form, the original cause persisting, or it may occur along with general chronic disease, such as tuberculosis. It is often difficult to distinguish clinically between the acute and chronic forms, as they shade into one another almost imperceptibly. As the symptoms depend upon the degree of histological alteration in the mucous membrane, the disease varies considerably in severity, some cases being very mild, while a few are so serious that only palliative measures can be adopted.

In a disease presenting such wide variation in its clinical manifestations, it is extremely difficult to give a satisfactory outline of the treatment that should be adopted in any given case without entering into great detail. The prescriber must therefore apply his knowledge of the physiology and therapeutics of the waters and baths to the treatment of such symptoms as may be present.

Membranous Colitis

This term should be reserved for cases in which shreds of membrane are passed per rectum with or without fæcal matter. The shreds consist chiefly of albumin, amorphous matter, degenerated epithelium, salts, and fatty granules, and invariably harbour many bacteria. The membranous shreds or masses vary greatly in size, from small filaments to long ribbon-like flakes, or even tubular casts of the intestine as much as six inches in length. During the passage of these membranes considerable abdominal uneasiness is experienced, amounting in some cases to actual pain. Constipation is a frequent symptom; occasionally it alternates with diarrhœa, and in a small percentage of the cases the latter is the predominating feature. These patients as a rule become chronic dyspeptics.

Chronic Mucous Colitis

These cases are very liable to acute exacerbations. The characteristic sign of the affection, as its name implies, is the passage of mucus with the motions. Pain is not a marked feature of the chronic condition, although some irregular abdominal pain may be present, but it is not infrequently absent. It occurs most commonly between the ages of twenty and forty, and the patients affected are generally nervous and excitable.

Treatment.—In the relief of these affections our object should be: (1) to procure a daily evacuation of the bowels; (2) to remove infective material from the large intestine by lavage; (3) to relieve pain; and (4) to improve the general health by treating the neurotic state which is usually present.

Regulation of the diet is an important factor in the treatment. As to what constitutes the most suitable diet there is a difference of opinion. By some it is held that the food should be bland and unirritating, leaving as little residue as possible; and should therefore consist mainly of milk, eggs, fish, minced meat, soups, and light-boiled puddings—with the exclusion of vegetables, fruit, and fat. Von Noorden, on the other hand, strongly advocates a diet rich in cellulose, leaving a large residue, and consisting chiefly of coarse bread, vegetables, and fruit, with plenty of butter and cream. Which view is correct will only be determined by prolonged experience and a more intimate knowledge of the pathology of the disease.

The bowels should be opened daily by a dose of a mild laxative, such as castor oil; strong purgatives are injurious, and should be avoided. The Mild or Strong Sulphur waters are often useful for this purpose. After the daily evacuation the bowel should be washed out by a hydrostatic douche of Beckwith or Starbeck water at 100° F. One to two pints should be run in, retained a few minutes, and then evacuated, the operation being repeated twice or even thrice at a sitting as the patient becomes accustomed to it.

For the relief of abdominal pain hot packs are useful; or the full length immersion bath may be given with Starbeck water at 98° F., with a subaqueous spray douche at 110° F. to the abdomen.

When the immediate symptoms subside tonic waters and baths should be given with the object of improving the general health and restoring the tone of the nervous system.

Hæmorrhoids

The treatment of hæmorrhoids may be briefly summarised.—The Old Sulphur water daily to evacuate the bowels and relieve portal congestion; the liver pack; the high frequency current applied locally by means of the rectal tube; the sitz bath with the anal douche of cold water; and, if necessary, general tonic baths to brace up the system, in addition to suitable dieting and regular exercise.

DISEASES OF THE LIVER

The affections which will be considered under this heading are—

(1) Functional Disorder of the Liver.
(2) Cirrhosis (primary stage).
(3) Chronic Catarrhal Jaundice.
(4) Gallstones.

Functional Disorder of the Liver

As a good deal of uncertainty exists regarding what is really meant by functional disorder of the liver, it will be necessary to describe the signs and symptoms which constitute this affection. It must be admitted that they are not so manifest as in functional disease of the stomach; nevertheless they are sufficiently apparent in some instances to justify a diagnosis of the condition. Moreover, the hepatic disorder is nearly always associated with some degree of gastro-intestinal disturbance, and the symptom group of the former is apt to be masked by that of the latter, but when the symptoms of disordered liver function predominate it is more accurate to refer them to the organ more prominently affected. Unfortunately, dyspeptic troubles are almost invariably attributed by the laity to the liver, and symptoms really of gastric or mixed origin are supposed to be due to the torpid state of this organ. When we glance at the complex and varied functions of the liver it will be conceded that any inhibition of or interference with its normal activities must have a modifying effect on the nutritional processes.

The liver is concerned (1) in nitrogenous metabolism, (2) in fat metabolism, (3) in the maintenance of the normal coagulability of the blood, (4) in the destruction of hæmoglobin, its action in this respect being a selective one,[1] (5) in the metabolism of carbohydrate, (6) in the secretion of bile, and (7) in the destruction of toxins.

The main causes of disordered function are: alcoholic excess, residence in the tropics, rich and highly seasoned food, sedentary habits, gastro-intestinal disturbance. It is sometimes associated with the climateric.

The symptoms are: lassitude, loss of appetite, a bitter taste in the mouth, nausea, a feeling of discomfort or constriction in the hepatic region and occasionally aching or pain, constipation, pain in the tip of the right shoulder, mental depression, irritability of temper, and frontal headache. Some patients complain of great drowsiness, insomnia, and irritability of the skin. The tongue is often furred at the base, the complexion is muddy, and the sclerotics are of a dirty white hue with a slight tinge of yellow. The liver may be appreciably enlarged, generally about one inch in the vertical diameter, and pressure over the organ generally causes tenderness, which may, however, be slight. Dilatation of the venous radicles is frequently observed in the skin over the hepatic area. This has been regarded as a sign of structural alteration in the organ, but is often noticed in cases where no evidence of organic disease could be detected even after the lapse of several years.

Treatment.—It should be remembered that chronic congestion of the liver may be the first step in the development of cirrhosis, and that this can be prevented

[1] Bain, "The Rôle of the Liver and Spleen in the Destruction of Blood Corpuscles," *Journal of Physiology*, 1903.

by suitable treatment. The Old Sulphur water is a valuable remedy in this condition. It has been shown experimentally that it increases markedly the quantity and solids of the bile, and this may fairly be taken as an index of the degree to which it stimulates the liver; and is, in fact, the most reliable indication of the value of a cholagogue. The water should accordingly be prescribed. Mustard bran packs to the hepatic region, followed by a sulphur bath at a temperature of 100° F. every alternate day, will aid in reducing the congested state of the organ. The diet should be restricted and carefully supervised, alcoholic drinks being forbidden. Regulated outdoor exercise is a most important factor in the treatment.

Cirrhosis (Primary Stage)

In this country alcohol is the main etiological factor in 99 out of every 100 cases of cirrhosis, and the withdrawal of the cause is an essential preliminary of successful treatment. In cirrhosis the liver is not the only organ affected, the deleterious effects of the poison being also observed in the spleen, kidneys, pancreas, heart, and blood vessels. Histologically, the two chief elements are a destruction of liver cells, and obstruction of the portal circulation by an increased formation of connective tissue. Experiments on animals have shown that while alcohol is a protoplasmic poison and causes fatty degeneration of the liver cells, it does not produce the typical cirrhotic liver; therefore it has been suggested that the organic changes are due to some product of abnormal metabolism acting in concert with alcohol. In acid intoxications of the body it is found that the ammonia is increased, and that whenever the alkalescence of the blood is threatened by an abnormal formation of organic acids, these are neutralised by an excess of ammonia. Bunge was the first to point out that the excretion of ammonia in cirrhosis was markedly increased, and that both in phosphorus poisoning and in some cases of cirrhosis it was linked with sarcolactic acid. Normally, ammonia is utilised by the liver in the synthesis of urea, the latter being less toxic than the former, and whenever the ammonia is augmented there is certain to be an excessive formation of some organic acid which might have a pernicious effect on the organism were it not for its neutralisation by ammonia. When the liver is diseased this important synthetical function may be imperfect, but it is a remarkable fact that in cases of liver abscess where portions of the organ are destroyed, the remaining parts appear to carry on the functions of the organ efficiently.[1] It is a point of considerable practical importance that cirrhosis has been frequently discovered *post-mortem* in persons who during life showed no signs of the affection. That being so, if the disease can be arrested in the very early stage, although perhaps the embryonic tissue already formed can never be absorbed, yet the patient may not experience any unpleasant effects.

The *treatment* is precisely similar to that outlined for functional disorder of the liver, but should be continued for a longer time.

[1] Bain, "The Relative Excretion of the Nitrogenous Waste Products in a Case of Liver Abscess," *Trans. Med. Soc.*, London, 1899.

Catarrhal Jaundice

The cases of catarrhal jaundice sent to Harrogate are those in which recovery has been imperfect. The catarrh of the common duct is probably preceded by a similar condition of the duodenum, and depends on the action of micro-organisms. The characteristic signs are due to the exclusion of the bile from the intestine and its absorption by the blood. In jaundice bilirubin is present in the urine, and also bile salts, but after the first few days the latter are absent. This disappearance of the bile salts from the urine in jaundice is exceedingly interesting. After a careful consideration of the facts, the only satisfactory explanation is that the liver cells in this condition lose to a certain extent the power of manufacturing bile salts. This loss of capacity appears to be a wise provision of nature in preventing the introduction into the blood of a substance which has a marked inhibitory effect on the action of the heart, for Röhrig has shown that the bile salts have considerable influence in retarding the heart's action; and in jaundice the slowness of the pulse is a matter of common observation. Apart from the defective absorption of fats, an important result of the absence of bile from the bowel is delay in the onward movement of the intestinal contents, and this leads to proteid putrefaction which is revealed by an increase of the ethereal sulphates and of indican in the urine.

Treatment.—A large dose of an alkaline carbonate water before breakfast should be given, and small doses half-an-hour before meals during the day. If an aperient is requisite, a sufficient quantity of phosphate of soda or of Carlsbad salts should be added to the morning draught. In addition, Thermal Sulphur baths should be prescribed. As a matter of experience patients suffering from various hepatic ailments derive great benefit from the use of these baths: no satisfactory explanation of this beneficial influence has been given: the effect can scarcely be psychological. As in all hepatic affections, the diet should be strictly regulated.

Gallstones

The cases associated with jaundice or accompanied by a rise of temperature with rigors (complicated cholelithiasis) are excluded from consideration.

Gallstones consist chiefly of cholesterin and bilirubin-calcium. Cholesterin is a monatomic alcohol occurring in a crystalline form, and is freely soluble in alcohol, ether, chloroform, and turpentine. The quantity present in normal bile is small, about 5 per cent., but in diseased conditions of the gall bladder it is secreted by the mucous membrane in much larger amount. Both cholesterin and bilirubin are kept in solution by the bile salts. As the amount of calcium in normal bile is infinitesimal, the moderately large quantity present in some gallstones is supposed to be derived from the inflamed mucous membrane of the gall bladder. The causes which pre-dispose to gallstones are: (1) advancing years, (2) sex—three-fourths of the cases occur in women, (3) pregnancy, (4) tight-lacing, (5) anything which interferes with the emptying of the gall bladder, such as sedentary habits, (6) gout, (7) mitral disease, and (8) the specific fevers. The exciting cause is unquestionably an infection of the gall bladder, the microorganism which is most frequently responsible for this infection being the bacterium *coli communis.* Naunyn suspected that gallstones were the result of bacteria setting up inflammation of the mucous membrane of the gall bladder, and this conjecture was experimentally proved by Gilbert and Fournier, who produced gallstones by injecting an attenuated culture of the typhoid bacillus into the gall bladder.

The excruciating pain of biliary colic is due to a gallstone engaging the cystic duct: for its relief drugs are required.

It should be noted that gallstones are not infrequently found *post-mortem*, although their existence was not suspected during life; and the failure to diagnose the condition is not always due to the absence of symptoms. Indeed some of these patients complain for years of abnormal epigastric sensations which are attributed to disorder of the stomach. Enlargement of the gall bladder may or may not be detected, but in nineteen cases out of twenty the organ is tender on pressure.

Treatment.—Since the bile salts prevent the precipitation of cholesterin and bilirubin, our aim should be to increase the quantity of these salts in the bile. This can be brought about by a generous allowance of nitrogenous food. In order to prevent gastro-intestinal disturbance, the carbohydrate intake should be restricted. The Old Sulphur water has a marked effect in reducing the distended gall bladder to its normal size and in promoting the dissolution of biliary calculi. This effect may be enhanced by the administration of iridin and urotropine.[1] Liver packs followed by the needle douche

[1] Bain, "An Experimental Contribution to the Treatment of Cholelithiasis," *Brit. Med. Journ.*, August 5, 1905.

soothe the irritability of the gall bladder, and may assist the sulphur water in diminishing the size of the organ. A sufficient amount of daily exercise should be taken.

Neurasthenia

The functional derangements of the nervous system included under neurasthenia have undergone a remarkable increase during late years, an increase which is in part due to the greater stress of modern life. The difficulty often experienced in the cure of neurasthenic patients explains their appearance in large numbers at all health resorts in the endeavour to get relief from their distressing symptoms.

The cases which are sent to us fall into one of three categories :—

(*a*) Severe cases which are sent away from home for a complete "rest cure."

(*b*) Similar cases which have undergone full rest treatment elsewhere, and are sent to Harrogate for an after-cure.

(*c*) Milder cases of slight or incipient neurasthenia, not of sufficient duration or severity to demand such radical measures, and for which a system of partial rest with tonic treatment directed to the removal of the cause, and to the building up of the nervous system, suffices to effect a cure.

As to the first category, many facilities are afforded by private enterprise at Harrogate for the thorough carrying out of the "rest cure." There are several well-equipped Nursing Homes to which patients may be sent with the assurance that nothing will be found lacking in comfort or detail. In the treatment of such cases baths and waters occupy no place except perhaps during convalescence.

For the second division a visit to pure moorland air in conjunction with stimulating baths and carefully regulated exercise will help to avoid the risk of relapse.

In the third group Spa treatment is often advantageous. The directions in which it should be applied may be best indicated by a brief reference to the most common causes of neurasthenia. Apart from predisposing causes, among which the most potent are the stress and strain imposed by the conditions of modern life, and especially of city life, hereditary transmission of an unstable nervous system, or congenital weakness of nerve tissue, the exciting cause is usually to be found under one of the following headings—

(1) Toxic states of the blood, either auto-toxic, from disturbances of the alimentary functions, or hetero-toxic, from some extraneous poison such as that of influenza, or following acute specific disease, or due to alcohol, tobacco, lead, or arsenic.

(2) Mal-nutrition, the result of debilitating diseases, such as arthritis deformans, phthisis, chronic renal disease, cancer.

(3) Fatigue of the nervous system from over function.

(4) Shock, either mental or physical.

(5) Eye strain from errors of refraction, especially if associated with astigmatism.

That neurasthenia is accompanied, in the large majority of cases, by digestive disturbance is well known. The alimentary system shares in the general "fatigue," and its derangement is to be looked upon in many cases as a direct result of the neurasthenia. The mal-nutrition following on defective assimilation of food aids in the maintenance of the neurasthenic state, and thus a vicious cycle is set up which tends to prolong the disease. Making due allowance for those cases secondarily affected there remains a considerable proportion in which the stomach trouble, often associated with defective teeth, is long antecedent to the onset of neurasthenic symptoms, and may be justly regarded as the true cause. In these instances a course of the sulphur waters may be prescribed with the object of rectifying the digestion and removing toxic material from the alimentary tract, and nutrition may be improved by a course of the massage douches, if sufficient rest be insisted upon to avoid the risk of unduly fatiguing the patient.

Similarly the sulphur waters may prove useful in the hetero-toxic cases, particularly those due to alcohol or lead. Neurasthenia resulting from mal-nutrition due to debilitating diseases may be dealt with by tonic waters and tonic bathing measures calculated to promote nutrition, due attention again being paid to rest and abundant feeding. Cases due to fatigue consequent upon mental or business worries derive conspicuous benefit from a few weeks' residence in Harrogate. Removal from the stress of their occupations, rest to the mind, gentle exercise to the body, together with bath treatment in the form of needle douches, the alternating spinal douche, electric baths, or massage douches, rapidly tone up the nervous system, provided that recourse to such measures has not been postponed too long, and the neurasthenia has not taken such a hold as to compel more drastic treatment. The speedy improvement that results sometimes tempts patients to curtail their stay unduly, and to leave, contrary to advice, before recovery is complete, under the impression that they are free from the risk of relapse. This should be guarded against by remaining until they are perfectly well.

In traumatic cases of neurasthenia in which symptoms of irritation or weakness of the spinal cord are prominent, bathing may do good in the form of sedative or stimulating douches to the spine.

Generally speaking, in the auxiliary bath treatment of neurasthenia those cases which are characterised by nervous irritability require sedative measures in the form of warm baths, wet packs, the Aix douche, or occasionally Turkish baths; those characterised mainly by weakness require tonic measures, needle douches, the alternating spinal douche, the galvanic or faradic electric bath, and the like. The majority of the symptoms of neurasthenia are referable to derangement of the sympathetic nervous system and through it of the vasomotor mechanism, loss of vasomotor control being a prominent phenomenon. As has been shown in the chapter on the physiological action of baths, one of the most striking effects of bathing is the variation that can be induced at will in the blood pressure, in the distribution of the blood in the body, and in relations of blood plasma to tissue fluid. By bringing about these variations in the direction in which they may be defective in a given case the vasomotor mechanism may be exercised in a manner analogous to the exercising of a voluntary muscle, and the tone of the unstriped muscle and of the nerves governing it may be restored until the normal circulatory adjustment of health is regained and the symptoms dependent upon loss of voluntary control disappear.

The high frequency current in the treatment of neurasthenia must be mentioned. In our experience the results of its general application by auto-condensation have been disappointing. In a few cases of mild type benefit has ensued, but it is by no means certain that the effect may not have been one of suggestion. In the more severe forms, though good results are sometimes observed, actual harm is more often done, particularly in the irritable type of the disease. On the whole, our experience has not been such as to justify reliance on this form of electricity as a method of primary election in the cure of neurasthenia. For the relief of symptoms such as headache, neuralgia, hyperæsthesia, the local application of the current in the form of the effleuve or by means of the vacuum tube is sometimes of distinct service.

Hysteria

Hysteria, though occurring by no means so frequently as neurasthenia in Spa practice, is not uncommonly met with.

Severe cases requiring Weir-Mitchell treatment may be dealth with successfully, the same facilities in the way of well-conducted Nursing Homes being afforded as for the rest cure. Others who have already been subjected to this treatment are frequently sent to Harrogate for change of air and scene, the climatic conditions and general environment being eminently favourable for an after cure. Milder cases are amenable to bath treatment, particularly by those forms of bathing which include massage; or, in the case of spasmodic manifestations, cold douches or needle baths. The most suitable cases are those in which the somatic stigmata of hysteria predominate, such as local anæsthesia, hemianæsthesia, contracted fields of vision, local contractures or paralyses.

Those in which the psychical stigmata, emotional instability, hysterical fits, and the like, are most in evidence, run some risk of having their ailment prolonged through the publicity unavoidably entailed by bath treatment.

The local circulatory disturbances so common in hysteria—contracted peripheral circulation, cold hands and feet, local vascular spasm—are probably indicative of similar disturbances in the blood supply of the central nervous system, which may account largely for temporary derangements of function through the resulting faulty nutrition. The vascular dilatation produced by warm baths, with or without massage, opens up the circulation and ensures an adequate supply of blood to all parts, a better state of nutrition of the nervous system is maintained, and function is gradually restored.

Electricity, either alone or in immersion baths, is of great service in the treatment of spasmodic or paralytic affections, such as monoplegia, paraplegia, or aphonia. As a general rule the faradic current should be employed in paralytic conditions, the galvanic when pain is the prominent symptom.

A few instances have been observed of good results from the use of the high frequency current. In some of these, of the emotional or psychical type, the effect was no doubt partly due to suggestion; but that this does not entirely explain it, is shown by the fact that in some cases of latent hysteria, somatic stigmata, which were present unknown to the patient, have been found absent after a course of applications.

As regards the use of waters, the indications are practically limited to the administration of the iron waters in cases which are anæmic.

Neuritis

The use of mineral waters in the treatment of neuritis will be largely determined by the cause to which the affection is due.

In neuritis of toxic origin, resulting from arsenic or lead, elimination of the poison may be favoured by a course of the sulphur waters. If due to faulty metabolism, as in the neuritis which may occur in gout and rheumatism, the constitutional condition must be dealt with on the lines laid down under those diseases. Neuritis of infective origin, following influenza, diphtheria, or typhoid fever, is not affected by the waters. Non-toxic neuritis occurring in anæmia and wasting diseases, or resulting from exposure to cold and fatigue, may be favourably influenced by tonic waters directed to the improvement of the general nutrition.

Excluding for the moment those associated with gout and rheumatism, the majority of cases of neuritis met with at Harrogate are of the more chronic type—*i.e.* in which the acute symptoms have subsided and the initial cause is no longer actively at work. Hence treatment must be directed to the removal of the effects produced, and must therefore be mainly local.

Acute neuritis developing in markedly gouty or rheumatic subjects is not infrequently met with and demands energetic general treatment, without which local applications are of little permanent avail.

The methods of treatment adopted in neuritis of various forms are legion, and a few of them may be best described by taking **sciatica** as a type, though they are applicable with suitable modifications to neuritis occurring in any accessible situation. It must not be assumed, however, that sciatica is regarded as invariably a neuritis. Probably this is so in but a small minority of cases, the large majority being cases either of pure neuralgia, or due to inflammation of the sheath of the nerve—perineuritis—or to a "fibrositis" in the neighbourhood of the nerve. The following points of distinction have been found useful. Pain which is practically constant and independent of movement, distinct tenderness down the course of the nerves, early and marked wasting of the muscles, and anæsthesia in the area supplied by superficial branches of the nerve, indicate a true neuritis. On the other hand, if the pain be brought on by movement, if tenderness be localised, if the muscles be not markedly wasted, and if there be no anæsthesia, the case is probably one of perineuritis. Lastly, if pain be the chief feature, and the other signs mentioned be absent, or present in a minor degree, the case is almost certainly neuralgic. The distinction is of importance as a guide to prognosis, for sciatic neuritis usually takes a much longer time to recover than sciatica of perineuritic or neuralgic origin. It may not be superfluous to insist on the importance of making a thorough examination before pronouncing a case to be one of simple sciatica. Patients have been sent to us for Spa treatment who were found to be suffering from malignant disease of the cervix uteri, secondary carcinoma of the pelvic bone, hip-joint disease, or diabetes. Hence the pelvis should be carefully explored—especially if the sciatic pain be bilateral —the hip-joint and spine examined, and the urine invariably tested.

Local treatment may begin with a series of hot sulphur baths preceded or followed by hot packs along the course of the nerve. In mild incipient cases they are often all that is necessary to effect a cure. When there is great tenderness, a hot douche applied under the surface of the water while in the bath—the so-called subaqueous douche—is very soothing. By some, the Scotch or alternating douche of hot and cold water is preferred, but should be reserved for the less acute cases in which tenderness is not a marked feature. In more intractable forms the Greville hot-air bath at a temperature of 300°–350° F., or over, for forty minutes on alternate days, or even daily, often rapidly relieves pain. On similar lines the Dowsing radiant heat bath at 250°–300° F. may be tried. Whether the luminous heat has any advantage over the non-luminous in this connection we have been unable to satisfy ourselves. The result of our experience with these baths in sciatica is that unless improvement takes place after a course of half-a-dozen or so, it is generally useless to proceed further with them. In the early cases they are of most use; in the more chronic they are often disappointing.

Certain cases that have failed to yield to other methods have done well with a course of peat baths, but the choice of these baths would seldom be primarily made for the relief of sciatica.

In other cases the high frequency current is decidedly beneficial when applied by auto-condensation for five or ten minutes, followed by the effleuve locally to the nerve for an equal period. Though occasionally useful in cases of true neuritis it would appear to be of more service in the purely neuralgic form of sciatica. The current is uncertain in its action; in some instances relief to pain is striking, in others the applications are without effect.

Electric immersion baths are often beneficial—the galvanic current when pain is troublesome and soothing treatment indicated, the faradic or sinusoidal current when there is atrophy of the muscles after prolonged disuse or severe neuritis.

If there be much wasting of the muscles and the nerve be not too tender massage should be employed, either dry or in the form of the massage douche. Operations should be confined to improving the nutrition of the muscles, and no attempt should be made to knead or manipulate a tender nerve. The massage douche is often preferable to dry massage, as it combines with topical treatment a constitutional action on the general condition underlying the local manifestation.

Other local measures—blistering, counter-irritation, acupuncture, nerve stretching by the open or closed methods—do not come within the scope of this work.

Emphasis should be laid, finally, on the fact that the local and general procedures above sketched are often unavailing unless the fundamental condition of success in the treatment of neuritis is complied with; and that is complete physiological rest to the affected nerve, in so far as it may be procured. In the acute cases rest is of first importance; in chronic cases it is not always easy to enforce, but is equally necessary.

Other Functional and Organic Diseases of the Nervous System

Apart from the more common functional affections such as neurasthenia and hysteria, other conditions are met with in Spa practice, though in fewer numbers—for example, migraine, epilepsy, neuralgia, insomnia, vertigo.

These have been grouped, for convenience, with various organic diseases which occur infrequently, such as tabes dorsalis, general paralysis of the insane, paralysis agitans, cerebral tumours, hemiplegia. In the functional affections, change of scene and the surroundings of a health resort are often of distinct advantage, and much may be done by Spa treatment towards removing the cause or improving the general health. In the organic affections mentioned, with the possible exception of tabes, nothing can be expected of treatment by waters and baths. With respect to tabes, certain baths and electrical procedures seem occasionally to be of service in relieving symptoms of pain or anæsthesia, and in promoting nutrition of muscle and power of co-ordination, but such treatment cannot influence the essential nerve lesion.

Heart Disease

The majority of cases of heart disease sent to Harrogate come for the Nauheim baths and resisted exercises.

In the section on the physiology of the baths the effects and mode of action of the Nauheim bath have been considered, and need not be further alluded to here; and under the therapeutics of the baths the kind of cases likely to derive benefit has been sufficiently outlined. It may, however, be again insisted upon that the selection of suitable cases should depend, not upon the antecedent cause of the heart trouble nor upon its nature, but upon the condition of the heart muscle with respect to power of recovery in response to treatment by mechanical means.

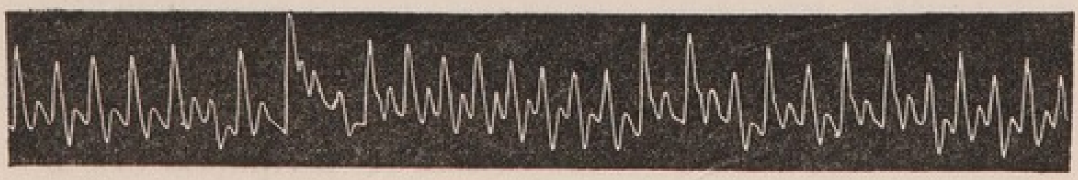
In dealing with the more advanced cases of failing heart it is necessary to proceed cautiously. If it seem inadvisable to subject the patient to the amount of movement entailed in going to the bathing establishment the initial baths may be given at his own quarters; or it may be wise to begin with simple resisted movements in the recumbent posture, while in the intervals absolute rest is enjoined. The variety of the movements and the amount of resistance should be gradually increased until improvement has so far taken place that a course of baths may be commenced. This should begin with the still bath, at a temperature of 90° to 93° F., for not more than five minutes, and prolonged rest should be insisted upon afterwards. If well borne the duration of successive baths may be extended to 7, 10, and finally 15 minutes, and the temperature gradually lowered to 90° or 88,° while the quantity of saline material in solution is progressively increased. A not infrequent mistake is to prescribe initial baths at too high a temperature, *e.g.* 98°, and to order too long an immersion. In many cases such a proceeding is not unattended by risk. When patients are undergoing their first experience of this treatment it is well for the medical attendant personally to supervise the first few baths. If a series of the still baths has been well borne an advance may be made to the aerated bath, beginning with a mild degree of effervescence and gradually increasing the amount, while the temperature of the bath may be further lowered to 86°, 84°, or 82° F. and the duration lengthened to twenty minutes. As a rule the baths should only be given on alternate days to begin with; subsequently they may be given daily, with an occasional interval after three or four baths. A good plan is to order the baths and exercises on alternate days.

Suitable cases respond well to treatment. The heart action becomes steadier, more regular, and the contraction more vigorous; the apex beat becomes less diffuse, and the acme of pulsation moves nearer the mid-line; the pulse becomes fuller, and heart beats which previously failed to be detected at the wrist become evident to the touch. Though such improvement may not be maintained, after each of the first few baths the effect of one soon begins to overlap that of the next, and through this cumulative action the contractile power of the heart is gradually re-established.

In illustration of these effects the following tracings may be given; they were taken by one of us during the course of a series of observations made on patients taking the Nauheim baths.

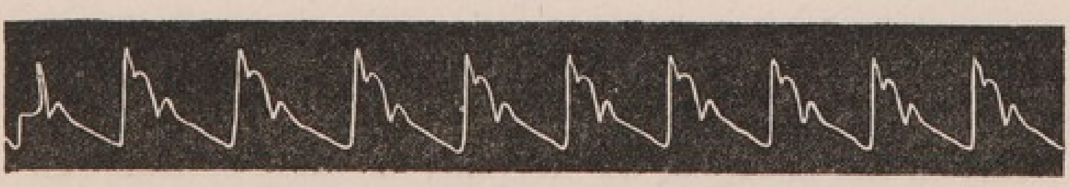
Male—aged 45. Moulder. Rheumatic fever several times. Mitral regurgitation. Apex beat $3\frac{3}{8}$ in. from mid-line. Marked epigastric pulsation. Pulse 130–140, very irregular. Tracing before 1st bath.

TRACING 1.



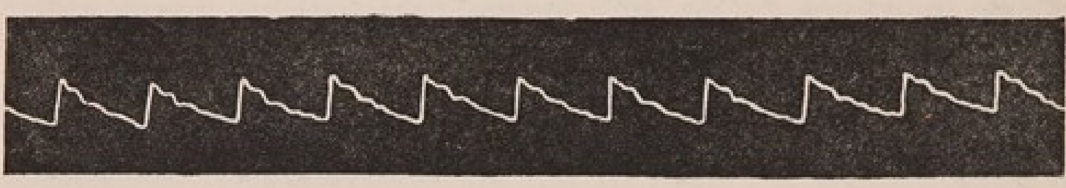
Tracing before 14th bath. Pulse 65, regular. Apex beat $2\frac{1}{2}$ in. from mid-line. No epigastric pulsation.

TRACING 2.



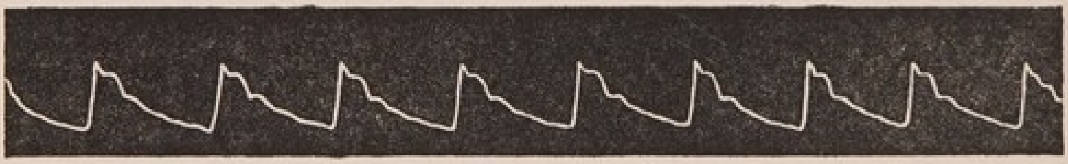
Male—aged 63. History of rheumatic fever. Mitral regurgitation. Apex beat 5th interspace, 5 in. from mid-line. Pulse 65, slightly irregular. Tracing before 1st bath.

TRACING 3.



Tracing after 9th bath. Apex 5th space, 4 in. from mid-line. Pulse 54, regular.

TRACING 4.



For the purpose of further toning up an enfeebled heart by graduated active exercise in the open air the situation of Harrogate is exceptionally adapted. While possessing considerable stretches of level ground it has a great variety of slopes of different inclinations, so that the needs of individual cases may be met by prescribing suitable routes for varying degrees of exercise.

One of the most useful applications of balneological methods is to cases of heart disease of peripheral origin. By heart disease of peripheral origin is meant dilatation, with or without hypertrophy, resulting from excessive intra-ventricular pressure, or over-work of the heart, occasioned by the attempt to overcome increased peripheral resistance of long duration, such increased resistance being due to contraction of the peripheral vessels induced probably by the action of toxic material circulating in the blood, as, for example, in cases of gout and renal disease. The poison may further tend to cripple the muscular tone of the ventricle and indirectly promote dilatation, both causes being in operation at the same time. Though actual valvular disease may not be present in the early stages, it may subsequently develop. Such cases are decidedly improved by the reduction in arterial pressure brought about by warm baths, especially if combined with massage, as in the Aix douche. Not only is the tension lowered immediately after the douche, but as the action of a series of baths is cumulative, it remains lowered, while at the same time elimination of the toxic material is favoured. Thus both the source of strain and the cause which gives rise to it are together diminished, and the heart is enabled to recover itself and regain its normal contractile power. The relief of symptoms such as palpitation, breathlessness, anginal pain, which often follows these baths, is very striking; and by repeating the course at intervals, improvement may be maintained.

ANÆMIA

The treatment of chlorosis and simple secondary anæmia by ordinary medicinal means is usually so satisfactory that but little occasion can arise for the deliberate choice of treatment by chalybeate waters unless some other conditions or circumstances are present for which the surroundings of a health resort may be thought desirable. There is, however, a small proportion of cases which prove refractory, either from their inability to absorb iron in medicinal form, or because they are not removed from influences which maintain the anæmia, These are the cases in which treatment by natural iron waters, combined with change of air, suitable dieting, and in some instances baths or massage, often proves successful. Whether the iron in such a form is more readily assimilable; whether the stimulus to nutrition given by the change of environment suffices to start the processes of regeneration of hæmoglobin; or whether removal to healthier surroundings alone can initiate improvement, are all problems not easy of solution in any given case. Each or all may be factors determining the result.

If the amount of iron present in the mineral waters be compared with that in the medicinal doses usually considered necessary to effect a cure of chlorosis, it may be thought that the quantity present in the former is wholly inadequate to make any impression. This does not necessarily follow, for, as has been pointed out under the pharmacology of the iron waters, the total amount of iron present in the blood is relatively very small, the quantity capable of absorption is minute, and the large proportion of that administered medicinally by the mouth passes out unabsorbed in the fæces. Hence, if iron in the form in which it appears in these mineral waters is more readily absorbable, as we believe it to be, the amount is considerable enough to exert a decided therapeutic effect. This statement is supported by the fact which is frequently observed, that patients peculiarly intolerant of iron in medicinal form will take it readily enough in natural waters without disturbance of digestion.

The wide range of iron waters available, from the Kissingen, which contains but a fraction, upwards through the Pure Chalybeate, Alexandra Well, Tewit and John's Wells, to the strong Chloride of Iron water, enables a careful selection to be made to suit individual cases. Rarely is it found that one or other of these fails to be tolerated. The Chloride of Iron water contains a large quantity of chloride of calcium (94 grains per gallon), and consequently has a considerable effect in increasing the coagulability of the blood and in lessening the tendency to hæmorrhage which may be present in severe cases.

Observations made by one of us[1] on the physiological changes in the hæmoglobin have emphasised the importance of *rest* in the treatment of anæmia.

Sufficient attention has not been drawn, we think, to the value of *baths* in anæmia. In very obstinate cases in which after successive examinations of the blood the hæmoglobin shows no increase, or if temporarily increased shows a tendency to diminish, baths are of undoubted service. Apart from the cardiac dilatation and the asthenic condition of the circulation, which commonly accompanies the more severe forms of anæmia, and which unquestionably is benefited by saline baths, such as the Nauheim, the stimulus to nutrition given by gentle massage douches will often enable a refractory case to pass the turning-point towards recovery. Improved cardiac action and vasomotor tone, together with more active metabolism, appears to aid materially in the rapid formation of hæmoglobin. Probably the absorption and utilisation of iron from the waters concurrently given is favoured by these measures, for without iron such baths would probably be valueless.

The high frequency current, as has been pointed out, is followed, in the normal subject, by a rise in the hæmoglobin value of the blood. It may therefore be used as an adjunct in cases which present functional nerve

[1] Edgecombe, "The Effect of Exercise on the Hæmoglobin: with Reference to the Value of Rest in the Treatment of Anæmia," *British Medical Journal*, 1898.

disturbances as a prominent feature. The inhalation of ozone seems worthy of more extended trial, not only in refractory cases of anæmia, but also in ordinary cases, as an accelerator to more common methods of treatment.

Anæmias of toxic origin, either auto-toxic, as the anæmia of constipation, and of the gouty state, or hetero-toxic, as that due to lead poisoning, should be treated by a preliminary course of sulphur water before proceeding to the iron waters. In the normal subject the Old Sulphur water causes a reduction of hæmoglobin, due to the presence in it of sulphuretted hydrogen gas. In cases of toxic anæmia a progressive increase in hæmoglobin may be observed during the taking of this water without other treatment, and may proceed to the extent of rendering the use of iron water unnecessary. Removal of the cause of the anæmia enables the normal powers of reconstruction of hæmoglobin to more than counterbalance the destructive tendency of the H_2S. This water administered minus its sulphuretted hydrogen might prove even more efficacious in this class of case.

In chronic gout, anæmia is often present when quite unsuspected. Estimation of the hæmoglobin alone may show it to be very little below or even up to normal, while in some cases there may even be an apparent excess beyond the normal standard. Estimation of the number of corpuscles, however, shows them to be much above the normal in consequence of a concentrated state of the blood. Hence the blood decimal or value of the corpuscle may be markedly reduced and a state of relative anæmia be present. A similar condition is observed in granular kidney and other diseases, and may be rapidly improved by a course of the Old Sulphur water.

Although in the list of cases pernicious anæmia appears, little hope can be afforded of its temporary remission by chalybeate waters or Spa treatment of any kind. The same applies to leucocythemia, of which one case occurred. The X-rays now used with apparent success in the treatment of this disease cannot fairly be included under Spa treatment.

CHRONIC DISEASES OF THE KIDNEY

The only affections which will be considered under this head are—

(1) Gravel.
(2) Gouty albuminuria.
(3) Chronic parenchymatous nephritis.

Granular kidney is excluded, as it is inadvisable for patients suffering from this malady to come to a health resort for the purpose of taking waters or baths. During the summer months Harrogate is, however, admirably adapted as a temporary residence for them, providing the waters and baths are left severely alone. So long as the patients restrict their nitrogenous intake, avoid digestive disturbance, adopt suitable clothing, guard against chills, lead tranquil lives, and take regular exercise, there is no necessity for medicinal treatment.

Gravel

Gravel may consist of (1) oxalate of lime, (2) uric acid and its compounds, (3) phosphate of lime, and (4) the triple phosphate of ammonium and magnesium. As uric acid concretions are by far the commonest, the causes which lead to its precipitation will be briefly mentioned. It may be taken as established that a high degree of acidity and an excessive percentage of uric acid in the urine favour the deposition of the acid or its salts, and it is probable that precipitation may be determined by a diminution in the saline material and in the pigments of the urine. If the urine be very acid, the nitrogenous elements of the food should be curtailed and plenty of green vegetables (other than leguminous) and ripe fruit should be given. The following treatment will probably relieve the condition, but the importance of attention to the physiological laws of health cannot be over-estimated in preventing a recurrence. A pint of Beckwith or Starbeck water before breakfast and two doses of the Magnesia water should be taken during the day, and a massage douche every alternate day.

Gouty albuminuria has already been considered.

Chronic Parenchymatous Nephritis

This affection often follows the acute variety, but it may arise independently. In treating these cases various points should be taken into consideration; (1) the specific gravity of the urine; (2) the pulse tension; and (3) the presence or absence of anæmia, anasarca, or dyspeptic symptoms.

The specific gravity depends upon the presence of salts and urea, and if the latter be excreted in average amount, or rather in amount proportionate to the diet, there need be no hesitation in prescribing sulphur waters. If the specific gravity be 1010, or if anæmia be a feature, an iron water is indicated. It has been mentioned that the Magnesia water has a marked effect in diminishing the amount of albumen in the urine and in promoting diuresis, therefore it is beneficial in conditions of effusion into the tissues. A useful combination in what may be described as the asthenic type of the affection is the Old Sulphur water before breakfast, the Magnesia water during the day, and the Aix douche—the last more especially if dyspeptic symptoms are fairly prominent. If the arterial tension be high—150 mm. of mercury or more—the high frequency current, either the bipolar massage or effleuve may be prescribed on alternate days with the Aix douche. The remarks on the subject of blood pressure made under gout apply equally to this affection.

Regarding diet, the importance of restricting the nitrogenous intake is apparent. The kidneys should be given as little work to do as possible consistent with the maintenance of the nutrition of the body. Since we know from Chittenden's[1] researches that the nitrogenous equilibrium can be maintained on a small proportion of nitrogen daily, there need be no fear of diminishing its intake in this disease. Even in health the enormous amount of work the kidneys perform must be apparent from the fact that the osmotic pressure of the urine is three times greater than that of the blood. Clinical experience has distinctly shown that milk ought to form a fair proportion of the dietary, and that alcohol should be forbidden.

Some authorities recommend a diminished intake of water. The reasons given are that the fluid increases the blood pressure and throws extra work upon the kidneys. It is difficult to conceive, however, how a few ounces of fluid gradually added to 5½ kilogrammes of

[1] "Physiological Economy in Nutrition."

blood circulating in vessels, whose calibre even in this affection varies considerably, can appreciably affect the blood pressure. If it does, it is merely a slight and temporary effect. The extra work in excreting this fluid is almost exclusively confined to the glomeruli, and is more than counterbalanced by the elimination of metabolic products which may have an injurious effect on the vascular and other systems.

DISEASES OF THE RESPIRATORY SYSTEM

In the treatment of certain affections of the respiratory tract the climate and waters of Harrogate are decidedly beneficial.

Naso-pharyngeal catarrh in children and the chronic catarrhal throat of the gouty undergoes improvement on the exhibition of the Mild or Strong Sulphur waters, together with nasal douching with a normal saline water like the Crescent Spring, or an alkaline water as the Beckwith or Starbeck. In **Bronchial catarrh** and chronic bronchitis in gouty subjects the sulphur waters have a distinct effect in promoting expectoration and lessening cough. Mucus is rendered less tenacious by the alkali of the water, and the sulphur may exert an antiseptic action in course of its elimination through the respiratory tract. The dry, stimulating climate by increasing oxidation has a favourable influence on catarrhal conditions of the respiratory tract, not only in the young but also in the elderly, especially during the summer months.

CHRONIC UTERINE AND OVARIAN DISEASES

The affections amenable to Spa treatment are: (1) chronic cervical catarrh; (2) chronic endometritis; (3) subinvolution of the uterus; (4) chronic pelvic cellulitis; (5) chronic ovaritis.

Menorrhagia and dysmenorrhœa are symptoms of most of these disorders. In *endometritis* and *subinvolution* of the uterus, curetting is unquestionably the best form of treatment, but some patients dread an operation and decline to be curetted if they can be cured by any other means. Even after curetting, a course of baths is sometimes advisable.

The first consideration in treating these cases is the general condition of the patient, as gastro-intestinal disturbance and neurotic symptoms are often prominent in uterine and ovarian disease. When the digestive irregularities are rectified and the general health is placed on a satisfactory basis it is remarkable how the local condition improves without any topical applications.

The general treatment consists in the administration of Strong Sulphur water at first to correct any disorder of the stomach, and, subsequently, a tonic water in combination with massage of the whole body, excepting the abdomen, plenty of fresh air and a moderate amount of exercise. During the periods patients should lie on a couch close to the open window in fine weather, draughts being avoided; or a few hours may be spent in a bath chair after the second day.

In *chronic cervical catarrh* and *chronic ovaritis* abdominal packs, followed by the needle douche, are useful in relieving tenderness or pain. Systematic vaginal douching is not necessary in these cases; in fact, cases of ovaritis improve more rapidly without it.

The three remaining affections may be considered together, as the local treatment is very similar. Vaginal douching is beneficial, but the fluid should flow into the vagina at a very low pressure, and the temperature of the water should not be under 99° F. To aid the absorption of effused products in the pelvis, peat baths are of distinct service. When the inflammatory exudation is absorbed and the uterus regains its normal size more stimulating baths may be prescribed, such as the Scotch douche, electric baths, sinusoidal or galvanic, and the Schwalbach bath.

Chronic Alcoholism

The essential point in the treatment of chronic alcoholism is, of course, to stop the alcohol. This done, there is no more efficacious method of removing its effects, provided they are limited to functional disturbances, than a course of Old Sulphur water, liver packs, and massage douches. Local evidences of toxic irritation —gastritis, congested liver, albuminuria—clear up in a satisfactory way by these means. Even if organic disease be present some good may be done in the early stages—for example, in cirrhosis of the liver. Change of environment, plenty of fresh air and moderate exercise, aid in the cure, serving to occupy the mind and brace up the physical and mental powers for the subsequent struggle against relapse which must inevitably come. Success is often achieved by the patient after such a course, and permanent abstinence or temperance ensues. Where the habit of drinking freely is too deeply rooted the benefit is merely temporary.

Diabetes

Normal urine contains a minute quantity of grape sugar, about 0·06 per cent. In some persons after the ingestion of an excessive quantity of carbohydrate, sugar may appear temporarily in the urine, these cases being termed alimentary glycosuria.

One function of the liver is to convert the sugar conveyed to it by the portal blood into glycogen, which is stored in this organ and in the muscles as a nutritive agent for future use in the production of energy. Pavy holds the view that the liver normally prevents sugar getting into the blood and eventually converts it into fat. Bernard maintained that the liver re-converted glycogen into sugar and passed it on to the blood as the needs of the organism demanded. Whichever view is correct, the fact remains that the blood does contain a small quantity of sugar, about 0·01 per cent.; in diabetes it may reach 0·5 per cent.

In spite of the most laborious researches the pathology of this affection has scarcely passed beyond the stage of speculation. It has been shown by Minkowski and others that total extirpation of the pancreas is followed by diabetes mellitus, but if a small portion of the organ be left, or ingrafted in the abdominal wall, sugar is absent from the urine; if this portion be subsequently excised, sugar appears in the urine. The pancreatic variety only represents a small proportion of the cases of diabetes.

Cases of diabetes may be divided into three groups: (1) slight cases, (2) moderately severe cases, and (3) acute cases occurring in young people. In the first group, if carbohydrate be withheld the sugar may almost entirely or completely disappear from the urine. These cases are generally gouty in origin, and are considered under that affection. In the second group, notwithstanding the exclusion of carbohydrate from the dietary, sugar is still present in the urine, although the symptoms are considerably modified by dietetic and other treatment. The third group pursues a downward course despite all medication.

In the treatment of diabetes, diet is the first consideration. If carbohydrate be absolutely excluded, the urine should be carefully watched for the presence of diacetic acid, as this substance is the danger-signal of diabetic coma. If diacetic acid appears in the urine, the diet should be modified—otherwise it may be continued for a month or so, after which a little relaxation is permissible.

The efficacy of alkaline mineral waters in the treatment of this affection appears to be established. Their mode of action is purely conjectural. The Beckwith or Harlow Car waters taken three times a day have a beneficial effect. Light massage or moderate exercise is also of service.

Syphilis

For the treatment of early syphilis exceptional facilities are offered. The sulphur waters being closely allied in chemical composition to those of Aix-la-Chapelle, a course of mercurial inunction can be carried out equally well at Harrogate as at that place. Incidentally the stigma which unhappily attaches to Aix in connection with syphilis may be avoided by undergoing the course at Harrogate, for so many different diseases are sent there for treatment that no suspicion can be aroused as to the nature of the ailment.

There can be no doubt that by the inunction of mercury concurrently with a course of sulphur waters and baths more of the metal can be introduced into the body without giving rise to salivation than can be done by inunction alone without these auxiliaries. The explanation of this fact is as follows: in the first place prolonged soaking in sulphur water prior to inunction favours the absorption of the drug, and in the second place the active elimination induced by waters and baths favours its rapid excretion from the body. By a suitable adjustment of the dose a continuous circulation of mercury can be maintained and the tissues kept in a state approaching saturation. Excretion, however, keeps pace with absorption, and the risk of an overdose and consequent salivation is reduced. With the help of eliminatory measures of this kind the patient can be kept more fully under the influence of mercury, and for a much longer time, than by ordinary methods—a matter of manifest importance in the treatment of this disease. Further, many cases which are more or less intolerant of mercury under ordinary circumstances will bear it perfectly well under these conditions.

Obesity

The excessive deposition of adipose tissue may be due either to an abnormal production or a diminished utilisation of fat. In connection with the first of these, fat formation is chiefly linked with the assimilation of carbohydrate. As regards the second, fat is largely a source of heat, and bulks proportionately in the dietary of very cold countries. This fact is important as indicating measures whereby the consumption of fat may be accelerated, namely, by increasing the loss of heat from the surface of the body. Each case of obesity should be treated on its merits: it should be borne in mind that in some many of the organs are functionally disordered and organic disease may be present.

The essential elements in treatment are the restriction of the carbohydrate and fatty food materials, regulation of exercise, and an outdoor existence if possible. Any tendency to anæmia must also be met. The acceleration of heat loss can be brought about by the use of light clothing, cool and well-ventilated rooms, and moderately warm baths (80° to 90° F.). It is generally advisable to begin with massage unless the degree of obesity be slight, but later on the patient must be induced to take sufficient exercise. The bowels should be well cleared out every morning by the Strong Sulphur water, but if there is anæmia an iron water with an aperient should be substituted.

The breathing in obese persons is generally shallow. This fact taken in conjunction with the diminution in the size of the lungs observed post-mortem suggests the advisability of respiratory exercises.

The d'Arsonval current applied daily aids in the reduction of weight, the modification that is most effective being the effleuve to the abdomen. If the diet be too restricted unpleasant consequences may occur. The criterion of successful treatment is an improvement in the general health coincidently with a steady loss of weight, which should average about two to three pounds a week.

Malaria

Residents in malarious districts come in considerable numbers to Harrogate, more especially from India and the West Coast of Africa, to recruit from the effects of successive attacks of fever. Early cases without marked organic changes do well and rapidly regain their health. Cases presenting the malarial cachexia, with enlarged liver and spleen, anæmia and loss of flesh, usually derive some benefit from a suitable course of waters and baths. We have seen the enlarged organs markedly reduced in size, the anæmia improved, and the general health to a great extent restored by even a few weeks' treatment. Repetition of the course at moderate intervals leads to further improvement and may secure for the sufferers a state of comparative health and enable them to resume their duties abroad.

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