ON THE
THERAPEUTIC FORCES
DR. MAYS

R. T. Edes.

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THERAPEUTIC FORCES:

AN EFFORT

TO CONSIDER THE ACTION OF MEDICINES IN THE LIGHT OF THE MODERN DOCTRINE OF THE CONSERVATION OF FORCE.

BY THOMAS J. MAYS, M.D.,

MEMBER OF THE LUZERNE COUNTY MEDICAL SOCIETY; MEMBER OF THE PENNSYLVANIA MEDICAL SOCIETY, ETC.

"Perfect knowledge of the action of medicines can only be obtained when the action of each force in each medicine upon each force in each texture of the body can be estimated."—H. BENCE JONES, *Pathology and Therapeutics*, p. 275.

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PREFACE.

HAVING firmly espoused the belief that the action of medicines in the animal body is, like everything else, amenable to unchanging laws, and that it is our duty to unravel and elucidate these laws, I endeavor in the following essay to give a brief and incomplete outline of the principles which underlie the action of some of our most important therapeutic agents in the light of the modern doctrine of the conservation or persistence of force. I think, from the present standpoint of physical science, we have great reason for believing that every phenomenon in nature must be viewed as the effect of force, and can only be interpreted intelligibly when reduced to the terms of the latter, and I further think that the claims of therapeutics, as being a part of the grand chain of natural phenomena, are just as legitimate as those of physiology or any of the other concrete sciences.

But such views will at once be denounced as being "too theoretic" by many of the so-called practical men of the day, who hold that the action of medicines is governed by more or less capriciousness, and can never be referred to or formulated into any precise law or principle. Notwithstanding the prevalence of this opinion among the profession, I believe that one of the fundamental principles in the successful practice of medicine is well-grounded theory, and even those to whom the term theory conveys an unpleasant odor are daily guilty of indulging in the very thing they stigmatize, and, in fact, cannot escape it if they think at all for themselves. For the crudest empiric bleeds to relieve the blood pressure of an inflamed part, administers cathartics to cool the body, and gives quinia to diminish fever temperature. To theorize is to think—is to give a reason for our actions, and when a medical man treats a patient he is presumed to have at least some idea or theory of the action of the medicine which he introduces, as well as the disease which he is striving to combat, or otherwise it is blind practice.

The chief aim of the physician is to alleviate and remedy human suffering, and his success in accomplishing this noble end will depend directly on a true knowledge of the laws of therapeutics; and if this small volume will advance such knowledge to even the slightest appreciable degree, I shall feel more than rewarded.

In conclusion I will add, not, however, for the purpose of evading criticism, that this paper was originally intended for a journal article; and had not its size precluded its publication as such, it would not have appeared in its present form.

UPPER LEHIGH, PA., April 11th, 1878.

CONTENTS.

THERAPEUTIC FORCES.

CHAPTER I.

INTRODUCTION.

EVERY phenomenon in nature can be measured in terms of force, for matter at rest is chiefly known to us by the amount of resistance which it offers to units of force, or of gravitation, and matter in motion represents the amount of force which maintains its motion. This holds true in physics, in chemistry, and in every other department of science. The clockmaker knows that the tension of the spring in the watch, and the weight in the clock, represent so many units of force, which are capable of setting the machinery of these instruments in motion, and keep it running for a certain length of time. The engineer is aware of the fact that a certain amount of coal contains a certain amount of latent chemical force, which, when liberated in the process of oxidation or combustion, will enable him to drive his engine for a certain length of time and distance. Indeed, were this law not so constant and so universal, chaos and uncertainty would prevail on every side, and life would be impossible. And whatever is true of inanimate matter also holds true of that which enters into the constitution and composition of the animal frame, for the latter likewise takes in from the outside a certain amount of food, representing a certain amount of chemical energy, through the liberation of which it is enabled to maintain its nervous, muscular, assimilative, and other forces in a physiological state. We must not, however, overlook the fact that not all the matter which enters the body is destined for force production, but some is also necessary for tissue construction. Force only manifests itself through matter, hence the latter is just as essential to the body as the former; yet here, like everywhere else, matter plays but a secondary part to force; for the ultimate aim of the body is power to transform and utilize force, and matter is only the instrument through which this can be accomplished.

Every piece of mechanism, then, no matter how simple or how complicated, must have two requirements fulfilled in order to operate it successfully; (1), it must receive a supply of material with which to build up and renew its structures, and (2), a supply of force to give it motion. Now the animal body is a machine of the highest and most complex order, and it is likewise subservient to these immutable laws. It derives its constructive or building material from the nitrogenous and inorganic foods, while its motor power chiefly comes, as we shall see, from the non-nitrogenous foods.

A great deal has been said in regard to the proper relation which the nitrogenous and non-nitrogenous foods hold to the vital activities of the body. Liebig held that all muscular force emanated from a disintegration and consumption of muscular tissue, and thus indirectly from the nitrogenous foods; but, since then, Traube and others were led to express views directly opposite to that of Liebig.

Now it is evident that if muscular action depends on the destruction of muscular or nitrogenous tissue for its moving force, then the waste which proceeds or results from such disassimilation must be proportionate to the amount of muscular work performed. With a view of ascertaining the truth or falsity of such a theory, Professors Fick and Wislicenus decided to put it to an experimental test. They determined to ascend the Faulhorn, a mountain of known height, collect their urine during the undertaking (since it is almost universally admitted that nearly the whole nitrogen waste of the body is eliminated by the kidneys), and estimate the amount of albuminous material thus destroyed in the body.

In order to make the experiment as simple as possible, they confined themselves almost exclusively to a non-nitrogenous diet, such as starch and fat in the form of cakes, sugar, beer, and wine. They divided the time during which the collection of urine took place into four periods. Six hours after the commencement of their non-nitrogenous diet they began to collect their urine, and all of that which was collected previous to the beginning of the ascent was called "before work" urine; that which was collected during the ascent "work urine;" that after the ascent was completed, "after work" urine; and the urine collected during the succeeding night, which was spent on the Faulhorn, when they took a bountiful meal of nitrogenous food, was called "night urine." They estimated both the quantity of urea and the absolute amount of nitrogen contained with the following results for the several periods. (For our present purpose it is enough to give only the amount of nitrogen waste.)

*Quantity of Nitrogen Excreted per Hour.**

	Fick. Grams.	Wislicenus. Grams.
Before work, ...	0.63	0.61
During work, ...	0.41	0.39
After work, ...	0.40	0.40
Night, ...	0.45	0.51

These results clearly show that the quantity of nitrogen waste is totally inadequate to account for the amount of labor which was performed by these two experimenters; in fact, the quantity of nitrogen eliminated during the time in which the ascent was made, diminished instead of being increased, as it should

* Pavy, Food and Dietetics, p. 59.

have done were it true that muscular work depends on the disintegration of muscular tissue for a supply of motor force. Similar conclusions have been reached by the late Professor Parkes, and by other distinguished investigators, and even Liebig himself acknowledged that he had made erroneous deductions on this question.

In 1870 Professor Austin Flint, Jr., made an elaborate investigation on this subject, full details and description of which were published in the *New York Medical Journal,* and from which he thinks he is justified in giving credence to the theory that muscular work results from muscular disintegration. Quite recently* he has reiterated this opinion at great length, in which he compares his observations with those of Dr. Pavy, made in 1876; but from a careful consideration of the true meaning of his facts and figures, taken in connection with most important factors, which he regards as insignificant in the process of muscular action, I candidly believe that his conclusions are altogether unwarranted.

It may therefore be looked upon as settled, which will become still more evident as we pass along, that the nitrogenous foods do not chiefly furnish the force with which the body is kept in motion, and from the general principle which we laid down at the outset of this paper we must conclude that if this is not their proper function, they must contribute material for

* The Journal of Anatomy and Physiology, October, 1877.

building up the living structure of the body, and this we shall find is confirmed by evidence of trustworthy character. Similarly we must also conclude that the non-nitrogenous foods principally serve to supply the force which keeps the animal body in motion. This is no more than what we might have anticipated from a knowledge of the general operations of nature, and especially since it is well established that the greatest part of the force which is manifested by the body is the effect of oxidation, for wherever we find oxygen combining free in nature it is always with that element for which it has the greatest affinity. And to assert that the muscular force of the body comes from the oxidation of nitrogenous material, as the Liebigian followers hold, is to say that oxygen combines less readily with carbon and hydrogen than it does with nitrogen, while the truth is that it has a much more powerful affinity for the two former elements than it has for the latter, and this appears particularly preposterous when we consider that no other element, perhaps, shows a greater chemical indifference than nitrogen. So, then, without much experimental evidence to confirm the above view, common sense would almost indicate that the chemical force of the body is derived in great part from the same source, as it is exterior to the body, viz.: from oxidation of carbon and hydrogen. This view, that the force which is exerted by the body is chiefly derived from the oxidation of carbon and hydrogen has been held by Lehman, Vierordt, H. Hoffman, and others.

If this is true, then, it must necessarily follow that carbonic acid and water must increase in proportion to the amount of force or work expended by the body. On this point Dr. Pavy, in his able work on *Foods and Dietetics*, p. 107, says: "Dr. Edward Smith, in the *Philosophical Transactions* for 1859, has given the results of an extensive series of experiments upon the elimination of carbonic acid under various conditions. They were mostly practiced upon himself, and carried out with zealous self-denial. A mask was closely fitted to the face, and a tube passing off from it conducted the expired air to an apparatus in which the carbonic acid was abstracted and absorbed by means of potash, and afterwards estimated by weighing. The amounts of carbonic acid exhaled by Dr. Smith, under varying conditions of exertion, stood as follows:

	Carbonic acid exhaled per minute, in grains.
During sleep, ...	4 99
Lying down and almost asleep (average of three observations), ...	5.91
Walking at the rate of two miles an hour, .	18 10
Walking at the rate of three miles an hour, .	25 83
Working at the treadmill, ascending at the rate of 28 65 feet per minute (average of three observations), ...	44.97

"Dr. Smith's results are drawn from the carbonic acid exhaled during limited periods of time. Pettenkofer, assisted by Voit, has instituted experiments whereby the observation extended through a period consisting of many hours. An air-tight chamber, sufficiently large to enable a man to live, move about, and sleep in, was provided. To this was adapted an arrangement for maintaining an ingress and egress of air, and for diverting a definite proportion of the latter for the purpose of analysis, in order that the amount of carbonic acid escaping might be determined. In this chamber, upon one occasion, July 31st, 1866, a watchmaker remained for twenty-four hours, passing a day of rest; that is, he occupied himself only so far as not to feel dull, reading newspapers and a novel, and repairing and cleaning a watch, which he had taken with him into the chamber. He went to bed at 8 P.M., and slept until 5 A.M., when he was aroused by some one on the outside. Three days later the same man entered the chamber and passed a day of work, the work consisting of turning a wheel with a weight attached to it. Rest and meals were taken at the periods usual with workmen, and the work was stopped at 5.30 P.M. The food taken was exactly the same as on the day of rest, but 600 grammes more water, which had been allowed *ad libitum* on both days, were consumed. The quantities of carbonic acid and urea eliminated are shown by the subjoined figures:

Day of Rest.

	Carbonic acid.	Urea.
6 A.M. to 6 P.M., .	532.9 grams, . . .	21.7 grams.
6 P.M. to 6 A.M., .	378.6 " . . .	15.5 "
Total, .	911.5	37.2

Day of Work.

	Carbonic acid.	Urea.
6 A.M. to 6 P.M., .	884.6 grams, . . .	20.1 grams.
6 P.M. to 6 A.M., .	399.6 " . . .	16.9 "
Total, .	1184.2	37.0

"It will be noticed from the above results that no effect was produced upon the elimination of urea. The food consumed was, as mentioned, similar on the two days, and, in accordance with this fact, there was a close agreement in the respective amounts of urea voided. The carbonic acid discharged during the actual period of work greatly exceeded that discharged during the corresponding period of rest. During the two night periods, when similar conditions prevailed, no material difference in the amount of carbonic acid was perceptible. The quantities, of course, represented the exhalation from both the lungs and the cutaneous surface."

I might go on and give other evidence to substantiate this view, but for our present purpose we deem it unnecessary, inasmuch as the question seems a very obvious one. However, I do not wish to be understood as saying that the nitrogenous foods are exclusive tissue-builders, and take no part as force-producers, for this would be a manifest error. It is pretty generally acceded that nearly all the nitrogen of the body escapes under the form of urea, and in thus making its exit carries with it other elements of the albuminous compounds, and leaves others behind to be disposed in a different way. Pavy, in his work above cited, on page 86, while treating of this subject, says that "the residual portion of an albuminous compound, after the separation of the nitrogen with the necessary quantities of the other elements to form urea, amounts, as has already been shown, to 66.80 per cent. of the whole. This consists of 46.86 parts of carbon, 4.79 of hydrogen, and 13.15 of oxygen, with small quantities of sulphur and phosphorus, which, in reference to the point now about to be discussed, viz., the application of this portion to force-production, may be left out of the question. It will be seen that we have here to deal with a considerable surplus of carbon and hydrogen, which represents latent force.

"The 13.15 parts of oxygen will appropriate 1.64 parts of the hydrogen to exhaust its oxidizing capacity in combination as water. Reckoning this amount of hydrogen, then, as appropriated by the oxygen present, we shall have 3.15 parts of hydrogen and 46.86 parts of carbon in a free state for undergoing oxidation.

"It thus appears, if we take away the nitrogen and the elements it carries off as urea, and also abstract from the hydrogen the amount which the residual oxygen would oxidize, that from 100 parts of albumen there remain 46.86 parts of carbon and 3.15 parts of hydrogen free to undergo chemical combination with oxygen supplied from without. These quantities of carbon and hydrogen will require, for their conversion into carbonic acid and water, 150 parts of oxygen, and this is tantamount to saying, according to the calculation given, that 100 parts of albumen will be capable of consuming this quantity of oxygen in undergoing oxidation. As the force produced is in proportion to the amount of chemical action, we may measure the value of different articles for force-production by the amount of oxygen they will relatively consume in undergoing complete oxidation. Regarded in this light, albumen stands in the following position in relation to grape sugar (anhydrous $C_{12}H_{12}O_{12}$ $[C_6H_{12}O_6]$), starch, and fat:

	Amount of oxygen appropriated in oxidizing 100 parts as consumed within the body.
Grape sugar (anhydrous), ...	106
Starch, ...	120
Albumen, ...	150
Fat, ...	293

"Thus, as a force-producing agent, if we are right in taking capacity for oxidation as a measure, albumen has about half the value of fat, and a greater value than both sugar and starch."

Thus, then, we see that the actual force-value of the albuminous substances is comparatively high; that they contain a large amount of latent energy in the form of carbon and hydrogen; but we must not lose sight of the fact that these substances or elements are essential to preserve the integrity of the albuminous molecule, and hence are locked up, and are not so readily oxidized as the hydrocarbons which are introduced from without. So we cannot look upon muscular force as emanating from the oxidation of the carbon and hydrogen existing in the albuminous tissues, for if this were true, then the nitrogen in these tissues would also be broken down with similar rapidity, and appear in the excretions, but the experiments of Fick and Wislicenus, and of Pettenkofer and Voit decidedly show that but a very small increase of the nitrogen waste takes place during bodily exercise, altogether insufficient to account for the amount of work given out.

Taking for granted, then, the position that, generally speaking, the nitrogenous foods are tissue-builders, and the non-nitrogenous foods force-producers, and in doing this we reduce our subject to the terms of matter and force. (The inorganic foods, which are capable of performing both functions, will be discussed in their appropriate places.) We have here, then, matter with which to build up a machine, as well as matter which has the power of giving impelling force to it. And that it is necessary for the animal machine to have a source from whence it derives its motive power is evident from the fact that it is the invariable tendency of all matter, organic as well as inorganic, to come to a state of rest. Such a state is effected by the influence of gravitation.

But, on the other hand, it is in virtue of this very same law of gravity that all motion, whether animate or inanimate, is produced. Of this we have many confirmatory illustrations. For example, it is the gravity of the water which sets the wheel of the mill in motion ; it is the gravity of the weight which gives motion to the clock ; and it is the attraction or the gravitation which exists between the atoms of carbon and those of hydrogen on the one hand, and those of oxygen on the other which causes them to clash and unite, giving out and transmitting their motion to the molecules of water in the steam-boiler, which, on receiving an additional amount of motion, tend to occupy more space, produce pressure on the piston or driving-rod, and set the fly-wheel of the engine in motion. And in the animal body we have great reason to believe that it is the same as in the steam-engine,—that the intense affinity or attraction which exists between the oxygen and the non-nitrogenous foods confers upon it the power of locomotion.

Nor is the power of receiving motion the only physiologic function which the organic structures possess, for they also have the power of acquiring potential or latent energy. And this is what becomes of a great part of the energy which is liberated through the oxidation of the non-nitrogenous foods in the body. These substances when burned up exterior to the body, give out all their force in the form of heat, but when they are taken into the body, and assimilated and oxidized there, hardly any appreciable rise in the temperature of the body takes place, at least not such an elevation of temperature as would take place if the stored-up energy of the hydrocarbons were directly transformed into sensible heat; hence we must believe that the heat which is liberated in the process of bodily combustion is appropriated to a different purpose than that of elevating the animal temperature. This is precisely in accord with our knowledge and experience of the behavior of physical substances under the influence of heat. For let us suppose that to a steam-boiler containing ice and a thermometer, incessant heat is applied. The column of mercury in the thermometer will not rise above 32° until the last particle of ice is melted, in spite of the heat which is constantly communicated to the ice and water. It is clear that the ice is impressed by the heat, for it melts—it is changing its condition, and this is proof that it is receiving additional momentum. Now the question arises as to what becomes of the heat which is communicated to the contents of the boiler, and of which the thermometer does not give the least indication? This is answered very concisely and clearly by Prof. Tyndall, in his work on *Heat as a Mode of Motion*, page 126, who, on speaking of this subject, says, "Suppose a certain amount of heat to be imparted to this lump of lead, how is that heat disposed of within that substance? It is applied to two distinct purposes; it performs two different kinds of work. One portion of it excites that species of motion which augments the temperature of the lead, and which is sensible to the thermometer; but another portion of it goes to force the atoms of lead into new positions, and this portion *is lost as heat*. . . . The atoms are pushed apart, but during their recession, they vibrate with gradually augmented intensity. Thus the heat communicated to the lead resolves itself, in part, into atomic potential energy, and in part into actual energy, which may be regarded as a kind of atomic music, the musical part alone being competent to act upon our thermometers or to affect our nerves.

"In this case, then, the heat not only imparts actual energy to the vibrating atoms, but also accomplishes what we may call *interior work;* it performs work within the body heated, by forcing its particles to take up new positions. When the body cools, the forces which were overcome in the process of heating come into play, the heat which was consumed in the recession of the atoms being restored upon their approach."

Now muscle, same as every other compound body, is molecular in its elementary structure, and let us for one moment conceive that these muscular molecules behave in a manner somewhat analogous to those of the water in the steam-boiler, or to those of the lead; that they are likewise capable of receiving a greater degree of motion from that store which is generated by the chemical union of carbon and hydrogen and oxygen; that in like manner they are separated, their mutual attractions partly overcome, and their tension increased. It is obvious, therefore, that molecules under such circumstances would bear a relation similar to each other, as does the weight of the clock to the earth, or to the water which is able to set the wheel in motion to the earth, and that the power to produce motion by their mutual attractions would thus be greatly enhanced ; and that if the motion which these molecules exert in their recessions can be properly utilized by the muscle, then these organs are capable of giving out a large amount of massive motion. Or, again, let us assume that massive motion is brought about by muscle in the same way as it is in the steam-boiler, viz., *by molecular pressure*, the principle still remains unaffected, for it matters not whether massive motion is produced by molecular affinity or by molecular pressure, it is nevertheless imperative that before motion is possible in either way the molecules should have their motion accelerated, and their tension increased. Now I believe that the enormous amount of energy which is constantly developed by the oxidation of the non-nitrogenous foods within the body endows the organic molecules with a vast amount of potential energy, which they expend as actual energy in performing the various functions of the body. This is the reason why it is that the force which is liberated through oxidation of the non-nitrogenous substances in the body does not manifest its energy in the form of sensible heat, same as it does when they are burned outside of the body, for it performs " interior work " in the shape of forcing the bodily molecules into working positions, and the heat which is employed in work of such a nature cannot be sensible to the thermometer.

CHAPTER II.

GENERAL LAW OF THE ACTION OF FORCES ON THE ANIMAL BODY.

THE foregoing rather lengthy digression is necessary to fully demonstrate the fact that there is a complete and distinct difference between those substances which supply working force to the body, and those which supply material to renew its structures; that one cannot permanently supplant the place and function of the other, and that the substances which confer force on the body in this manner, do so by increasing the tension or motion of the bodily molecules. The constructive agents, however, which naturally comprise all the nitrogenous as well as some inorganic foods, do not strictly fall within the scope of this essay, and I shall, therefore, confine myself strictly to the consideration of some of those forces or agents which tend to modify the molecular activity of the body.

Now a force can only be known by its effects on matter, or by the amount of motion it produces. Two forces moving in the same or parallel direction will enhance and intensify each other's movement, and two forces of unequal strength moving in opposite directions will produce motion in the line of the stronger force. This is the result of a primordial law in nature, according to which motion takes place in the line of least resistance.* From this law it necessarily follows that our therapeutic forces, when viewed from the standpoint of life, can be divided into two great classes, viz., those which move in harmony with the vital forces, and those which move in antagonism to them. Thus, for example, when a weak, emaciated, and debilitated subject regains his former weight, strength, temperature, and appetite, under the judicious use of cod-liver oil, we must necessarily conclude that the effects produced by this agent are in harmony with the vital forces, since such effects are the attributes of health; but when, on the other hand, we find that exposure of the body to a very low degree of cold will inhibit its processes of oxidation and nutrition, depress its temperature, and in a very short time cause death, we must with equal reason, conclude that such effects are antagonistic to the vital forces.

We have already indicated one method by which the momentum of the organic molecules can be accelerated, viz., by the oxidation of the non-nitrogenous foods—and in fact all substances which undergo oxidation in the body possess this power; but this is by no means the only way in which molecular motion of the

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* Motion takes place in the line of least resistance, or of greatest traction, or in a line which is a resultant of the two; but I think the first will be sufficient to illustrate, at least, in a crude manner, the action of forces on the body.—AUTHOR.

body can be increased, for the application of friction to any part of the body will also induce accelerated molecular motion, and we shall treat of substances further on which have the undoubted efficacy of increasing molecular motion in this manner, without undergoing any necessary chemical transformation themselves; hence we at once see that molecular activity of the body can be accelerated both by chemical and mechanical stimulants or forces, which are governed by the laws of motion in their action on the body.

Stimulation, however, is a term which is not to be confounded with that of irritation, for these are two distinct and different steps of the same process, the one physiological, and the other pathological. When, for example, slight and gentle friction is applied to the body, the molecular activity of that part can be immediately aroused to its utmost physiologic capacity, and this procedure, as is well known, is a most powerful and valuable adjuvant in the treatment of disease, notably so in that of chronic diseases. But when the friction is carried to excess, as in the case of the palmar surface of the laborer's hands, where large blisters occasionally form in consequence of the handling of tools, the process assumes a pathological phase, and can no longer be considered as being within the limits of health. Now these two widely different phenomena are the result of a process which is exactly the same in kind, differing only in degree. The organic molecular activity is accelerated in both instances, but since rapidity of molecular motion of the body and health are not synonymous, there must naturally be a point where this activity can be pushed over the bounds of health into those of disease. And this is the line of discrimination which I wish to draw, and think ought to be drawn, between the action of stimulants and the action of irritants, the former always tending towards health, and the latter invariably towards disease.

CHAPTER III.

CHEMICAL STIMULANTS.

I WILL in the first place, then, discuss the action of the *chemical stimulants*, but before doing so I would add that any force or agent which has the power of enhancing molecular activity of the body, either chemically or mechanically, will also, in a great measure, enhance its nutrition, for increased molecular activity implies wear and tear of the tissues, and increased waste implies increased repair and active blood flow.

HYDROCARBONS.

Fat and Oil.—Although fats are a constituent part of the animal body, it cannot be said that they are organized into regular tissue which is fit to perform actual work, but fat must be looked upon as being a deposit which holds some very important physiological relations to the body; a conservator of animal warmth, and a storehouse of energy. However, not all the fat which enters the body behaves in this manner, but under certain conditions it may give out its motion without being first deposited.

As regards the digestion of fat, it does not undergo much if any change in the mouth or stomach, but as soon as it enters the small intestines it is emulsified by the pancreatic juice, aided, probably, by the bile, and by the secretion of Brunner's glands. In this form it is taken up by the lacteals, and introduced directly into the general circulation. All other alimentary substances are absorbed by the portal circulation, and before they are fitted to enter the general blood-current must pass through a special preparatory organ, the liver.

Now all fats and oils have entering into their constitution but a very small percentage of oxygen, and it is a law of chemistry that the capacity for force-production in any substance is in proportion to the absence of oxygen in its composition—is in proportion to the amount of oxidizable material which it possesses; and since fats only contain about ten per cent. of oxygen, and the remainder consisting of carbon and hydrogen—seventy-nine per cent. of the former and eleven per cent. of the latter—it is evident that they possess a power for force-production which is unequalled by any other alimentary substances. According to Professor Frankland, the oxidation of one gram (15.432 grs.) of fat generates force sufficient to lift 27,778 pounds one foot high. And we have no reason to disbelieve that the same amount of fat when oxidized within the body will give rise to the same amount of force, and the quantity of energy which is thus set free by this one substance alone is almost inconceivable, and at once demonstrates the superiority of fats and oils over nitrogenous foods, as stimulants or force-producers—hence, as an article of diet in health and in disease, they cannot be overestimated.

Another reason why the hydrocarbons or the carbohydrates are better adapted for force-production in the body than the nitrogenous substances, is that they are wholly oxidized, while the latter are only partially and imperfectly used up in the body: the nitrogen making its exit under the form of urea, which retains about one-seventh of the force which originally existed in the nitrogenous compound. Were it true that the animal body derived its force from the oxidation of its nitrogenous tissue, it might be looked upon as being exceedingly profligate in wasting such a large share of its force-producing material.

The following table* of Professor Frankland clearly shows the relative force-producing value of our principal articles of diet:

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* See Pavy, Food and Dietetics, page 416.

Force-producing Value of One Gram (15.432 *grains*) *of Various Articles of Food* (*Frankland*).

NAME OF FOOD.	Per cent. of water present.	FORCE-PRODUCING VALUE.		
		In units of heat.	In kilogrammeters of force.	
			When burnt in oxygen.	When oxidized in the body.
Cod-liver oil, ...		9107	3857	3857
Beef-fat, ...		9069	3841	3841
Butter, ...		7264	3077	3077
Cheese (Cheshire), . . .	24.0	4647	1969	1846
Oatmeal, ...		4004	1696	1665
Flour, ...		3936	1669	1627
Arrowroot, ...		3912	1657	1657
Ground rice, ...		3813	1615	1591
Yolk of egg, ...	47.0	3423	1449	1400
Grape sugar (commercial).		3277	1388	1388
Ham, lean (boiled), . . .	54.4	1980	839	711
Beef (lean), ...	70.5	1567	664	604
Veal (lean), ...	70.9	1314	556	496
Potatoes, ...	73.0	1013	429	422
White of egg, ...	86.3	671	284	244
Milk, ...	87.0	662	280	266

It will be seen by this table that cod-liver oil stands at the head of the list of force-producing foods, next beef-fat, and then butter, which comprises the most important substances of the hydrocarbon group; while the pure nitrogenous foods, as beef, etc., rank very low as such; however, before we allude to the therapeutic applications of fats and oils, we shall carefully discuss the physiological action of their congeners—the carbohydrates—at least that of the principal ones.

CARBOHYDRATES.

Starch.—Starch is a very important ingredient in nearly all vegetable products, and on this account it becomes one of our principal alimentary substances. It is unfit for absorption by the alimentary canal until it is changed into dextrin, and finally into sugar, under the influence of the saliva, the pancreatic juice, and the secretion of the intestinal glands.

Cane Sugar.—Cane sugar, like starch, is also of vegetable origin, and is largely employed as an article of diet. It is, however, pretty well ascertained that it is changed into grape sugar before it enters the general circulation.

Grape Sugar.—This form of sugar exists in the juices of many vegetable products, and is, perhaps, the most important among the group of carbohydrates in an alimentary point of view. It is a very diffusible substance, and hence is readily absorbed and assimilated. In a chemical sense it may be called the lowest of the neutral carbohydrates, and they all manifest a tendency to change into this form of sugar. Of all the carbohydrates this seems to be the most oxidizable kind.

We have already observed that the carbohydrates, unlike the hydrocarbons, are taken up by the portal circulation and carried to the liver, where they undoubtedly are subjected to other modifying influences before they enter the blood. But the question here arises, whether the carbohydrates are destined to become oxidized in the blood and tissues, and expend their energy in this shape, or whether they are changed into another substance before the body is capable of oxidizing them and utilizing their force. Upon this point a difference of opinion seems to prevail among noted and thoughtful physiologists, some holding that sugar is oxidizable by the body, while others, among whom are Pavy, Persoz, Boussingault, Lawes, and Gilbert, incline to the belief that they are previously transformed into fat by the body before they are fit for oxidation.

Whether the carbohydrates are transformed into hydrocarbons or not before their force is liberated, does not affect their final destination or utility to a very marked degree, for it does not diminish their force which they possess already. Indeed, if they are thus changed, they have conferred on themselves an extra amount of energy, for the hydrocarbons are superior to the carbohydrates as force-producers, from the fact that they contain a less quantity of oxygen; hence, in order to transform the latter into the former, they must be deprived of a certain amount of oxygen which they possess. To say, however, that the animal body is qualified to effect such a change as this is to accord to it a power which is thought to belong exclusively to the vegetable kingdom, for the animal body is looked upon as being the great oxidizing agent, while vegetation is believed to be the instrument of deoxidation. It is now a well-established fact, which was noted by Priestley in the last century, that plants under the influence of sunlight give out oxygen; that plants, through the aid of the sunbeam, have the power to separate oxygen from carbonic acid and water, and weave the carbon and hydrogen into vegetable fibre. This process of deoxidation implies that the atoms of carbon and of hydrogen are to be separated from oxygen, for which they have a strong and intense affinity, and be transferred to the vegetable organism, for which they have a weaker affinity; and to effect this change requires the expenditure of some kind of force, which is ordinarily supplied by the sunbeam. But in certain localities, and under certain circumstances, vegetation flourishes in total darkness; as, for example, it is a very common thing to find old boards and timber in coal-mines literally covered with fungi. Now, in the growth of these fungi, the same process of deoxidation, the same process of separating the carbon and hydrogen from oxygen is going on, for these plants are also largely composed of those elements which are common to other vegetable structures, but wholly without the stimulating influence of the sunbeam.

Here, apparently, is a reversal of the usual order of things, for these plants, by being deprived of the rays of light, are hid from that power which infuses life into vegetable matter on the surface of the globe; yet this seeming anomalous phenomena of nature will disappear if we can account for the deoxidation which takes place here by some other force than that of the sunbeam. And we may with good cause suspect that if any other force were brought to bear on these oxy-compounds with the same degree of intensity, that it would accomplish a similar result.

Now, it is a most remarkable fact that all these fungi are exceedingly rich in nitrogen, and it is very likely that their growth and development in absolute darkness is due to the presence of this element, for we well know that all substances which are noted for the suddenness with which they liberate their force and act, contain a large proportion of this element. Take, for example, nitroglycerin, dynamite, hydrocyanic acid, yeast, animal ferments, etc.; all possess nitrogen, which undoubtedly empowers them with such great activity. If a chemical action is once set up, the amount of disturbance which is thus generated will be equal to the intensity of the primary action, and if the conditions are at all favorable, it will be transmitted very readily to the surrounding particles. Now, if a portion of the nitrogenous compound which enters into the tissue of the fungi undergoes any sudden chemical change, like that which is characteristic of other nitrogenous compounds, gives out its force, thereby decomposing the carbonic acid and water which are constantly present in coal-mines, it may in this way liberate the elements which are necessary for the construction of the plant. Possibly the carbohydrates, on their way to the main blood-current, come in contact with some nitrogenous principle, perhaps in the liver, which has the power to deprive them of a portion of their oxygen, and thus become changed into a fat or hydrocarbon; at any rate, if it is possible for these fungi to live and flourish in a condition which is the opposite of that in which the general mass of vegetation grows, it is not without some reason to believe that an operation somewhat similar in nature to the above, although not believed to be a common quality of animal life, may take place in the animal body.

Both the hydrocarbons and the carbohydrates then are designed to undergo oxidation, confer their energy on the body, and thus act as pure stimulants, but anything, or any process which, as I remarked before, accelerates the normal molecular activity of the body must also in a measure enhance or promote the nutritive activity of that part; for greater molecular activity implies an increased quantity of blood and plastic materials, as well as increase of waste and repair; hence these substances, though stimulants in the true meaning of that term, also in a measure serve as nutrients.

The indication for the therapeutic employment of these substances, on the basis of the above principle, is in such diseases or tendencies to disease, in which there is a great mark of general debility, conditions in which the molecular activity of the body inclines to descend below the normal standard; and this is confirmed by universal experience, for cod-liver oil is the sheet-anchor of the profession in diseases like tuberculosis, scrofula, rickets, etc., which are all distinguished by a depressed and vitiated state of the general health.

Without entering into a consideration of the intimate nature of the pathology of tuberculosis, it is sufficient for our present purpose to recognize the general bodily condition which constitutes this diathesis in order to render clear the *modus operandi* of these stimulants in this disease, or tendency to disease. The tubercular diathesis, which assumes an active state more frequently in the lungs than in any other organ of the body, is above all other conditions one which is marked by great general feebleness of all the functions of the body. The decided diminution of bodily temperature, the reduction in the amount of carbonic acid excreted, and the loss of muscular and nervous power in this disease, indicate that the molecular activity of the body is depressed to an inordinate extent.

There can be no doubt that it is with good cause that cod-liver oil ranks so high as an agent in counteracting the fatality of pulmonary tuberculosis, and various views have been promulgated from time to time in regard to its mode of action. Some have held that its therapeutic value depends mostly on the phosphorus, iodine or bromine, which enter into its composition; but none of these substances, if administered singly or combinedly, give the same beneficial results which are derived from the use of cod-liver oil.

Now, if we take full cognizance of the relative force-producing value of the hydrocarbons and the carbohydrates, as exhibited in Prof. Frankland's table, which we copied above, the superiority of the action of cod-liver oil to all other stimulants becomes very obvious; for the only plausible reason, it seems to me, which can be given for its great value in this disease, is due to the fact that it possesses a greater capacity for force-production by undergoing oxidation than any other substance in the whole list of non-nitrogenous foods. Every one is aware of the great utility of beef-fat and butter in maintaining the bodily health, in fact, they form some of the essential elements of our daily existence, yet experience teaches that cod-liver oil is superior to either of these agents in securing the same end, and the deductions of science, which are in accord with this, point out that the force-producing value of the latter exceeds that of the two former.

It is thus, then, I hold that cod-liver oil when introduced into the body liberates its force during oxidation, confers actual and potential energy and vigor on the weak and enfeebled molecules of the body, infusing a new life of activity into textures which hitherto were prone to indolence and disintegration.

After this pressing want of the body is fully compensated and its employment persisted in, then it becomes deposited as a store of fat. The acceleration of molecular motion in the body is not the only advantage which accrues from the use of cod-liver oil, for it is well known to have the power also of improving the nutrition of every tissue in the body. This sanatory effect, as we have previously pointed out, can be solely attributed to its stimulant properties, for any stimulus when applied to the body tends to enhance nutrition as well as molecular activity of the part to which it is applied.

That it is possible to improve the nutrition and consistency of the bodily textures by simply conveying motion to them, is well shown by Dr. S. Weir Mitchell in his admirable and suggestive little volume on *Fat and Blood*, in which he lays a great deal of stress on the value of massage and electricity in diseases which are attended by a general loss of vitality. His success in restoring the flesh, color, temperature, and strength of weak and nervous subjects, chiefly women, by these means is certainly remarkable, and he deserves credit for systematizing a plan of treatment for the relief of such cases, which are commonly regarded as being rather intractable. Now as far as massage and electricity in their action on the body are concerned, they, like friction, are but means by which molecular activity is increased; they do not add any material directly to the body, but by inciting and accelerating molecular motion, they reinvigorate the nutritive processes of the body also. And from this we can conceive how it is possible for cod-liver oil to stimulate growth and development of the nitrogenous textures without becoming a portion of them itself.

We cannot, however, attribute the great value of fats and oils exclusively to this stimulant action, for fat is not only a necessary ingredient in the subcutaneous regions of the body, but it is equally essential that every nitrogenous molecule in the whole body should possess its full physiological complement of fat, hence they must also serve to repair this important deficiency, if there is any such.

In all diseases which are characterized by defective oxidation and nutrition, such as scrofula, rickets, tertiary syphilis, tabes mesenterica, skin affections, chronic ulcers, extensive suppuration, constitutional debility, etc., cod-liver oil is an invaluable agent. It should be given directly after a meal, or on a full stomach, as this will help to cover up the unpleasant taste of the oil, while at the same time it will also serve as a stimulant to digestion, for it is well demonstrated that albuminous foods are digested more speedily in the presence and by the aid of fats or oils than without them. If it cannot be taken pure it ought to be tried in the form of an emulsion. One important fact in the administration of the fats and oils which must not be overlooked is this, that their passage from the alimentary canal into the blood is greatly facilitated by the aid of bile; hence it is always necessary to maintain a healthful action of the liver, for any deficiency of action of this organ will prevent the system from obtaining the full value and benefit of these dietary articles.

ALCOHOL.

We now come to discuss the physiologic and therapeutic properties of alcohol, a substance to which has been attributed a greater variety of modes of action than to any other within the whole range of our materia medica. Some professional men, as well as laymen, look upon alcohol as the cause of the greater proportion of the sins and miseries which befall the human race, and firmly believe that if it were eliminated from existence, the advent of the millennium would be hastened ; while on the other hand there are many in the profession, as well as outside, who see in alcohol an agent of inestimable worth,—one whose place in the prevention and treatment of disease could not be supplanted by any other substance.

From time almost immemorial alcohol has been known to intoxicate, but probably the first tangible notion of its action was derived from its known power to coagulate, and thus preserve, albuminous substances for almost any length of time when immersed in it; hence it was believed to act in a similar manner when introduced into the body, *i. e.*, by coagulating the tissues and thus checking animal waste. Thus, Dr. Carpenter, says* that, "Among the most important

* Dr. Wm. B. Carpenter, On the Use and Abuse of Alcoholic Liquors, page 26.

of the chemical changes which alcohol has the power of effecting, is the coagulation of soluble albumen; and although it will rarely, if ever, be introduced into the mass of the blood, or into the serous fluids of the tissues, by any ordinary alcoholic potations, in a sufficiently concentrated state to effect this, yet we should anticipate that its presence, even in a very dilute form, *must* affect the chemical relations of albumen, and can scarcely do otherwise than retard that peculiar transformation by which it is converted into the more vitalized substance, fibrin." That this is a most erroneous and fanciful view of its action when administered in comparative small quantities needs not much proof to the contrary, for we shall show conclusively that the animal textures never under these circumstances encounter alcohol in quantities large enough to produce such results.

Again, it is well known that alcohol, when applied to the web of a frog's foot, has the power to excite it, and from this it has been inferred that it acts in the same way when introduced into the body. This idea of its action, as will be noticed, is wholly inconsistent with that of its anti-waste action, for in one it inhibits molecular activity, while in the other it accelerates it. That under certain circumstances it does and may act so, as, for example, on the stomach when given internally, we have no reason to doubt, but the question arises here same as before, Does alcohol come in contact with the textures of the other parts of the body in the same quantity as it does with the stomach, when given in small quantities? This we also believe to be contrary to the latest scientific investigations on this subject, as we shall prove hereafter.

That alcohol is a narcotic we have no reason to doubt, and, in fact, the evidence which supports such a view of its action is so plentiful and plain that even he who runs may read it; but we are just as firmly convinced that alcohol does not act similarly in different doses—that it is in large doses only that it acts as a narcotic, while in small doses it possesses an opposite—that of a stimulant action.

Liebig was the first one to suggest the idea that alcohol, when introduced into the animal economy, is oxidized, and its force, which is thus liberated, is applied to the performance of muscular and nervous work, but subsequently Messrs. Lallemand, Perrin, and Duroy, by a series of pseudo-scientific experiments, presumed to have proven that alcohol, when administered internally, was eliminated *in toto* by the different emunctories of the body. Obviously, if this were true, alcohol could not perform the function of a force-producing substance, and in order to prove the truth or falsity of this assertion of the French chemists, Drs. Anstie, Dupré, and others, made special researches on this particular point, and all of them arrived at the unanimous conclusion, that only a very small amount, if any, of the whole quantity of ingested alcohol is thrown off by the body. But I invite special attention to the investigations of Dr. Anstie, which are given below in a condensed form, and which are noted for their great accuracy and decisiveness.

His experiments were conducted somewhat as follows: Two drachms of brandy containing 47.73 grains of absolute alcohol were given to a dog, the animal then being inclosed in an air-tight box—a modified Pettenkofer air-chamber—in which all the exhalations and excretions can be retained, and their contents estimated. After remaining there for four hours, it was found that the whole amount of absolute alcohol thrown off by the body was 0.128 grain. This experiment was repeated, and the same result obtained. Another dog received one ounce of brandy daily for ten days, which is equal to 190.92 grains of absolute alcohol, and on the tenth day he was placed in the same box, and kept there for five hours and a quarter, during which time the whole amount of absolute alcohol eliminated was 0.21 grain. On the eleventh day, two hours after receiving half a drachm of brandy, he was killed and cut up into small fragments, none more than an inch in length, which, together with the blood, was placed into a secure stone jar, already containing eight pints of distilled water. The mixture was frequently agitated, and in about two hours and a half it was found on estimation that only 23.66 grains of absolute alcohol remained.

Commenting on these experiments, Dr. Anstie*

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* Final Experiments on the Elimination of Alcohol from the Body. Prac., vol. xiii, page 24.

uses the following terse language: "It must be remembered, moreover, that this figure ought probably to be much reduced, as it really stands for the whole of the substances in the body which were capable on oxidation of yielding acetic acid. From Dr. Dupré's previous researches, it would seem probable that the amount of such substances, not being ingested alcohol, was considerable. But taking the whole as ingested alcohol, 23.66 grains is of course a perfectly trivial residuum to be found in the animal's body after ten days' daily allowance of 190.92 grains absolute alcohol, of which 95.46 grains had been taken not two hours before death. Add to this the fact that the total alcohol eliminated on the tenth day of brandy diet was only 1.13 grain absolute alcohol, and it must, I think, be plain to any candid reader that the dog did, on each day, dispose by other means than by elimination of very nearly the whole of his portion of 190.92 grains absolute alcohol.

"The evidence, indeed, which is afforded by those experiments on dogs, appears to me overwhelming; and even did it stand quite alone, I do not see how its force could be evaded. The experiments on the dog A show that 47.73 grains of alcohol can be disposed of by a little terrier within eight hours with only the elimination of one-fifth of a grain of unchanged alcohol by all channels together. The experiments on the dog B show that a terrier of less than ten pounds weight could take with comparative impunity nearly 2000 grains of absolute alcohol in ten days; that on the last day of the regimen he only eliminated by all channels 1.13 grain of alcohol; and that on his being killed (two hours after swallowing 95.1 grains of absolute alcohol) only 23.66 grains were recovered from his whole body and all its contents, elaborately treated so as to provide against material loss during the examination. These experiments certainly furnish us with final and conclusive demonstrations, as regards dogs, of the correctness of Dr. Dupré's arguments against the possibility of material *accumulation* of alcohol in the body. Had such accumulation occurred, nothing could possibly have prevented its becoming apparent on analysis of the body of the dog who had been brandy drinking to such a large extent for ten days together. Remember that the daily portion of this animal was equivalent (reckoning in proportion to weight) to 14 ounces of brandy per diem for an adult man of average growth."

Now the above experiments prove to us, in the most decided manner, that the animal body is capable of consuming alcohol, and, according to the calculations of Dr. Anstie, the human organism can destroy about 600 grains of it; and if this amount is not oxidized, and the force which is liberated in this operation not appropriated to the performance of vital functions, then we have not a shadow of right to believe that fat, butter, and oil are force-giving substances to the body; for we have no such decisive experimental proof on record to show that they are destroyed in the body like alcohol, yet, from their effects, which are analogous to those of alcohol, no sane mind can question the fact that they undergo chemical changes in the body, and confer motor energy on it. This is almost self-evident, for no substance can undergo extensive oxidation in the body without contributing some force to the maintenance of its functions. Again, alcohol is so closely related to the above substances, both in chemical composition and in point of combustibility, standing midway, as Dr. Pavy says, between the hydrocarbons and carbohydrates, that it is astonishing, indeed, that its force-producing power has ever been doubted since it was first suggested by Liebig.

Moreover, the view that alcohol is a force-producing substance under certain conditions is strongly corroborated by clinical experience. Evidence of such a character points out that alcohol is employed in those adynamic states of the body which are the result of typhoid and typhus fevers, pneumonia, diphtheria, erysipelas, etc., conditions in which the forces of the body are very often reduced to the lowest ebb compatible with life, and in which the action of such a substance is precisely indicated on pure theoretical grounds.

But some deny that alcohol sustains the body under such circumstances by a force-giving power through oxidation. They maintain that it acts somewhat similar to the whip which is applied to a horse for the purpose of increasing his speed; that it in this manner goads the body to renewed activity. This seems to us a most unfortunate comparison, for a horse, like every other animal, expends energy in proportion to the amount of muscular work which he performs; hence, by being goaded on with the whip, he will, of course, increase his speed, but at the same time he will also increase the consumption of his motor energy, and the longer he is driven in this manner the more frequent will the necessity arise for using the whip, until at last he becomes utterly exhausted. But is this the case with the action of alcohol? Take, for example, a case of pneumonia, or of typhoid fever, and during the period of greatest exhaustion, such patients will take and bear well large and inordinate doses of alcohol without experiencing the least narcotic or unpleasant effects; but the capacity of the body for taking alcohol almost *ad libitum* and with benefit in such cases also diminishes in proportion as improvement takes place, until at last, when a healthy equilibrium of the body is restored again, very small quantities produce unpleasant and injurious effects. The action of the whip on the horse and that of alcohol on the body in disease, therefore, have nothing whatever in common—in fact they stand in opposite relations—for the horse is only impelled to move faster by applying the whip with greater frequency, and, instead of gaining, he loses strength; while, on the other hand, the body revives under the administration of alcohol, and its quantity the longer it is used, instead of being increased, must be steadily diminished. The action of alcohol, under such circumstances, can only be accounted for on the score that it furnishes force to the body, whereby the latter is enabled to renew and repair its rapidly failing functions, utilizing a large amount when it is most depressed, and naturally, as recuperation takes place, the necessity for large doses is gradually obviated, since less and less force is required, until, at last, the chasm is bridged over, and ordinary food becomes able to supply the requisite force to sustain it.

But if alcohol is a force-giving substance to the body, why is it that food which supplies the needful force to the body in health is not equally efficacious, or, perhaps, superior to alcohol in disease? There are various reasons for this, among which are the following: Alcohol is a very diffusible and highly combustible substance, superior in these respects to ordinary food; hence in it we find a most desirable instrument, which is capable of bearing the necessary force to the diseased body, which the latter could not obtain from any other source. Especially does this become pregnant with meaning when it is coupled with the fact that a person prostrated by disease is usually unable, on account of the disturbed state of the stomach and bowels, to take and digest the requisite amount of ordinary food, while alcohol is readily introduced and assimilated in spite of these obstacles.

Thus, then, we possess evidence of the most unmistakable character which makes it certain that alcohol is a force-giving substance in small or oxidizable doses, and as such is an invaluable adjunct in the treatment of the adynamic forms of disease; but it is also true, on the other hand, as we have remarked before, that in large or unoxidizable doses it is a narcotic, and so gives rise to many evil consequences. Hence it is supposed, by those who merely jump at deductions, that the latter phase is characteristic of its universal action, and on this account an ill-conceived and unfair war has been waged against it, which debarred it in a great measure from a righteous and unbiassed consideration. The fact, however, that under some circumstances its use, or rather its abuse, is fraught with terrible evils, is not the least evidence that under other circumstances it is not an unmitigated blessing; and this close alliance between the good and evil should stimulate us to endeavor to distinguish between them, and to make efforts to utilize the former and to eliminate the latter.

PHOSPHORUS.

The therapeutic and dietetic action of phosphorus cannot be discussed in all its varied phases under the head of chemical stimulants alone, for, at the same time that it has the power of undergoing rapid oxidation and of communicating this resultant motion to neighboring molecules, and thus incite them to greater activity, it also constitutes an important ingredient in the animal frame, especially in the nervous system; hence it is both a nutrient and a stimulant. Certainly, the phosphorus which forms an elementary part of the nervous system, and of other tissues, undergoes a more or less gradual oxidation, in accordance with the respective functional activity of the organ into which it enters; yet, aside of this, there remains the uncontroverted fact that phosphorus when introduced from without, will undergo chemical metamorphosis in the body without previously becoming an integral portion of the latter.

The experiments of Demarquay, Duméril, and Lecointe, conclusively point out that phosphorus, when administered in small doses, increases the animal temperature from five to nine degrees Fahrenheit. Such a result might have been anticipated, for among all the elements there is none which manifests such a strong and intense affinity for oxygen as phosphorus, and we have no good reason to doubt that it displays any other than the same affinity inside as it does outside of the body.

The phosphates are very often administered under the mistaken belief that the effects of the action of phosphorus are obtained thereby. Nothing could be more delusive than this, for phosphorus differs just as much in its action from that of the phosphates as does that of sulphur from sulphuric acid or the sulphates, or that of nitrogen from nitric acid or the nitrates. Phosphorus combines with oxygen under four different forms, viz.: oxide of phosphorus (P_3O_2); hypophosphorous acid (PO); phosphorous acid (PO_3); and phosphoric acid (PO_5). Now it is very evident that a wide difference exists between the hypophosphorous acid and phosphoric acid, as far as the affinity for oxygen is concerned; for, in the former the phosphorus is only in combination with a single atom of oxygen, while in the latter its desire for oxygen is fully satisfied, and is perfectly useless for all purposes of oxidation; and, what is true of these is equally true of the *phosphides* and the *phosphates*. Hence it is not from the phosphates that we must expect to derive the beneficial action of phosphorus, but from the phosphides, those which still have left the power to combine with oxygen, and thus assist in promoting healthy function.

It is very probable that most of the beneficent action of phosphorus, in a therapeutic point of view, is derived from its property of rapid combustibility, and not from the fact that it forms a proximate principle of the inorganic class, although this latter relation to the body is important enough not to be overlooked. It is very clear that a substance like phosphorus, which combines so eagerly with oxygen at even a very low temperature, must, if it becomes diffused throughout the body, which it undoubtedly does, generate an inordinate amount of heat-force, which can be applied to economical purposes in the body; and as a heat-producing substance it ranks with our most valuable hydrocarbons.

Now the various hypophosphites which, as we have seen, are in a very low state of oxidation, such as those of soda, lime, and potash, for all practical intents and purposes take the place of phosphorus. The affinity for oxygen in these compounds continues to be very strong, each atom of phosphorus in the latter still has the capacity to combine with four of the former before it becomes fully satisfied.

According to this hypothesis of the action of phosphorus, the therapeutic indication for its employment is in those diseases which are characterized by a too rapid waste of this substance, as we actually find is the case in many disorders of the brain and of the nervous system; in diseases where there is found a deficit of phosphates, as in rickets, necrosis of bone, early decay of teeth in children, etc., as well as in those low states of the body which are accompanied by a depressed and debilitated functional activity, either local or general.

In paralysis agitans, progressive locomotor ataxy, nervous breakdown from overwork, the administration of phosphorus in the form of the hypophosphites, or of the phosphorated oil, is said to have great value.

Drs. Broadbent, Radcliffe, Thorowgood, and Mr. Thompson, speak very highly of the use of phosphorus in neuralgia. In the toothache of pregnancy, which is believed to be caused by the abstraction of phosphorus or of the phosphates from the blood and textures for the purpose of constructing the bones of the fœtus, I have administered the hypophosphite of lime in three-grain doses, every four hours, with the most signal relief.

The hypophosphites are considered to be valuable adjuncts in the treatment of pulmonary consumption by Drs. James Henry Bennett, Thorowgood, and others; and Dr. J. F. Churchill, of Paris, accredits them with a specific action in this disease. There can be but little doubt that they are beneficial in counteracting and relieving this dreadful malady; and, indeed, from our knowledge of its pathology we are warranted in the belief that their therapeutic use is strongly indicated, but to impute to them any specific action in this disease seems to me premature, and not in harmony with well-established principles. My opportunity for observing their action in this disease has been very limited, but in one case in which there was unmistakable evidence of inherited tubercular disease of the left lung of a young girl, I found the symptoms gradually vanishing under their administration. In another case of laryngeal phthisis, complicated with tubercular deposit in the upper apex of the left lung, which I have under my care at present, the hypophosphite of lime has effected a marked change in the condition of the patient. This patient is eight years old, and she had a persistent cough for three months, which was ushered in by hæmoptysis. At about the same time that she had the hæmorrhage she also began to get hoarse, and in the course of a short time she lost her speech to such an extent that she was not able to talk above a whisper. Symptoms of tubercular infiltration in the upper portion of the left lung also began to develop themselves at the same time. She has taken the hypophosphite of lime in three-grain doses, three times daily, for two months, and during this time she regained her speech altogether, and her left lung has also improved.

In that prostration of the system which is the result of an exhaustive disease, like that produced by acute pneumonia or bronchitis, I have found that the use of the hypophosphite of lime in five-grain doses, three or four times a day, hastens the process of convalescence very materially.

OXYGEN.

Oxygen bears a most vital relation to all organic processes. It is an elementary part of the component tissues of the body, and it is also destined to form a chemical union with many substances in the body, whereby force is generated and its functions maintained; so it performs the twofold office of nutrient and stimulant.

According to the investigations of Regnault, Reiset, Valentin, Vierordt, and others, five per cent. of the whole volume of oxygen inhaled is consumed during each inspiration. This is equal to about one cubic inch of oxygen which is absorbed by the blood during one inspiration, or about seventeen and a half cubic feet of oxygen is consumed by the body during twenty-four hours. This, by weight, amounts to a little over one pound avoirdupois.

Of course it has been found that there are important variations in the amount of oxygen taken up by the body under different physiological conditions, as for instance, when the body is in repose, or fasting, or asleep, the quantity of oxygen absorbed by it is considerably less than what it is during digestion, or mental and muscular activity. Regnault and Reiset have shown that more oxygen is consumed by carnivorous than by herbivorous animals, and they also showed that "the relative quantity of oxygen absorbed by small birds, such as the wren, was ten times greater than that of the fowl."

We have already stated that oxygen is an integrant portion of the animal tissues, but it is well determined that this is not the only and most important function which it performs in the body. Its intense chemical affinity, which it manifests for many elements and they for it, fits it especially for the purpose of liberating that large quantity of force which is necessary to maintain the functional activity of the body. It shows a marked difference in its affinity for the various elements. Its union with carbon and hydrogen is more intense than that with any other elements,* and it is well known that nearly all the force which is generated outside of the body results from its chemical combination with these two elements. And what is true of the mode of generation of force exterior to the body, also holds true of the body inside; for the large amount of force which is constantly given out by the body in the shape of mental, muscular, and other work, originates mainly through the oxidation of carbon and

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* Except phosphorus.

of hydrogen. That oxygen does unite with other elements in the body besides carbon and hydrogen, is a very palpable fact, for oxidation is the main process by which depuration of the body generally takes place; by which those tissues that have survived their usefulness in the body can be prepared for removal.

The main import of the oxidation of the albuminous tissues, is to change them from their colloid and indiffusible state into the crystalloid condition, in which they are diffusible and can be readily thrown out of the body in the shape of urea, carbonic acid, etc. It is as a stimulant, therefore, that oxygen displays its greatest usefulness in the animal economy.

We have already seen that it requires about seventeen and a half cubic feet of oxygen to maintain the functions of the body in a normal condition during every twenty-four hours of its existence, and any decided diminution of this quantity will be a serious detriment to its activity. It is not only the deficiency of oxygen which entails so much mischief in the body, but it is the rapid accumulation of carbonic acid in the blood which leads to the most disastrous consequences. Moreover, carbonic acid is more difficult to exhale when present in an excessive quantity in the lungs, for it is by the power which gases have of diffusing through each other, or the diffusion of carbonic acid through oxygen, that the process of exhaling carbonic acid from the lungs is facilitated, hence the want of the proper quantity of oxygen in the lungs is an indirect cause of carbonic acid poisoning in this manner.

Here then the organic processes suffer for the want of proper material to support them, while at the same time they are choked by an insidious and deadly poison.

Be this process of carbonic acid poisoning ever so slow, its impress will nevertheless be stamped on the body, those organs which are mostly exposed to its deleterious influence, as the right side of the heart, will especially bear the brunt of its action. This organ is the receptacle of all the blood coming in from every part of the body, already loaded with carbonic acid, even in the natural state; but when under certain circumstances the blood becomes almost completely saturated with this effete product, its deteriorating effect must be vastly multiplied, and if such an abnormal state of things continues for any length of time, the walls of the right side of the heart will soon begin to show signs of disintegration, the tricuspid valves will become deranged, and regurgitation, with all its natural consequences, will follow, such as anasarca, hæmorrhoids, congestion of the abdominal organs, etc.

Not less disastrous are the consequences to the lungs when they are deprived of their normal and accustomed supply of oxygen. Aerial voyagers, when reaching very high altitudes, invariably experience a sense of languor and sleepiness, fulness of the chest, tendency to suffocation, hæmoptysis, etc. The blood unused to such a dearth of oxygen as is found at elevations like these, is hurriedly pumped by the heart into the bronchial capillaries, and the lungs, in their effort to make up for the deficiency of oxygen, accelerate their movements in order to afford the usual supply of oxygen to the blood ; but this gives rise to a new and strange relation of things, which, if not removed, must soon terminate in actual disease. The blood in its eagerness to become duly oxygenated, so to say, fills and distends the bloodvessels of the lungs to such a degree as to rupture them, and hæmoptysis results. When there is not left sufficient resiliency in the capillaries after the body is restored to its wonted supply of oxygen, the congestion thus produced will often end in bronchitis or pneumonia, or at any rate will lead to an enfeeblement of the respiratory functions.

Persons who are engaged in the occupation of mining coal inhale the fine particles of coal-dust to which they are constantly exposed, and which become deposited on the surface of the bronchial mucous membrane, preventing the free ingress of oxygen to the blood, and giving rise to dyspnœa, cough, accelerated pulse, muscular weakness, etc. And in connection with this part of our subject we will append the report of a case which is a typical instance of disease among those who are employed in the manufacture of coal, and which is a fair illustration of the result of a diminished supply of oxygen to the body.

L. R——, aged 49, presents himself to me, October 6th, 1876, and states that he has been mining coal for the last twenty years. During the last five years he has been subject to giddiness, weakness, and shortness of breath. He attributes his ill health to laboring in foul air, for he says that he spits up a great deal of black-colored mucus, and that whenever he spits up less of this black stuff he feels better. During a recent suspension of mining operations for six months, he quit work, and during that time all of the above symptoms, which were very aggravating when he stopped, disappeared, and did not return until he had been mining coal again for about two months, and have been increasing up to the present time. He says that his breath is so short that in coming up the slope from work, he is compelled to sit down and rest himself a number of times. After a long rest his pulse is now 82, and his respiration 22 ; after walking two hundred yards his pulse is 112, and respiration 26.

I prescribed for him tincture of senega, and iodide of potassium, and after taking it for three days he reported himself very much improved. At this time he says that " he did a better day's work to-day than he had for a long while, and also, was able to walk up the slope with the other men." I attributed the improvement principally to the expectorant action of senega, and so continued it alone for one month, when I discharged him as well.

Indeed, there is no question of greater magnitude to the sanitarian than that of the relation which exists between oxygen and the preservation of life. How to secure to man a liberal supply of this vital gas, whether he is in his office or dwelling ; in his counting house or storeroom ; sitting in church or walking in the street; delving underground or working in the factory ; or whatever legitimate calling he may follow, is a problem which presses itself for solution upon the attention of every thoughtful individual, and especially upon that of the engineer, the architect, the builder, and the employer.

CHAPTER IV.

MECHANICAL STIMULANTS.

HITHERTO I have discussed the action of some medicinal substances which enhance molecular motion of the body by undergoing oxidation within it, and I called them chemical stimulants, in contradistinction to another class which also possess this power, but in a manner altogether different to that of the former, as I now proceed to show. Among this class are found

Quinia,	*Calumbo,*
Quassia,	*Gentian,*
Berberis or Barberry,	*Nectandra or Bebeera.*

We have already stated that it is possible to excite or accelerate molecular motion of the body by means of friction. Such an operation involves the antagonism of two forces moving in opposite or at least different directions, and is governed by two fundamental physical laws, viz., that motion takes place in the line of least resistance; and that action and reaction are always equal, or, in other words, one force acting on another will always call forth a corresponding reaction, unless the former is out of all proportion to the latter.

When two forces of equal strength meet each other from opposite directions, rest is produced, but an attacking force of comparative moderate strength will disturb the equilibrium of a force of somewhat less resistance, and cause it to move in a direction parallel to its own, to such a point where a mutual balance occurs. And although the latter tends to rebound and assume its former position, yet, by a series of such impactions, it will be forced to seek a new equilibrium in which it will remain after the attacking force has ceased to act. This phenomena is well illustrated by the gentle gale blowing over a field of tall grain, disturbing the latter and giving to it a wavelike motion; and it is well known that a steady and continuous breeze in one direction will often cause the grain to lean in that direction, and to remain that way for some time after the disturbing force has ceased to operate. Again, it is also well known that a wind or breeze from an opposite direction will have the effect of rendering the grass straight again. But, it is also true on the other hand, that an attacking force of great strength will ultimately overthrow the resisting force altogether — this latter result varying in proportion to the relative strength of the two forces. This portion of the principle is well exemplified in the case of a cyclone or violent storm blowing across a forest. If the force of the wind is sufficiently powerful, every tree, however strong, will have to go down before it, if it is more moderate in strength the weaker will only succumb, while the stronger survive.

This, then, is another mode by which motion can be generated, and if we can conceive that our medicines or remedies and the bodily structures are the embodiment of forces which move in various directions, some in harmony and others in discord with each other, it becomes a comparative easy matter to comprehend that remedies which move in a direction opposite to that of a force, or the forces within the body, must give rise to phenomena which correspond somewhat to the principle laid down above.

Let us then examine the substances which form the heading of this section, and endeavor to find out whether they give evidence of any action analogous to such a principle, and first of all we will take quinia, the action of which has perhaps been more fully investigated than that of any of the others, and in order to form a just and correct conception of its action, it is essential to first consider it in that phase of its action in which it is best known, that is, in relatively large quantities.

It has long been known that quinia has the power of preserving milk, flesh, urine, etc., of preventing putrefaction, of checking alcoholic fermentation, and of exerting a poisonous and fatal influence on all kinds of infusorial life; and the researches of Drs. Binz, Martin, and Kerner, demonstrate that quinia limits the pathological multiplication of the colorless blood-corpuscles, and impairs their migratory movements. And, besides, it has been established clinically, as well as physiologically, that quinia in large doses has the undoubted power of lowering animal temperature. Now all these facts point to the conclusion that quinia has the power of retarding chemical and nutritive changes, and any substance which displays such a tendency must be antagonistic to all kinds of life; must represent or be equivalent to a force which moves in a direction contrary to that in which the combined forces of animal life move. It is impossible for any substance or force moving in harmony with the forces of the body to produce such results, hence we cannot but believe that quinia in large doses manifests an anti-vital action.

The action of quinia in relatively large doses, then, is similar to a strong force coming in contact with a weaker one, and is analogous to the wind or storm blowing across the forest, before which the weaker trees fall, and the stronger ones survive; or, were the dose sufficiently large, it would extinguish life (for such instances are on record), and then its action would be similar to the fierce tornado sweeping down everything in its path.

This, then, is all in conformity with our knowledge of the action of comparatively large doses of quinia on the body in health and in disease. The quantity which has the power to depress fever temperature two or three degrees, has hardly an appreciable influence on the temperature of the body in health. This follows from the law referred to above, that motion takes place in the line of least resistance. Fever or elevation of the bodily temperature is caused by a disturbance of the processes of nutrition and oxidation, and under such circumstances the forces of the body have less resistance than in health. To say the contrary would be to assert that the body is stronger in disease than in health. Hence, the body, although containing a greater quantity of heat, and its process of oxidation is manifesting greater activity, still offers less resistance, and gives way under, and moves along with, a force which would much less affect it under opposite conditions. This much and no more shall we say about the action of quinia in large doses, for it is not in such quantities that it manifests its stimulant property, but to render intelligible this latter action it is of vital importance to possess a knowledge of the character of its antipyretic or depressant power.

Now then we are aware that a comparatively strong antagonistic force has the power of curbing the organic activity of the animal body; but we also saw that a force of the same nature, only diminished in quantity, does not only not tend to impede motion, but, on the other hand, it calls forth reactive energy in the opposing force, and thereby accelerates and enhances its motion; and if this is so, then, small or comparatively weak doses of quinia must tend to promote functional activity of the bodily organs.

Such a view of the action of quinia is corroborated by the medical profession everywhere, from the fact that its members administer it under opposite bodily conditions, and for widely different purposes. The intelligent practitioner does not, when he wishes to invigorate a debilitated state of the body, give it in fifteen or twenty-grain doses as he would in a case of confirmed fever, but he orders it in one, two, or three-grain doses, according to the degree of atony, and secures desirable results. It is universally acknowledged unconsciously, if not consciously, that quinia in small quantities stands pre-eminent as a tonic or stimulant, and it is also just as true that in large doses it outranks every other article of the materia medica in reducing exalted temperature of the body. Now these are in some respects two opposite, or at least altogether different, pathological conditions for the alleviation of which it is administered,—in the former case to revive failing activity, and in the latter to depress exalted activity,—and if quinia had a similar effect in quantity and quality on the body, in small and large doses, then such different results would be impossible. And it is only when we consider its *modus operandi* in the light of the above principle that its action becomes intelligible.

From this we learn that quinia in small doses is analogous in its action to a mild force of wind blowing across a field of tall grass. That it moves in a direction contrary to that of, and comes in contact with, the weaker molecular forces of the body, and motion necessarily takes place in the line of least resistance, which is in consonance with that of the attacking force, until at such a point where a momentary equilibrium is restored by the action of the bodily force, after which motion takes place in an opposite direction. By the prolonged action of quinia a series of such oscillations or waves is produced, and in this way the bodily molecules are impelled to their former degree of energy and activity; they thus acquire an additional amount of strength, which will remain even after the attacking force has subsided. In this way it serves as a stimulant to the weak digestive powers, and owing to its great diffusibility, it is equally efficacious in imparting vigor and strength to every texture and function of the body.

What constitutes a tonic or stimulant dose of quinia depends very much upon the habits and constitution of the individual to whom it is administered. It stands to reason that it requires a larger dose to arouse the system from a low state of debility than if there is less prostration present, but if a person is not an habitual quinia-eater, as is the case with some, then from half a grain to two or three grains at a time usually suffices to develop its stimulant property. The following case well illustrates its stimulant or tonic action:

About two years and a half ago, W. P——, then 64 years of age, came under my care, suffering from cerebral congestion. He was a mine boss and had a large amount of mental work to perform in order to operate the mine successfully. The mental work became a mental worry, and he began to have sleepless nights and pain in the head, and finally he broke down to such an extent that he was obliged to keep his bed. He made a very slow recovery, and when he was able to resume work, which was about two years after he was taken, his whole body, especially the nervous and muscular systems, were extremely debilitated. For nearly a year he was unable to make more exertion than was required to walk from his house to his office, a distance of one hundred paces. He was very sensitive to the slightest variations in the atmospheric temperature, and perspired profusely on the least exertion, directly after which he became cold and chilly. His appetite kept good. His whole state was one indicative of nervous and muscular depression and weakness, and after trying various remedies, I advised him to take a grain of quinia sulph., morning and evening, and this he has continued to do regular for about eighteen months, with the exception of some days when he felt very dull and bad he took an extra grain or two. He has improved very markedly under its use and became able to resume his regular vocation six months ago, which he has followed without much interruption ever since. He says that if he does not take his quinia every day, he is sleepless at night, feels dull, languid, and "without any heart or spunk to do anything" during the day.

The almost specific action of quinia in some kinds of neuralgia, especially if it is of malarial origin, is familiar to every one, and we have reason for believing that its beneficial action in this form of pain can be ascribed to its stimulating influence. In our inquiry into the nature of pain, we further on show that it is due either to perverted nutritive or molecular activity, or to both, and if malarial neuralgia is caused mainly by diminished molecular activity, then it is an easy matter to conceive of the nature of its therapeutic action in this disease. That this is the manner in which it probably acts in neuralgia is rendered probable by the fact that it is not near so efficacious in sciatica and in other neuralgic affections of longer standing. Malarial neuralgia, in which quinia seems to be almost invaluable, is usually of an acute character, of short duration, in which not sufficient time has elapsed to allow any serious organic changes in the nerve to take place; while the more chronic forms of neuralgia are not so amenable to the influence of quinia, for the probable reason that they require more active stimulation than quinia is able to yield, or need some nutritive or organic reparation which can be secured better by other means. At any rate, it is not in large, but in small and stimulant doses that quinia relieves neuralgia. I have witnessed the most lancinating supraorbital pain of this kind subside in the course of a few hours, under the administration of one grain of quinia sulph., every hour. On the efficacy of quinia in neuralgia, Dr. Anstie* speaks as follows: "The use of quinine as an anti-malarial agent has been already referred to; its employment in non-malarial cases is of much more restricted scope and benefit. Experience has taught me to agree in general with the opinion of Valleix, that it is a very unreliable agent,

* Neuralgia, p. 227.

the one marked exception to this being the case of *ophthalmic* neuralgias. What the reason may be I cannot in the least say, but it is a fact that quinine does benefit these neuralgias, in cases where there is no room for suspicion of malaria, with a frequency which is very much greater than in the treatment of the painful affections of any other nerve in the body. The quantity given should be about two grains three times a day."

It is, therefore, unscientific to speak of quinia as having such and such an action, without stating or qualifying the amount which is to be or has been given, for we have seen that in accordance with the dose it gives rise to results which are not only altogether different in degree, but also in kind. The same is equally true of a great many, if not of all, of our therapeutic agents; and, in fact, this is just what we may reasonably anticipate, if we hold that our medicines are the representatives of so much force, for the quantity of, and the effect of force, are exactly equal. If a large amount of force operates on the body, its results will be proportionate to its quantity, and this is also true of a smaller quantity.

In regard to the action of the other substances which I have classified with quinia, we shall find that it bears a very close relation in principle to that of the latter. Quassin, the active principle of quassia, is described by Stillé as being poisonous to insects and mammals, even to the extent of causing death. Phillips says that berberis, or barberry, and calumbo, contain the alkaloid berberina, which is a fatal poison, and the same authority asserts of the physiological action of gentian, that "there can now be little doubt that gentiopicrin, the true active principle of gentian, is a bitter closely allied to quinine, alike in physiological and therapeutic action. . . . . The former has been proved to be undoubtedly efficacious in cases of intermittents, by Lange, who published a series of thirty-four cases in which attacks were cut short or prevented by half-drachm doses." Concerning the action of nectandra, or bebeera, we have the authority of Wood, who quotes from Virchow's *Archives* that "Albers found that three grains (of bebeera) introduced beneath the skin of a large frog, produced death in six and half hours," and Professor Binz discovered that it is destructive to the lower forms of animal life in a manner similar to quinia. No doubt if more of their physiological properties were known, other substances, like boneset, goldthread, the different kinds of dogwood, etc., which are used as stimulants or tonics, would be found to have an allied action to quinia.

For various reasons these substances are not employed in medicine for the purpose of obtaining their depressant action, and one of the principal of these is, that we possess such a superior substitute in quinia, but they are merely used as tonics, *i. e.*, for their stimulant effects. Now, from what has already been said on this part of the subject, I hope it is needless to say anything more to render the action of these latter substances any clearer, for they resemble that of quinia in almost every particular.

Therapeutically they are indicated in a depressed condition of the digestive functions, loss of appetite, a foul stomach, or a coated tongue, in which they usually act very beneficially, and no doubt when absorbed into the systemic circulation, they, like quinia, enhance all the functions throughout the body.

AMMONIA.

Ammonia is a stimulant, recognized as such by the profession everywhere, and we have already seen that a stimulant substance or agent is one which confers energy on the body, either by undergoing oxidation and thus giving out its store of energy, or by coming in contact with the bodily forces, moving at a rate and in a direction dissimilar to its own. The question here at issue is, whether ammonia acts according to the former or to the latter method, and we think that from all the data concerning its action which we have been able to collect, we are warranted in saying that it acts in the latter manner.

Ammonia is an active and highly diffusible agent, and its effects, like the other stimulants which we have discussed, are proportionate to the amount which the body encounters. A small quantity will merely quicken molecular activity, and enliven the circulation, and arouse the part to which it is applied to a healthful activity ; a large quantity, however, will produce violent irritation and inflammation. This action of ammonia is analogous to that of friction applied to the body, to which I have already alluded, and which is such a clear illustration of the effect of a force moving in a direction contrary to that of the forces of the body; for stimulation, irritation, and inflammation, are but the legitimate results of accelerated nutrition and oxidation. Thus, it is but reasonable to believe that any force having the power to increase the depressed or normal activity of these processes will, in greater quantity, have the power of precipitating them into irritation and inflammation.

The therapeutic indication of ammonia, then, is in conditions of the body which are characterized by great and sudden depression, and owing to its great activity and diffusibility it is one of the most effective agents which we possess for temporarily arousing the flagging energies of the body.

It forms the chief ingredient in the majority of our liniments, which are applied to the exterior of the body for the purpose of exciting healthy molecular action in parts which are *bruised* and *strained*, and it also very often successfully allays the pain which accompanies such injuries. It is useful in reddening the skin over an organ which tends to inflammation, when only a transient effect is desired, as in the incipient inflammatory symptoms of the thoracic organs in children.

When administered internally it is by reason of its affinity for the pulmonary mucous membrane, by which it is in a great measure excreted, that it serves as a valuable stimulant to the lungs in some of the stages of the various inflammations which occur in these organs. It is also beneficially employed in restoring the action of the heart when abruptly depressed and overpowered by some devitalizing agent, as in poisoning by venomous serpents, or in the speedy collapse and shock which follows severe injuries, in cholera, etc.

That it is almost exclusively in the stimulant manner which we have described that ammonia acts therapeutically, seems most certain from the fact that it is only effectual in relieving those sudden functional disturbances in which not much organic change has taken place; and from what we have said of its action, it is evident that if such changes were present, ammonia would have but very little power to repair them. This idea is also corroborated by Dr. H. C. Wood,* in the following language: "Internally the chief indication for the use of ammonia is *failure of the heart's action.* The more sudden and purely functional this is, the more efficacious is the remedy, which should in such cases be not only administered by the stomach, but should also be inhaled through the nostrils, as the local action of the irritant vapor upon the mucous membrane has a very arousing influence. When the failure of the circulation depends upon a slow and persistent cause, as in *dynamic fevers*, ammonia is not

* Treatise on Therapeutics, page 111.

generally useful, but may be employed as an adjuvant to alcohol in the crisis of the disorder."

IODINE AND THE IODIDES.

Whatever can be said to be true of the principle of action of quinia, ammonia, etc., also holds true of the principle of action of iodine, for the action of this substance tends in a direction which is antagonistic to the life-forces. When it is applied to any portion of the body, it excites molecular action, and in large quantities produces congestion and inflammation, and, if repeatedly applied, will give rise to blisters. When taken internally, it will cause gastric and intestinal irritation and inflammation. From these few leading characteristics of its action, we may judge that it does not act harmoniously with the bodily forces, but in opposition to them, and in this way its action is allied to that of quinia, of ammonia, and of other remedies.

But there are peculiarities which distinguish the action of quinia from that of ammonia, and which causes it to give rise to effects widely different; and in the same manner iodine has its peculiarities, which characterize its action. This special action is not due so much to the difference in the quantity of force which either of the former substances exert, but more to a difference in their respective natural constitutions. And this is in accordance with what we should expect to find; for it is not possible that any two or more bodies or forces moving even in the same direction, and being of a similar nature, could produce the same effects; and how much greater divergent results should we expect to have produced, then, by bodies or forces of unequal strength, and differing widely in their nature, though they move in a similar direction? Mark the difference with which the unison sounds of a piano and of a violin, or those of any two dissimilar instruments fall upon the ear, yet both and all of these sounds move in exactly the same direction, and are produced by the same number of undulations, the only difference being the nature of the material which generates the respective sounds. Thus, then, a class of substances can have the same general tendency of action, and yet may vary widely in their special physiological properties.

As already stated stimulation, according to our view, implies accelerated molecular activity with all its consequences, such as increased waste and repair, etc.; but there can be no doubt that iodine, in addition to its general physical stimulant tendency, also possesses a chemical action on the solid and fluid constituents of the body, which brings its action in still greater contrast with that of the more purely physical stimulants, quinia and ammonia. For it is well known that the administration of large doses of iodine causes an elevation of the bodily temperature, emaciation, and an increased waste of the nitrogenous tissues of the body, and Dr. Kammerer, of Nürnberg, in speaking of the therapeutic action of iodine, says that it exerts its greatest influence on the albuminous compounds of the body.

The iodides owe most of their therapeutic virtues to the iodine which they contain, for these compounds are in such loose combination that they are very easily decomposed by oxygen or ozone, and hence it is impossible for these substances to enter the body without becoming disintegrated. Dr. Kammerer, in tracing the chemical changes which the iodides undergo in the body, says: * "If we now follow the chemical changes and actions which iodide of potassium must necessarily undergo and exercise in its passage through the circulation, it is to be noted that it undergoes no change in the stomach, for, whilst on the one hand, the extremely dilute hydrochloric acid of the gastric juice is incapable of decomposing it, so on the other it neither precipitates nor is decomposed by the albuminous compounds, sugar, starch, and salts, that are or may be present in that organ. It then enters the blood by diffusion in an altered state; but even were the iodide decomposed by the hydrochloric acid of the gastric juice to some extent, it would only result in the entrance of hydriodic acid instead of iodide of potassium into the blood, the action of which would be similar. The large quantities of carbonic acid which are continuously produced in the blood will immediately act on the very dilute solution of the iodide in the blood, especially at the high pressure under which the gas exists

* See London Practitioner, vol. xiv, page 216.

in the blood. Hydriodic acid is set free with the formation of the bicarbonate of the alkali. The acid is, however, immediately broken up into iodine and water. Thus, by the direct action of the oxygen of the blood upon the iodide of potassium, iodine must be set free. . . . . The action of iodine depends, like that of bromine and chlorine, upon its affinity for hydrogen, which it displaces from the compound, and unites with to form free hydriodic acid. The molecule of hydrogen withdrawn from the compound is at the same time replaced by one of iodine; but this new compound, being unstable, immediately breaks up, and the secondary products readily undergo oxidation. In the same way the hydriodic acid dissolving in the blood, itself undergoes oxidation, and the iodine is again set free to pass through the same series of changes. A single molecule of iodine may thus aid in the decomposition of many molecules of organic matter, which explains the action of small doses of it." *Virchow's Archiv und der praktische Arzt*, Jahrgang xv, p. 81.

From such a theory of its action it may be inferred that iodine, instead of being a stimulant is a universal depressant, a disorganizer instead of being an organizer, and this would be literally true were it given in doses sufficiently large to overwhelm the bodily forces altogether, but the dose in which it produces its stimulant effects is comparatively small; and although it causes an increase of tissue waste in even such small quantities, it still invigorates the part on which it operates. This may not seem clear at first sight, but it is nevertheless true. It sacrifices a portion of tissue which is replaced by a more vigorous and healthy kind, and such a principle we find well illustrated in the action of nitrate of silver on chronic ulcers. The action between the silver and such a surface is of a chemical nature, and this operation generates molecular motion, which is communicated to the underlying molecules, and arouses them to renewed activity. Such an impulse is sufficient to awaken the dormant molecules beneath, and to force them to a more healthy nutritive activity in spite of the destruction and denudation of the surface parts; and the ulcer tends to a healthy mode of granulation, and heals up in every direction. Now we do not mean to say that iodine in its action is exactly parallel to that of nitrate of silver, yet the two can in some respects be compared with each other. Iodine, by increasing the bodily waste, must certainly tear down tissue which would not otherwise be torn down, and this is replaced by material endowed with greater activity; for any perturbation thus brought on in the body by any physical or chemical cause, if not too violent, will promote constructive metamorphosis. This accounts for the fact that patients, in whom the iodides are strongly indicated, do not lose in weight, but, on the other hand, they become strong, stout, and active.

Iodine, therefore, should never be introduced when there is reason to suspect that the body is unable to counteract its anti-vital tendency, for if the latter has not sufficient stamina to react, it is evident, from what has been said of its action, that it must undergo disintegration under its influence. It would be just as sensible to plunge a cholera patient, in the stage of collapse, into a cold bath and retain him there, as it would be to give the iodides to a patient who is suffering from the debilitating effects of a low and protracted form of fever, with the hope of arousing his depressed and flickering energies.

The efficacy of the iodides in the cure of syphilis stands unquestioned, and their action in this affection probably becomes clearer in the light of the above theory. It is only after the disease has become constitutional that the iodides prove most effectual, and this is precisely that stage of the disease when the syphilitic germs have become ingrafted and woven into the very texture of the body—particularly into that part which constitutes the white tissues, for which they appear to have a special affinity. Now the destructive action of iodine and the iodides will cause an increased waste, and if continued will aid in ridding the body of the diseased as well as healthy material, of course, and so give an opportunity to the constructive process to supplant it with healthy texture altogether. Such a *modus operandi* of the iodides in relieving syphilis would not be conceivable were the poison supply as unlimited as the nutritive supply, but it is reasonable to believe that if the depurating action of iodine be continued for a sufficient length of time, the poison will ultimately become exhausted, although it has the power of self-multiplication; while, on the other hand, the construction of healthy tissue is stimulated, and the body resumes its former vigor.

In all affections which are characterized by general or local molecular inactivity, such as indolent enlargement of the lymphatic glands, chronic swelling of joints, goitre, etc., iodine, if persistently applied, will very often arouse these parts and deflect them from their course of disease. Internally it is sometimes employed by inhalation for the relief of pulmonary consumption, but its internal use by the mouth is almost wholly superseded by the iodides, especially those of potassium and sodium, the action of which is almost identical to that of pure iodine. The iodides, in virtue of their superior diffusibility and greater adaptability, are more desirable for internal administration. And in subacute rheumatism, in rheumatic neuralgia, in sciatica, in the various chronic inflammatory affections of the pericardium and pleura, iodide of potassium, when given by the mouth, is a potent remedy.

COLD.

According to modern science, heat and cold are but two relative modes of molecular motion. We call a substance warm or cold when it possesses more or less molecular motion than our own bodies. Now motion, as we have seen, takes place in the line of least resistance, and generally speaking a great quantity of motion offers greater resistance than a small quantity;

hence motion, unless impeded, always tends from greater to less motion, or, in other words, from warm to cold. If the animal body comes in contact with a colder medium, or one that has less molecular motion than itself, it must necessarily lose a certain amount of its heat or molecular motion, and it is obvious that if the surrounding temperature were diminished to a sufficient extent, the body would be deprived of more heat or motion than is consistent with the maintenance of life; hence cold in this way becomes a direct depressant to the body.

In discussing the action of quinia, ammonia, etc., we saw how a moderate force which is antagonistic to life when brought in contact with the bodily forces, calls forth an equal reaction, and how by a succession of such impacts it is possible to elevate the standard of molecular activity of the body. We also saw how a force of such a nature by coming in contact with the bodily forces in overwhelming power, will ultimately limit and restrain the bodily functions. Now, in cold we possess a principle of action which is exactly analogous to the action of the above substances, and one too which is divested of all primary chemical complications.

But, before proceeding any further, let us briefly inquire whether the foregoing generalizations concerning the action of cold are found to be in accord with the knowledge which we obtain from experiment and clinical experience. Dr. H. C. Wood, Jr., while writing on the action of cold, in his excellent work on therapeutics,* says that, "It is *a priori* impossible to determine what effect upon the production of heat the rapid abstraction of it would have, but from the well-known powers of the organism to resist external cold, it seems probable that the heat-production would be increased, rather than diminished by the abstraction of caloric. An experimental study of this problem has been made by several observers, but with, unfortunately, different results. Weisflog has found that the local abstraction of heat, by a cold sitz-bath, causes a rise in the temperature of the axilla, and that in fever patients, unless the sitz-bath is prolonged over twenty minutes, no fall of the bodily temperature results. In 1860, Kernig found that a healthy man in a bath of the temperature of 28° to 30° C., produces about twice as much heat as normal; in baths of 24°, about three times as much; and in baths of 20° C., about four times as much. Liebermeister found that in a healthy man exposure to cold for a brief period of time causes a rise in the bodily temperature, and on extending his researches into fever proved, that where the external cooling was not too powerful or too long continued, the same was true of fever patients. From this it follows that the use of external cold stimulates heat-production. This, to my mind, has been confirmed by the clinical researches upon men of J. Gildemeister, of Dr. L. Lehmann, and of Prof. Liebermeister himself, and by those of A. Roeh-

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* Op cit., pp. 613, 614.

rig and N. Zuntz upon animals, all of which show that both in health and in fever very much more carbonic acid than normal is eliminated under exposure to cold. This would appear to prove that cold baths increase the production of animal heat. It seems most probable that this is the case; but A. Murri believes that he has proven that the cold baths have no such influence. At any rate, investigations of Liebermeister and others have shown that the first rise of temperature produced alike in healthy and in fever subjects, by exposure to a moderate and not too long-continued cold, is followed after removal of the cold by a fall of bodily temperature of greater or less degree. Whilst, therefore, external cold probably first stimulates, it afterwards depresses the production of animal heat. The further experiments of Liebermeister upon the elimination of carbonic acid are also in accord with his temperature study, for he found that after the bath, the elimination sank below normal, and continued so for some considerable time."

Now in order to harmonize, or intelligibly explain the discordant results which have been obtained by these different investigators concerning the action of cold, we must take special cognizance of several leading elements which determine its mode of action, viz., the degree of cold, the length of time that the body is exposed to it, and the condition of the body at the time of exposure.

A healthy body can be exposed to cold of a certain degree for a certain length of time without receiving any other than pure stimulant effects; while, on the other hand, a fevered body, when exposed to the same degree of cold for the same length of time, will in all probability become depressed in activity. This follows from the uniform physical laws that action and reaction are equal, and that motion takes place in the line of least resistance. A healthy body is able to withstand the aggressive action of a force, but this is not the case with a fevered body, for it possesses less resistance. In the former instance, the body is momentarily thrown out of its accustomed equilibrium, but in virtue of its inherent strength it is soon enabled to recoil and neutralize the action of the disturbing force; but in the latter case the body is too feeble to offer much resistance to the aggressive force, and hence a force of such a nature overcomes and depresses the augmented and abnormal activity of the body. Thus the effects of the same degree of cold on two dissimilar conditions of the body may be directly opposite in their nature. And, again, a body of feeble resistance may, if exposed to a cold bath or medium for a very short time, derive no other but stimulant effects from it; while, on the other hand, the same degree of cold will have a tendency to depress a body of stronger reactionary power, providing it be exposed to it for a longer period of time. Such results also follow from the above-mentioned physical laws. An aggressive force of a certain strength in operation for only a short time will make a slighter impression than it will if continued for a longer period of time, hence a body with but feeble resistance is able to counteract the effects of such a force for a short time only; while a body with greater resistance, if exposed to the same agent for a greater length of time, must eventually become depressed in function.

These are almost self-evident deductions, and our somewhat lengthy reference to them may seem unnecessary and superfluous, yet they are of extreme importance in studying the effects of cold upon the animal body; and it is for neglecting or omitting this precaution that the above-quoted observers have arrived at such directly opposite conclusions on this question, and in which their varying results will find a consistent explanation.

To say, then, that cold is an antipyretic, without qualifying the circumstances under which it so acts, conveys no intelligible meaning at all, for we also know that it is just as truly a stimulant; and these two terms are contradictory to each other, and can never be true of the same substance acting under like or similar conditions. We are here again reminded of the stern but oft-forgotten truth, that few, if any, therapeutic agents are characterized by but a single mode of action, but produce effects in keeping with the quantity administered or applied, and the condition of the body at such a time.

As a stimulant, cold is very efficacious in imparting a vigorous and transient impulse to the body. Most persons, by experience, know the refreshing and wholesome effect of a good wash of the face and head with cold water immediately after rising in the morning. It animates the senses, quickens the circulation, and infuses a new feeling into the whole body. So likewise a cool bath, provided the body possesses sufficient reactionary power, has the same invigorating effect on all the functions of the body. The plunge-bath is sometimes employed effectually for the purpose of suddenly arousing the bodily energies. A very successful mode of preventing persons from "catching cold" is to direct them to bathe their feet in cold water every evening before retiring; especially does this benefit those whose feet are the most fruitful sources of their colds. Such a procedure has a tendency to augment the resistance of the feet to extreme cold. A cold bath, or sponging of the abdomen, often proves of great value in relieving constipation. A cold drink before meals serves to invigorate the function of digestion.

Opium.

But very many of our medicinal forces manifest a decided tendency to act principally on special bodily textures, like the nerves, muscles, etc. The reason for this almost exclusive and special action of these substances I do not at present propose to discuss, but, in passing, I will say that one cannot overlook the fact, that by treating our therapeutic measures and the bodily functions as the embodiment of forces, this perplexing question becomes materially simplified. For the various functions or forces of the body, although they move in the same general direction and in harmony with each other, do yet differ in that special motion which is peculiar to each one; for one organ cannot perform the function of another, and hence a single force cannot affect them all in the same measure and to the same extent. A therapeutic force then may, on the one hand, move in greater harmony with a certain force of the body than with another, and so may accelerate the motion of the former, or may even be opposed to it and still enhance its molecular motion by acting as a mechanical stimulant; or, on the other hand, it may tend to move adversely to all the bodily forces in general, but on account of their relative differences of motion it will affect those functions with the greatest violence which are opposed to it in the most direct manner (for such will either be brought to a state of rest or become wholly disintegrated), and only partially deflect those functions which move with a less degree of opposition to its course. This, however, can only serve as a partial explanation of the principle which governs the elective affinity of medicines, for the intensity with which they act, and the readiness with which they are absorbed and distributed throughout the body, are also important factors in determining the territory on which they act.

It is universally recognized that opium is one of those substances which by its almost exclusive action on the nervous system has the well-known power of relieving pain. And in order to carry out the true idea or design of this paper, it is extremely important for us to arrive at some definite conception of the nature of its action, and hence are constrained to ask in what manner does opium relieve pain? To answer this properly, we must study the physical basis of pain, and hence must inquire into the function and action of the nervous system.

The animal organism possesses two distinct sets of nerves, one which receives impressions from the outside, and transmits them to the centre, where they are reflected by gray matter, and taken up by another set of nerves and transmitted in a centrifugal direction. The first set is called the sensitive nerves, and the second set is called the motor nerves. The former only manifest the characteristic phenomena which we denominate pain. Now the reception of an impress by a nerve from the outside implies the reception of some kind of motion or force, and sensory, like motor nerves, have the power of only transmitting a certain amount of force or motion for the time being. Any long-continued impression will destroy their physiological capacity for further conduction. If, for example, any mechanical, thermic, or electric stimulation be applied to a sensitive nerve, instantaneous contraction of the corresponding muscle takes place, but the muscular contraction thus set up will only be momentary, even if the stimulation is continued; however, if the latter is omitted, and the nerve allowed to rest for a short period and then reapplied, the nerve will be able to throw the muscle into contraction again with almost the same vigor as before. Now the interval between these nerve-pulses or waves are employed in recuperating the exhausted condition of the nerve, for the performance of work implies a concomitant destruction and waste of its matter and force.

Again, take the optic nerve, which is a purely sensitive nerve, and which is capable of receiving the ordinary waves of light; but if the eye is suddenly exposed to the strong glare of the noonday sun, vision is totally abolished, and the eye becomes positively painful. Intensified noise can likewise destroy the sense of hearing, and actually cause pain in a perfectly normal ear.

Or, again, a gentle degree of warmth exercises a marked pleasurable influence on the body, especially if previously exposed to a lowered temperature, but an extreme degree of heat will give rise to intense pain and suffering. Now all heat is a mode of molecular motion, and these two opposite conditions of the body, the one normal and the other abnormal, are the effect of different degrees or quantities of molecular motion. In the former instance the nerves of the body encounter waves of molecular motion which move in close conformity to their own, or, at any rate, are such as they habitually receive and transmit; hence, in virtue of being in harmony with the waves or oscillations of the nerves, they move in the same direction together and cause an agreeable sensation; but in the latter instance the waves of molecular motion, which we call heat, are so intense, and their rate and intensity of motion so adverse and incompatible with those of the nerves, that they impair the delicate structure of the latter to such an extent as to destroy all power of communication, and the pain is the legitimate result of this nervous disorganization.

From all these facts we are able to learn that all impressions which consist of oscillations in harmony with those of the sensitive nerves, produce agreeable sensations, and those which are incongruous with them, give rise to pain. This line, however, may be moved from one position to another, for an impression may produce a feeling of comfort and pleasure at one time in a nerve, and at another time may become a source of pain, as, for example, the optic and auditory nerves in an inflamed state are exceedingly sensitive, and manifest a sense of pain under an impression so slight, which would prove nothing else than an agreeable stimulus to these organs in a state of health. This is in strict conformity with what we have reason to expect, for a nerve in health has one kind of wave motion, while in disease it must have another, and that of an inferior kind, because its structure and functions differ, however slight, in the two conditions; hence the reason why a nerve in disease has not that capacity to transmit an impulse which it has in health.

So then we have strong ground for believing that the intimate nature of pain has some direct connection with and dependence on the molecular structure and motion of the sensitive nerves, for it is always absent where a correspondence or co-ordination exists between the impress and the state of the nerves, and, on the other hand, it is always caused when these two factors are out of all normal relations. But before assuming too much let us see how far this view is corroborated by important and well-known authority.

The late Dr. Anstie,* while speaking of pain in general, says that, "The leading fallacy, in the common view, is the confusion which is perpetually being made between *function* and *action*. Now, the function of individual nerves is very nearly a constant quantity, at least it varies only within narrow limits, while the action of the same nerves may be almost anything. The function of the nerve is that kind of work for which it is fit when its molecular structure is healthy; it is the series of dynamic reactions which are necessarily produced in nerve-tissue by the external influences which surround and impinge upon it in the conditions of ordinary existence. The action of nerves under the pressure of extraordinary influences, may include all manner of vagaries, which really have nothing in common with the effects of ordinary functional stimulation, which are, in fact, nothing but *perturbation*. . . . . . If pain be not a heightening of ordinary sensation, then we seem to be shut up to the idea that it is a perversion owing to a molecular change of some part of the machinery of sensation which *frustrates* function." And Dr. J. K. Spender† says that, "What has now been said ought not to

* Neuralgia and Diseases which resemble It, pp. 8, 9.

† Therapeutic Means for the Relief of Pain, p. 5.

forbid us to study pain predominantly on its physical side. From this side we may hope to approach it, to meet it, and to grapple with it. Endowing it with substance, if not with form, we seem to see our enemy and to challenge him. Clothing pain in the reality of fact as much as we can, we are the more impelled to search for a physical basis to physical phenomena, and to discard the idea of 'functional derangement' as unphysiological and irrational. . . . . It is at least safer to act as if physical changes were at the root of morbid phenomena; for we can contend more distinctly with them, and it is much more comfortable to believe that we are dealing with objective truths than with ghostly and unimaginable things."

But if pain is the result of disordered molecular activity, or of nutrition of the nerve in which it occurs, then we ought also to find confirmatory evidence to this effect in those pathological conditions where it is a characteristic symptom. Definite evidence of such a character can perhaps best be found in pain which is caused by pressure on nerve-structure. Such examples we find in the history of cases of aneurism and organic tumors, which very frequently develop in close proximity to some important nerve or nerve-centre, and by continuous pressure occasion the most excruciating pain. Now it is very obvious that any pressure on a nerve will at once greatly interfere with its molecular activity at least. Dr. Anstie, in the work above quoted, states that in neuralgia "it is universally the case that the condition of the patient, at the time of the first attack, is one of debility, either general or special. . . . . It is certainly the case that the larger half of the total number of cases of neuralgia which come under my care, are either decidedly anæmic, or else have undergone some exhausting illness or fatigue."

Moreover, the migraine, or sick-headache, which is brought on in women who suffer great loss of blood during childbirth, the constant pain in mercurial salivation, the pain in inanition, the pain of locomotor ataxy, the pain of dysmenorrhœa, of chronic alcoholism, of syphilis, of gout, and of rheumatism, all point to the undoubted existence of an enfeebled and depressed state of either the *nutritive* or molecular activity of the nerves, or of both. While, on the other hand, we very frequently find that pain disappears more or less quick as the circulation becomes more active in a part; for, toothache, as a rule comes to an untimely end when the face begins to swell, the neuralgic pains of herpes zoster usually subside as soon as the inflammatory eruption appears, and the incipient gout and rheumatism usually are alleviated when the local inflammation of the joints has fully developed itself.

Thus, then, pain can no longer be looked upon as being due to an overexcited or hyperæsthetic condition of a nerve, and be accordingly treated with measures which are calculated to lower its vitality still further; but, on the other hand, we must be alive to the fact that pain is always an indication of a deranged state of nerve function, and for its alleviation, as a rule, requires the most persistent supporting treatment.

The leading indication, then, in the treatment of pain is a supply of material which has the power to promote and enhance the molecular action and nutrition of the nerve-structure, and this object, whenever practical, is best obtained by the administration of good, nutritious, and stimulating food. This may seem heterodox, and rather a strange doctrine to preach, for it is currently believed among the profession that it is absolutely vital to abstain from all kinds of food when a patient is suffering from pain; but from information gained through others, and from repeated observations on this point myself, I am convinced that many kinds of pain, such as some forms of headache, neuralgia, etc., are often very rapidly relieved by the ingestion of a good wholesome meal. Anstie lent the whole strength of his powerful pen in support of this idea, and this belief is shared in by a great many other prominent writers. Dr. G. Fielding Blandford, in an article in *The* (London) *Practitioner*,* "On the Value of a Large Supply of Food in Nervous Disorders," says that, "Believing with many others that neuralgia is one manifestation of impaired sensibility, as other neuroses may be displayed in mental symptoms, and in these alone, I think that the radical cure, and not the mere allevia-

* Vol. iv., p. 340.

tion, is to be found in many cases in the supply of a large amount of nutriment to the nervous system. . . . . . Those whose experience is greater than mine, speak highly of the utility of fatty food, of cod-liver oil, cream, butter, and the like. Whatever the form of food specially indicated, it generally will be found that the entire amount requires to be increased, and that the quantity taken for a series of years has been deficient."

Now, I do not wish to be understood as saying that food is the best way of relieving pain under all circumstances, for in many cases that end can be attained more effectually and securely by other means, simply because they are more practicable, are more readily introduced into the circulation, and hence they act more speedily; but, whenever and wherever food is or can be assimilated or taken up by the blood-current, it is the most serviceable and permanent remedy for the relief of pain that we have at our command; especially is this true of the fats and oils. And this is precisely what it should be if what I have already said is true, for if pain is the result of deranged molecular activity, or of deficient nutrition in a nerve, then ordinary food is the most suitable vehicle in which to restore this want. That pain very often solely depends on a disturbance of the molecular activity of a nerve, without any, or at least a great deal of nutritive impairment, is evident from the fact that very often this morbid phenomenon is readily relieved by forces or agents which do not supply anything but molecular motion to the nerve. Witness, for example, the suddenness with which the domestic mustard plaster, or the gentle friction, or the hot plate, or the hot poultice, often relieves intestinal colic and other forms of acute pain! Now, these agents do not, and cannot, relieve pain by contributing any material wherewith to repair nerve-structure, except such as we have seen naturally follows the act of pure stimulation, but merely by increasing or promoting its molecular activity.

As a preliminary to the discussion of the action of opium I would say that we have good grounds for believing that in small doses it relieves pain by acting as a mechanical stimulant. But it is quite a difficult matter to discriminate between the action of small and large doses of opium, if we are compelled to rely wholly on experimental evidence, for this is mostly unreliable and unsatisfactory; but the fact that about four hundred millions of the earth's inhabitants are daily consumers of opium, and also seem to thrive under its use, is one of great significance and of very great value in obtaining a clew to its action in ordinary or small quantities. We cannot for a moment suppose that this large proportion of mankind uses opium with a view of obtaining its narcotic or paralyzing effect, for this would lead to terrible fatal results, and would soon depopulate that portion of the globe; but, on the other hand, we have the most unquestionable proof that opium sustains these people under the most laborious and protracted physical exercise. The palanquin-bearers and messengers of India, for instance, travel over almost incredible distances on nothing but a bag of rice, opium, and a cup wherewith to obtain water. The Tartar couriers, when compelled to travel both day and night across the hot deserts of Asia, use opium in connection with their often small allowance of food. Dr. Barnes, an Eastern traveller, in his *A Visit to Scinde*, etc., gives a telling instance of the usefulness and reviving influence of opium in the following language: "On one occasion I made a very fatiguing night-march with a Cutchie horseman. In the morning, after having travelled thirty miles, I was obliged to assent to his proposal of halting for a few minutes, which he employed in sharing a quantity of about two drachms of opium between himself and his jaded horse. The effect of the dose was soon evident in both, for the horse finished a journey of forty miles with great apparent facility, and the rider absolutely became more active and intelligent.* Dr. Barnes declares that moderate opium-eating does not appear to shorten life or to decrease vigor, an opinion in which he is supported by numerous competent authorities on the customs of the East—amongst others by Dr. Eatwell, who states that the health of the workmen in the opium factories is quite up to the average standard, and that the effect of the habitual use of the drug on the mass of the people (in China) is *not* visibly injurious." . . .

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* See "Stimulants and Narcotics," Dr. Anstie, p. 148.

"De Quincey mentions the fact that many poor, overworked folk, in towns like Manchester, consume regularly a moderate amount of opium; not using it as the means of a luxurious debauch, but simply to remove the traces of fatigue and depression; and the experience of physicians who know the poor of London, would testify to the considerable prevalence of this custom among that class. It has frequently happened to me to find out, from the chance of a patient being brought under my notice in the wards of a hospital, that such patient was a regular consumer, perhaps of a drachm of laudanum, or from that to two or three drachms, *per diem*, the same dose having been used for years without any variation. And I am assured that the practice is very extensively carried out in many parts of the country, just in this way, by persons who would never think of narcotizing themselves any more than they would of getting drunk; but who simply desire a relief from the pains of fatigue endured by an ill-fed, ill-housed body, and a harassed mind."

Now any effort to attribute this phase of the action of opium to its narcotic influence would simply be puerile, to say the least of it, for narcotic action implies devitalization, and it is inconceivable that a substance having such a tendency of action could, under such circumstances, directly revivify and reinvigorate the depressed and worn-out body. Some believe that this action of opium, in small doses, can be accounted for on the supposed principle that it impedes or checks the tissue-waste of the body, but after a little reflection this view likewise appears untenable. For the sake of argumeut, let us suppose that a certain amount of force is expended by the body in the shape of muscular work. We very well know that, in accordance with an elementary law in physiology, no muscular or other work can be performed by the body unless a preceding consumption of force and tissue occur in the body; hence anything which will have a tendency to retard this waste or metamorphosis of tissue, will just in that measure diminish the working capacity of the body. An agent, then, having such an action would not only not enhance the endurance and working condition of the body, but would be a positive detriment to a performance of its healthy functions.

Thus, then, the only plausible and logical theory of the action of opium, at least in small quantities, is that it has the power of rendering support to the bodily functions. That it cannot accomplish this by undergoing chemical change in the body, like alcohol and the fats and oils, for example, and thus act as a chemical stimulant, is evident, for we possess no proof at all that it is so changed in the body, at least not to any great extent, nor that it is capable of maintaining life for any length of time alone. Hence the only way which is left to account for its action is that of a mechanical stimulant; or, in other words, that by means of the circulation it comes in contact with the nerves of the body and arouses their molecular activity, and thus restores the depressed activity of a painful nerve, in a manner similar to the action of a mustard plaster, or of friction when applied exteriorly. That it is possible to conceive of such an internal action of opium is plain, if what has already been said concerning the action of quinia and of other mechanical stimulants be true. For there can, I think, be no question but that quinia in small quantities invigorates the bodily functions by acting as a mechanical stimulant, and if it is possible for quinia to act in this way on the body generally, why is it not possible for opium to act in somewhat the same way on the nervous system specially? And what is true of the action of opium, is also substantially true of the action of cocoa, haschish, tobacco, coffee, and chocolate or cacao, for all these substances yield indisputable support to the animal body while performing severe labor, either manual or mental.

That opium does not, in the majority of instances, relieve pain by large or narcotic doses, is very clear from the fact that in such quantities it produces pain. The "opium pains" are of very frequent occurrence among those who consume it in continued large and intoxicating doses. The same is also true of large or narcotic doses of alcohol, for the pains of chronic alcoholism visit all those who are in the habit of abusing alcoholic drinks. And it is also true that the pain which is produced by large and continued doses of opium can be relieved by small doses of the same article, and small doses of alcohol are also capable of alleviating the pains of chronic alcoholism; in fact the administration of alcohol in small quantities in delirium tremens—a morbid condition produced by the same substance in large and inebriant quantities—is often resorted to by the medical profession, and is looked upon as rational and expedient practice. In this we find a striking corroboration of the theory of pain which I have advanced in these pages (by no means original with me), as well as of the probable method by which opium relieves pain; for if pain is, in great part, the result of a devitalization of nerve-force, then it is exceedingly unwise to administer opium in such a quantity that it could still further impair the vitality of the nerve (which a narcotic dose would do); but rather, if possible, give it in such a manner as to re-invigorate the enfeebled nerve.

Again, the sleep or stupor (for sleep it cannot be called) which is brought about by large or narcotic doses of opium is not associated with a condition of the brain similar to that which accompanies natural sleep, nay, we have some reason to believe that the sleep of opium narcosis is the result of a condition of the brain precisely opposite to that of normal sleep; for in the former state we find hyperæmia and congestion of the bloodvessels in and around the brain, while the latter state is always marked by cerebral anæmia.

Physiological sleep is a certain state of rest of the brain, which is superinduced by a state of activity. Although the cerebral circulation is exceedingly active during waking hours, not a sufficient amount of aliment is afforded to the brain to enable it to undergo thorough repair under continuous exertion, hence very naturally there must arrive a period when its expenditure exceeds its income to such an extent that it becomes essential to check the amount of waste, and allow the process of repair to regain its lost ground. This period of repose we call sleep, which is very nearly constant in each individual.

Now, in disease the processes of oxidation and of nutrition in the brain are very often greatly impaired, and sleeplessness results, and any measure which is calculated to promote these processes will tend to deflect this abnormal condition of the brain, and thus secure sleep. We are, therefore, inclined to believe that by replacing the waste force of the brain, opium, in small doses, brings on sleep; for it is in this wise only that we can account for the hypnotic influence of good and easily digested food. It is frequently observed that the administration of rich and nutritious food, such as milk, meat-juice, etc., to a patient suffering from the restlessness and sleeplessness of typhoid fever is followed by a deep and refreshing sleep.

Thus, then, in all probability we can look upon opium in small doses as being capable of relieving pain by its power to supply the elements of force which are essential to maintain the functional integrity of the nerve in which the pain is located. Although there is no question on the other hand that pain can be, at least temporarily, relieved by opium in large doses; yet it is a very easy matter to decide which of these two methods of relieving pain is the most rational and scientific treatment: in the former way the nerve is elevated from its diseased to a normal state, and by the latter method it is still further depressed.

CHAPTER V.

MECHANICAL STIMULANTS—CONTINUED.

Antimony,	*Turpentine,*
Croton oil,	*Picis,*
Cantharides,	*Hot Linseed Poultices,*
Mustard,	*Hot Baths,*
Ammonia,	*Friction, etc.*
Iodine,	

THIS is a class of medicinal substances which, when brought in contact with the body, give rise to increased activity, and are commonly known under the name of *counter-irritants.* I believe, however, that this term as applied to the remedial action of these substances to be out of place, for I shall bring forth evidence to show that irritation is not one of their common products, and that even when such an effect is produced, as is the case with some of them, it ought never, as a rule, to be transmitted to the seat of disease; and the prefix counter, which indicates that they act contrary to disease, seems to me equally misapplied, for the obvious reason that the majority, if not all of our medicines, tend to act contrary to disease, and we might for the same reason have counter-tonics, counter-depressants, counter-nutrients, etc. We shall see that their action naturally falls in with the class of remedies which we designated as mechanical stimulants, for their action in principle is somewhat analogous to that of quinia, ammonia, etc., in small quantities, only that the latter act by being introduced into the body, while these act by being applied externally.

The *modus operandi* of these substances is currently believed to consist in causing accelerated action of the surface of the body, producing redness, and thus inviting the superabundant blood away from the diseased organ over which they are applied. The validity of such a depletory view of their action may well be questioned on the strength of various well-founded reasons; for the happy effects which we obtain from the treatment of neuralgia by blistering cannot possibly be owing to the depletion which is believed to be occasioned by the latter. The pathology of neuralgia and the depletion theory of the action of these remedies, are in such direct opposition that no conceivable benefit can be derived from a blister on the depletionary plea. It is now well known, that neuralgia is dependent on an anæmic and depressed state of the circulation, and a depletory operation would certainly deprive the already diseased blood of a valuable and important ingredient, and thereby aggravate the disorder instead of mending it. Nor can the action of these substances on deepseated inflammatory diseases of the chest, for example, be explained in the light of such a theory. For as we have said elsewhere,* "Let us suppose . . . . that an inflamed lung contains about ten or twelve ounces more blood than it does in the normal state, and now let a reasonably large blister abstract from the skin and subjacent tissues about two ounces of serum, which is surely a large allowance. The drain, of course, primarily falls upon the mammary, intercostal, and thoracic bloodvessels, which are given off by the aorta and other principal vessels; hence the whole circulation through the medium of the aorta is drained, each portion of the blood receiving its proportionate share. Now, by abstracting two ounces of serum from the whole body of the blood (which amounts to near 300 ounces), we can imagine what an insignificant loss would be sustained by one or both lungs.† . . . . Or again, take any cutaneous inflammation, *eczema* for instance, and where, let us ask, is the medical practitioner who has not witnessed a disappearance of the redness and inflammation and a healthy color of the skin substituted under the influence of a poultice? The evident hollowness of this theory becomes very glaring in this latter case, for here the supposed counter-irritant is brought in direct contact with an inflamed portion of the skin, and if it were true that this agent relieves disease by

* American Journal of Medical Sciences, July, 1877, p. 166.

† Since writing this, we found that Dr. Anstie had made use of an almost identical illustration in showing the absurdity of this depletory idea.

simply inviting a larger amount of blood in its immediate vicinity, then it should take place here; but instead of this the part becomes paler, and the inflammation disappears. . . . Such are some of the invulnerable obstacles in the way of accepting the depletion theory of counter-irritation as being the true one, and it is very manifest that a theory which does not make clear all the facts which it is professed to explain must fall to the ground."

Before discussing the influence of these substances on disease, let us briefly inquire into the law or principle, if there is any, which guides their physiologic action. We have already learned that when two forces meet in antagonism, that motion will take place in the line of least resistance, and that an opposing force, if moderately applied to the body, will ultimately promote molecular activity. Let us again, and more minutely, follow the intimate changes which take place when a force like friction is directed against the body. The primary effect of such an action consists in an increase of molecular activity, which in turn excites the circulation; if the force is applied with greater severity, more and more blood will be invited, and the capillaries will become distended to such an extent as to force the serum of the blood through the meshes of their walls, and hence effusion is the frequent result. The concentration of the blood, the rapidly filling of the vessels, and the effusion or vesication, only follow when the attacking force operates actively and with intensity; whereas, on the other hand, if the operation is slow, protracted, but also severe, the process partakes more of the nature of a regular course of inflammation, and pustulation—one of the products of inflammation—will be the result. This last effect, however, as a rule, is not brought about by friction. Among this class of medicines we possess substances which represent every variety and stage of the above process.

In friction we have an agent which is calculated to induce only a mild degree of molecular activity. In cantharides, ammonia, and mustard, we find substances which act with great rapidity and consequently produce vesication; and in antimony and croton oil, we possess those which are slower in their action, and which usually produce pustulation.

Since heat is a mode of motion, it cannot be said that it operates on the body in the same way as an antagonistic force does, at least not in small quantities; but the greater or heat motion is merely communicated to the body, and in this manner excites molecular activity, the result in the two instances being similar, differing only in their modes of action. Friction is an example of pure physical stimulation, but cantharides, mustard, etc., partake more of the nature of chemico-mechanical stimulants.

The quantity of motion which is thus conferred on the body is then, generally speaking, equal to the capacity of the substance for causing such motion, and is transmitted from molecule to molecule until its energy is expended. The impulse of a blister penetrates deeper than that of moderate friction, or that of a transient mustard plaster, a principle which is of paramount importance in the practical application of these agents. However, those of the above substances which produce the most violent effects, are also capable of bringing about effects which are characteristic of those of milder action, provided they are applied for a short period only; hence, we also see that time is an important factor in determining the resultant action of many of these substances.

Having taken a hasty glance at the physiological action of this class of stimulants, and offered some reason for the belief that they act by enhancing molecular activity, we will now also consider their therapeutic action in the same light. In these substances we control forces which can be made to yield their power for good or evil, according to the manner in which they are directed. But if we direct a force against another, it is very obvious that we should at least have some definite or partial knowledge of the force which we are endeavoring to combat, *i. e.*, disease, hence arises the intimate nature between therapeutics and pathology.

To study the effects of mechanical stimulation in disease, and as a still further verification of our hypothesis, we will inquire, somewhat briefly, into the pathology of neuralgia, of rheumatism, of gout, and of inflammation, diseases in which this form of treatment has proved highly successful.

In all cases of neuralgia, either the general or local condition of the sufferer at the beginning of the attack is one of anæmia, depression, and debility. The affected nerve has not sufficient power to retain its healthy function of nutrition, and hence its vitality falls below that standard which constitutes *nerve health.* Now, among the external applications in neuralgia, none rank higher than the blister, and, indeed, Valleix asserted that it is the most efficient mode of treating this disorder. But the beneficial action of a blister in neuralgia cannot by any means be attributed to the drain of serum. The intention to deprive a half-starved nerve of its nutritive plasma, and thereby depress it still further, is the acme of folly and the very thing to be avoided. More in accordance with facts and reason is it to believe that the blister by its chemical action on the skin, imparts its motion thus generated to the molecules of the nerve through the intervening textures, and thereby it is stimulated to increased and more healthy action, and the serum which forms on the surface is to be looked upon as the result of a violent action which had taken place between the blister and the skin.

In gout and chronic rheumatism, Dr. J. K. Spender, in his work on *Therapeutic Means for the Relief of Pain*, says, "that the application of blisters is proverbial for its almost immediate efficiency," and if there is some disagreement in regard to the pathology of rheumatism, there can certainly be none concerning the cause and pathology of gout, for in this disease the *materies morbi* has been isolated and its nature determined. Dr. Bence Jones says* that "the urate of

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* Pathology and Therapeutics, p. 125.

soda bears the same relation to gout that sugar does to diabetes; and as the want of oxidation of sugar is the cause of the diabetic diathesis, so the want of oxidation of the urates, and their consequent accumulation in the textures and blood, is the cause of the gouty diathesis." Now in health all the albuminous foods and tissues pass through a complex series of chemical changes in the body, until finally transformed into urea, carbonic acid, and water; but if from any cause the albuminous food is not fully oxidized, and the chemical transformation is thus suspended, partly or wholly, after the production of uric acid, then this substance combines with soda, accumulates in the blood, diffuses into all the structures of the body, becomes deposited in the least active parts of the body, and hence it manifests itself in the non-vascular tissues under the familiar name of gout.

One noteworthy phase of this disease is the fact that although the poison diffuses equally very nearly throughout the whole body, yet it almost exclusively manifests itself in those textures in which there is the least amount of activity. This evidently shows that the urates are eliminated and probably oxidized in those localities where the greatest activity prevails, and remain behind and perform their mischievous work in those parts which are least active. Obviously, then, the most prominent indication in the treatment of these deposits in the joints and cartilages, is to promote the molecular activity of these structures, and thus expel them from the body. Now we are already aware that mechanical stimulants have the power to enhance molecular activity, and in this way promote the disappearance of these deposits; hence we can account for the benign action of these remedies in this disease. The intense chemical motion which is set up by a blister, for example, in the molecules composing the skin and subcutaneous tissues, is transmitted to the molecules of these less vascular tissues, which, in consequence, are impelled to a greater degree of motion. This increased molecular motion invites a more active circulation of blood to the part, and in this manner the processes of oxidation and nutrition are stimulated, and thus we follow that mode of action which takes place in other parts of the body where this same poison is eliminated naturally.

The morbific poison of rheumatism has not yet, like that of gout, been detected and separated, but there is every reason to believe, from the great similarity of their symptoms and course, that a close relationship exists between their etiology and pathology. Drs. Richardson and Harley have successfully produced artificial articular rheumatism, even complicated in one instance by endocarditis, by the injection of lactic acid under the skin of animals. But the cause of rheumatism may be lactic acid, or some other product yet undiscovered, which, like that of gout, is oxidized and thrown out of the most active parts of the body, and retained in those of the least activity; and if this is true, then, the advantageous action of mechanical stimulants in rheumatism can be accounted for in the same manner as their action in the case of gout.

Dr. A. B. Garrod, in his article on "Rheumatism," in Reynolds's *System of Medicine*,* says that "Dr. Herbert Davies has recently revived the use of free blistering, and orders armlets, wristlets, and even fingerlets of blister plaster, at the time when the inflammation is most acute; he recommends linseed-meal poultices to be subsequently applied, in order to promote the free flow of serum; he places these blisters entirely around the affected limbs, and in the case of the knees, orders them of at least three inches wide, regarding any slight strangury which may arise as of little importance compared with the benefit afforded by free vesication.

"According to Dr. Davies the blister treatment causes a speedy diminution in the frequency of the pulse, rapid subsidence of the joint affection, and lessens the liability to cardiac inflammation; within twenty-four hours after the removal of the blisters the urine is stated to become alkaline in reaction. Dr. Davies's results in a large number of cases appear to be favorable."

Such a plan of treatment in rheumatism we can give our unqualified approval, having frequently seen the most intense articular pain relieved in the course of five or six hours by means of a good-sized blister applied in close proximity to the joint.

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* Vol. i, p. 951.

Through the researches of Burdon-Sanderson and others the intimate nature of inflammation has come to be well understood. It is characterized by a sudden and decided perturbation among the normal forces of the body. Molecular motion is increased, the circulation is hurried, cell proliferation is augmented, and finally blood stasis ensues. The processes of oxidation and nutrition are unduly excited, and impairment of the textures and of their functions is the result. Inflammation is a disintegrating force, and its effects are exactly proportionate to its violence, and it tends to spread like any other force in the line of least resistance, and does propagate itself from molecule to molecule until resisted by some opposite or healthy force. If this latter event does not occur, then it will overcome all the essential bodily forces and produce death. If the disease is less violent and the bodily forces in a comparatively healthful state, then extensive diffusion is restrained, and it is limited to a smaller area than under opposite circumstances.

Thus, then, the severity of the inflammatory process depends on several factors, viz., the quantity and quality of its own force and those of the bodily forces. This is well exemplified in the process of mortification, where the "line of demarcation" forms on the battle-ground between healthy and morbid molecular action; indeed, this line may be locating itself in a certain place, and the strength of the patient from some cause be suddenly depressed still further, thus diminishing the resistance of the healthy forces, and allowing the line to settle still closer to the central part of the body. Or, in the severe shock of injuries, the blow very often is grave enough to disturb the equilibrium of the forces of the body so completely that molecular reaction becomes impossible, and death is the consequence.

On the other hand, a strong and healthy body is almost entirely exempt from the invasion of any disease, at any rate such a constitution is less liable to contract disease than one which is already partly broken down. Again, it is well known that mortification and gangrene are more apt to follow wounds which occur in individuals with a depraved health than under opposite and more favorable conditions; and that even wounds themselves heal more rapidly and kindly in strong than in weak bodies. The same conflict between healthy and diseased action is well witnessed in chronic ulcers, where the line between health and disease advances and recedes, making the ulcer appear large at one time and small at another, in direct correspondence with the strength of the part; and it is a noted fact that the line of treatment which is pursued by all rational practitioners in this disease is that of endeavoring to maintain or enhance the resisting power of the patient by various means, among which the mechanical stimulants occupy a very important place. In threatened invasion of mortification and of gangrene, the early application of a warm poultice will often avert the danger, or at least tend to circumscribe it and limit it to a smaller area than if left to its own unrestricted course. In lacerated and crushed wounds and contusions, such as are usually produced by heavy machinery, there is often a disposition towards coldness, and with but little tendency to react; the persistent application of a warm poultice will frequently restore the injured parts to a more healthy state.

But, inflammation is a phenomenon of increased molecular activity, and *mechanical stimulation* the same: how is it possible to derive any benefit by bringing the latter to bear on the former? Apparently it seems like adding fuel to the fire instead of quenching it, but on closer inspection this difficulty vanishes.

We have already seen that the process of inflammation is a disintegrating force, tending towards death; hence it cannot move in harmony with, but from its very nature must move in opposition to the vital forces. And we have also seen that any force which has the power to increase the molecular activity of any portion of the body to the full limits of health, will just in that proportion enhance the strength and resistance of that part; therefore, the effects of such a force must conform with the motion of the vital forces.

Mechanical stimulants then have the power to generate a more healthy impulse among the bodily molecules, if rightly directed, and in this manner elevate their standard of action and enhance their resisting power; and it is invariably true that in inflammation, as well as in all other diseases, the resisting power of the body declines considerably, especially in that portion which immediately surrounds the diseased process. For it cannot be said that there is any sharp and abrupt line between health and disease, but rather that one gradually merges into the other. Not only are the morbid effects of inflammation confined to the spot which is visibly involved in the degenerative process, but they radiate in every direction, from the centre to the circumference, becoming fainter and fainter until they die away. They are like the inaudible waves of sound, which could be detected and heard had we but instruments wherewith to perceive them. Thus in acute catarrh or tonsillitis, for example, where the inflammation is limited to a small territory only, a feeling of depression and of demoralization pervades the whole body.

Hence the chief aim in the employment of these remedial measures in inflammation is to direct them in such a manner as to arouse the surrounding molecules from their depressed state, and to promote their resisting power, and thus by degrees encroach on disease, and move the battle-line into regions previously occupied by it. It is plain that this can be accomplished; for any cause which will promote healthy action in a molecule, will spread its influence further, and will also enhance the resisting value of any contiguous molecule, and by the continuation of such a process of stimulation, healthy action will be propagated from molecule to molecule, and the province of inflammation will be invaded, and the disease itself be driven from its intrenchment and gradually obliterated. Mechanical stimulants in this way not only serve to repel disease, but also to hinder its spreading, and hence they must be looked upon as preventives as well as means of cure.

From the consideration of the action of these substances in such a light, another very important inference is to be drawn in regard to their therapeutic employment, viz., to generate only that much molecular motion on the outside as is necessary to overcome and successfully deflect or remove the disease within. In order to reap the greatest practical advantage from this principle it is necessary to possess at least an approximate idea of the relative strength of the two forces, as well as of the facility with which an impulse can be transmitted from one to the other. Now, an active and vascular tissue (since great vascularity and great activity go hand in hand) is more easily stimulated and impressed than one which is less vascular and less active; hence, as a rule, less force is required to stimulate and transmit an impulse through a vascular texture than through one which is more dormant and less vascular. Again, chronic diseases, other things equal, are more firmly located, and offer more resistance than acute diseases, hence a greater quantity of force is necessary to disturb the equanimity of the former than that of the latter. And again, those diseases which occur in the more quiescent or white tissues of the body, such as the serous and fibrous, are less easily displaced and impressed than those in the more active and vascular structures; hence a greater degree of force is necessary to dislodge the former than the latter.

This serves to explain the fact, which is confirmed both by theory and experience, that the violent forms of mechanical stimulation, such as blisters, etc., if indicated at all, act more favorably in acute inflammatory affections of the white tissues, as in pleurisy, peritonitis, rheumatism, etc., particularly in the last; while the milder forms, such as poultices, are employed with greater benefit in acute inflammatory states of the mucous and more vascular tissues, as in pneumonia, bronchitis, enteritis, etc. While, on the other hand, it is in chronic diseases in which poultices or the milder forms of stimulation alone are altogether useless, and that blisters act with the most decided benefit.

The meagre success which has attended the administration of mechanical stimulants in the hands of some, has been due in a great measure to their reckless employment, for no doubt a large number of acute inflammatory diseases, as pneumonia and bronchitis, for example, have been greatly aggravated by the blind and indiscriminate use of large blisters, no doubt wholly contraindicated in the majority of cases. It is safe to say that the application of blisters in many of the acute inflammatory diseases, is an unwarranted measure, and a much better result is achieved by the use of the milder forms of mechanical stimulation, which diffuse their influence quickly enough, without being attended by the risk of generating morbid action in the already diseased organ, which unhappily is too often the case when the harsher forms are employed. For that part which is immediately exposed to the violent action of a blister, for instance, surely is forced into a morbid state; but this irritation, if the stimulant proves serviceable, is never transmitted to the seat of disease below, but is confined to the superficial tissues. Hence it must be evident that any irritation on the outside, sufficient to cause extensive and deepseated inflammation, may soon extend its effects to the underlying structures, and thus provoke instead of alleviating the disease.

In the treatment of neuralgia by mechanical stimulation, the late and much-lamented Anstie, in discussing the action of these substances, says that "the view which I am strongly convinced alone explains the beneficial action of blisters, is that which supposes them to act as true stimulants of nerve function. In order that this effect shall be produced, it will be necessary that the skin irritation be either produced at some distance from the seat of the greatest pain, or that, if applied in that spot, it shall be comparatively mild in degree; and, accordingly, I have been led, in my later observations, to apply the blister at some distance from the focus of pain. *An indifferent point, however, will not do;* there must be an intelligible channel of nervous communication between the irritated portion of the skin and the painful nerve. This object is accomplished by placing the blister as close as may be to the intervertebral foramen, from which the painful nerve issues; the effect of this is probably a stimulation of the superficial posterior branches, which is carried inward to the central nucleus of the nerve. I must say that the results which I have derived from this plan of treatment have been far more satisfactory than those which I used to obtain when I habitually applied the vesication as near as might be to the focus of peripheral pain; and I think that this result tallies well with the idea that the essential mischief in neuralgia consists in an enfeebled vitality of the central end of the posterior root."

In the *spinal irritation* which is usually found in women, these remedies act very favorably, as is shown by the following cases:

Case I.—Mrs. M——, aged 42, I found suffering with great pain in the region of the stomach, which pain, on examination, proved to extend around that part of the body to the spine, where, on pressure, it was intensified. She had been subject to it for about three months, disturbing her sleep and appetite. I immediately applied a Burgundy pitch plaster, dusted over with a grain of tartar-emetic, over the seat of spinal tenderness, and in two days she was entirely free from pain, and her sleep and appetite returned and improved from that time.

Case II.—Mrs. W——, aged 32, complained of pain in the stomach, which was associated with nausea and loss of appetite. On pressing over the last three or four dorsal vertebræ, she evinced a great deal of sensitiveness there, and which also increased the gastric pain and nausea. I applied a Burgundy pitch plaster over the spinal tenderness, and in several days she was totally relieved of all pain, and also of her difficulty in the stomach.

CASE III.—John T——, aged 29, a subject to occasional epileptic fits, has been suffering from violent pain in the upper half of the chest and spine. The pain along the spine, on pressure there, became very much intensified, as well as that around the upper part of the chest. I applied a blister along the seat of spinal tenderness, and the following day, after the application, the pain was relieved.

In the exhaustive diarrhœa and vomiting of infants, where there is a marked tendency towards coma and convulsions, I have derived great benefit from the application of small blisters to the head in several cases which I have on record, one of which I will relate.

A. M——, aged 15 months, became subject to diarrhœa on August 16th, 1877. To check this, I gave her pulv. ipecac., gr. j; pulv. opii, gr. $\frac{1}{6}$; magnesia, gr. j; tannin, gr. ij, every three hours, with the desired effect. Two days afterwards, however, her stomach became so irritable that she was unable to retain anything on it, and she also at this time began to manifest symptoms of general collapse. By appropriate treatment her stomach became settled, but she now began to develop marked symptoms of a tendency towards convulsions, such as turning up the eyes and rolling them about, and tossing her head almost constantly from side to side. I now applied a blister of cantharidal collodion, about the size of a silver quarter dollar, on each temple, and from that time she became quiet, the head symptoms began to improve, and in a short time she was well. The excessive drain from her stomach and bowels, no doubt produced cerebral as well as general exhaustion—for coma and convulsions are indicative of such a state—and the small blisters evidently had an invigorating effect on the brain, and served to stimulate that organ to a more healthy condition. Probably, if the blisters had been more extensive, they would have outstripped their usefulness and caused a great deal of harm, for I have knowledge of a case in which the indiscreet application of a large blister to the head was followed by the most disastrous consequences.

In acute inflammatory diseases of the chest, as well as in other diseases of an acute inflammatory type, mild mechanical stimulation in the form of mustard and linseed poultice, about one twelfth of the former to one of the latter, should be applied, and renewed as often as necessary to retain the temperature of the poultice above that of the body; or an application of mustard sufficient to redden the skin, every four or five hours, with a warm linseed poultice during the intervals, is of equal benefit. The heat of the poultice must be persistent and moderate; therefore it should be covered with oiled silk, or some other non-conducting substance, to prevent the rapid radiation. The application of mustard and linseed poultice, in combination or separate, must be extensive, not simply confined over the inflamed part, but to extend to the surrounding and more healthy tissues. If there is widespread inflammation of the pulmonary organs, the whole thorax should be enveloped by the application.

I have found great benefit from such a plan of treatment, and uniformly employ it in the majority of acute inflammatory diseases of the chest which fall into my hands, and, if it were necessary, I could cite numerous illustrations of its almost unfailing good results. In acute pleurisy, however, I am convinced that a small blister over the affected part will materially assist the poultice in removing the disease. That a blister often aids the action of a warm poultice, is evident from what has been said, and I will cite a single case to illustrate this:

Mrs. W—— was delivered of a child on September 23d, 1877, and on the third day following she began to show marked symptoms of peritoneal and ovarian inflammation, accompanied by watery stools, pain, and tympanitis, the most violent pain being confined to the region of the left ovary, where she could hardly bear to have the bed-clothing touch her. I poulticed her steadily with no improvement, and also gave her other appropriate treatment, such as quinia, opium, beef-tea, etc. On October 2d, when she felt the worst of any day since she was taken sick, her temperature at 9 A.M. being 101°, pulse 125; at 3 P.M. temperature $104\frac{3}{4}$°, pulse 135; gave her a large dose of quinia, and at 5 P.M., her temperature was $104\frac{1}{2}$°, and her pulse 130, but the pain and tympanitis remained all the same. I now also placed a small blister of cantharidal collodion over the left ovary and continued the poultices as before. On October 3d, at 9 A.M., I saw her again, and found that the blister had drawn well and relieved the pain entirely. Her temperature at this time was $102\frac{1}{2}$°, and her pulse 125; at 6 P.M., of the same day her temperature was 103°, and her pulse 96. October 4th, 8 A.M., temperature 101°, pulse 88, and she continued to improve until October 9th, when I discharged her well.

Here evidently the form of stimulation which I employed in the first place was not powerful enough to bring the affected parts to the required degree of healthy activity, but when it was combined with that of a blister, their beneficial effects were soon apparent. Under all such conditions, especially in diseases of the respiratory organs, it is, I think, advisable to give the milder forms of stimulation a fair trial before resorting to the more active forms.

I have already remarked that diseases of long standing are more securely fixed and located in the tissues which they affect, and that they require a greater degree of force to disturb their equilibrium and to unseat them, than those of more recent existence. Now, in chronic inflammatory diseases we find this principle of treatment fully verified, for it is a stern fact, and one confirmed by sound theory and successful practice, that the more severe forms of mechanical stimulation are more effectual in relieving these diseases than the milder ones. Cantharides, ammonia, croton oil, antimony, and iodine are principally employed under such circumstances—the first and second where a sudden action is desired, and the remaining three where a slow and protracted effect is wanted. Under these conditions, such measures hardly ever fail to give satisfactory relief in my hands, and I believe that similar testimony could be secured from every practitioner in the land.

Dr. Horace Dobell, in his work on "*Winter Cough*,"* very ably describes the value of external mechanical stimulation in the treatment of chronic inflammatory diseases of the respiratory organs in the following language: "There is no class of complaints in which counter-irritation gives such unquestionable and unqualified relief as in affections of the respiratory tract of mucous membrane. The relief to the oppressive dyspnœa, and to the irritability of the tubes long narrowed by thickened lining, which speedily occurs under the influence of decided counter-irritation, is delightful to witness. In severe and chronic cases I am in the habit of ordering at the commencement of treatment three blisters, one for the front of the chest, and one for each side, between the scapula and the breast, to be used in succession; each blister to

* Page 204.

be allowed nearly to heal before the next is applied. The application of the first I *insist* upon, the other two I leave to the patients' judgment to apply or not, as they choose, after having found what relief is obtained by the first. It is very rare, indeed, to find that they fail to apply all three; much more often they are so pleased with the effect as to volunteer to put on more if necessary. . . . . If the case is severe or of old standing, and the patient will allow it, never fail to start with a blister."

Dr. Greenhow advises the use of blisters in his work on *Chronic Bronchitis* with much confidence; and Dr. J. K. Spender, in his work already quoted, tells us that "blisters generally relieve the pain of many chronic inflammations and of *quasi* inflammatory states: notably chronic pleurisy and pericarditis, chronic ovaritis and some subacute conditions of the brain and spinal cord."

CHAPTER VI.

NARCOTICS.

If it is true that medicines are the representatives of forces, which they manifest in various degrees of strength according to the amount introduced into the body (and we saw that this force idea holds remarkably true in regard to those substances, like quinia, for example, which in small doses are mechanical stimulants, and in large mechanical depressants), then it must also be true that those medicines which are chemical stimulants, as well as others which are mechanical stimulants in small doses, will behave differently when administered in large doses, for larger doses imply the introduction of a greater quantity of force into the body, which must produce its quantitative effect, and this we shall find to be strictly true. We are already aware that there are certain medicinal forces which tend to operate exclusively on the nervous system, and it is very obvious that if such forces act with sufficient energy, they will ultimately destroy the working condition of this portion of the body, benumbing or deadening the nerves of sensation, and paralyzing those of motion. Such forces or agents are known by the fitting title of *Narcotics*.

Of such forces we have no more illustrative example than that of the action of alcohol in large doses. This substance, as we have already learned, is in small doses an invaluable chemical stimulant, giving support and energy to the whole body; while in large and poisonous doses, as we shall see, it expends its force principally on the nervous system, the function of which it overthrows, and thus becomes a most decided narcotic.

The nervous system is essentially the great medium for the reception and transmission of external and internal impressions, and for regulating and presiding over all the different functions and processes of the body; and any force or agent which disturbs or destroys this equilibrium, or, in other words, moves with excessive energy in a direction contrary to its own, will just in proportion as it does so incapacitate it for performing the manifold duties which are necessary for the continuation of life. Now, under the detrimental and deteriorating influence of large quantities of alcohol the brain, the nerves of sensation and of motion, the vaso-motor and pneumogastric nerves suffer speedy injury; and hence the intellectual and moral faculties become paralyzed and disabled, the tactile sense deadened, convulsions and vomiting appear, the secretions, from vaso-motor paralysis, are impaired, some accelerated and others diminished, and the functions of the heart and lungs are invariably disturbed.

That such morbid phenomena as convulsions, spasms, etc., can be induced by anything which has the capacity of destroying the soundness of the nervous system is evident from the fact that any violent mechanical, chemical, or electric irritation of a nerve will throw the muscle to which its fibres are distributed into convulsions. Again, in the experiments of Kussmaul and Tenner,* and of others who made researches on this subject, we are shown conclusively that when important nerve-centres, like the brain and medulla oblongata, are suddenly deprived of their wonted blood-supply, convulsions are almost sure to follow. Now, it matters not in what special manner the nervous texture is injured or disabled, whether, as in the former case, by damaging it directly with an irritant (for irritation denotes morbid action), or, as in the latter, by depriving it of its source of nourishment and thus impair it indirectly, the result is all the same, viz., more or less complete abolition of nerve integrity, and is to all intents and purposes the same as if it had been disabled or paralyzed by some poisonous or narcotic substance.

Thus, then, it becomes apparent how a single disintegrating force like alcohol, by simply abrogating and deranging the governing and co-ordinating influence of the nervous forces, can become a common cause of so many varied morbid phenomena.

It is very obvious that any force which has the power of destroying the integrity of the nervous system, must also have the power of abolishing pain, and this is true of all the narcotics. Chloroform, ether,

* On Epileptiform Convulsions from Hæmorrhage.

alcohol, opium, tobacco, etc., in large doses possess this property in a very eminent degree. But it will also be seen that pain relieved in this way is at the expense and sacrifice of the nervous system, and ought never to be resorted to unless the same end cannot be attained by the action and influence of stimulants as described in the preceding pages. The latter is, without question, the most philosophic mode of relieving pain, but at times it is necessary that a little evil should be done in order to secure greater good; the good, however, which is derived should always greatly exceed the evil.

CHAPTER VII.

CONCLUSION.

In the foregoing chapters I have considered examples of the three great general classes of therapeutic agents, viz., the chemical and mechanical stimulants, and narcotics, and think that I have at least given some reason for the belief that all these varied, and in some cases opposite phenomena which are produced by these agents, are but the result of the action of forces, and, before coming to a close, I will make a brief recapitulation, and point out certain conclusions to which these deductions lead.

The animal body, then, is composed of organic molecules which in health are in a constant state of activity. This molecular activity is maintained in the natural way by chemical stimulants, substances which undergo oxidation in the body, and thus give free their force. In diseases, however, the ordinary chemical stimulants are not always capable of furnishing the requisite degree of molecular activity to the body; hence they are reinforced by others, like alcohol, the hypophosphites, etc., which possess a superior capacity for undergoing combustion. On the other hand the molecular activity of the body may also be enhanced by the mechanical stimulants—substances like quinia, ammonia, etc., which transmit their motion directly to the body without undergoing previous oxidation, and these are powerful adjuvants to the chemical stimulants in treating disease. And, again, we have especial mechanical stimulants of the nervous system, like opium in small doses, as well as special mechanical depressants of this tract of bodily tissue, like opium and alcohol in large doses. We thus find, then, that these three general classes comprise the action of many of our most reliable and important remedies, and it might easily be shown that the therapeutic action of many other substances would become intelligible if considered in a similar light.

By regarding our remedial agents as the embodiment of forces we can readily account for the cause of the great difference in the effects of small and large doses of medicines. It must, however, not be imagined that this twofold action of medicines is confined to those which have been discussed in this paper, for it will be found that the majority, if not all of our therapeutic measures are subject to the same law. It will, also, from what has been said, be seen how unfair and even how censurable it is to define the action of a medicine without at the same time qualifying the quantity and the bodily conditions under which it so acts. It would be just as unwise for one to make the broad assertion that ipecacuanha is an emetic, while every one knows that in small doses it also relieves emesis, and it is equally well known that in doses in which it ordinarily produces vomiting, it is also very efficient in curing dysentery without displaying much, if any, of its emetic properties; and moreover, the recent researches of Dr. Ruterford and M. Vignal shows it to be a most powerful cholagogue, superior even to calomel and podophyllin. This is likewise true of aloes, for in large doses this substance possesses a decided cathartic action on the lower bowel, but in small doses it is also a tonic to this section of the alimentary canal. Instances of a similar character might be multiplied, but they would only serve to still further demonstrate the careless and unscientific spirit with which we treat our therapeutic forces.

From the foregoing, we likewise learn that all therapeutic forces when viewed from the standpoint of life, must either move in harmony with or in opposition to the vital forces. But we have also seen on the one hand that there are medicinal forces, of which quinia affords an example, which move in opposition to life generally, and do yet in small quantities have the power of enhancing the life process; while, on the other hand, there are others, like alcohol, which move harmoniously with the bodily forces in small quantities, but in large doses they become powerfully antagonistic to the latter. Hence, the chief and only true aim in the investigation of the action of therapeutic forces, consists, not merely in determining the action of each particular medicine, but the *degree* of force in each medicine which promotes or retards the bodily forces, *i. e.*, the action of small and large doses. But since therapeutics is, or ought to be, the science and art of curing disease, it follows that a complete knowledge of the action of these forces cannot be gained by a study of their effects on the healthy body, but these must be confirmed by observation and experience at the bedside, although much can be learned in a general way from physiological experiments or "provings" on the healthy human system, as well as on that of the lower animals. Indeed, one of the most promising avenues to the determination of the action of medicines consists in studying the influence of these agents on disease induced artificially in the lower animals.

I think these deductions illustrate the fact that the equality of cause and effect is as true when applied to therapeutics as to any other department of nature, and they furthermore impress on us more than ever the stern truth, that the medical man in pursuing his calling has to deal with the most intricate and delicate forces, which are potent for good or evil, and which require to be regulated by the most consummate skill and enlightened judgment. And, finally, I indulge in the hope that this feeble effort in placing the study of therapeutics on a firmer basis than it has heretofore occupied, may give an impulse to future inquiry in this direction; for just as soon as the medical profession rightly appreciates that the art of curing disease is controlled by invariable law, so soon will it be wrenched from the uncertainty of empiricism* and of charlatanism, and rise to the dignity of a science.

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* It is far from my intention to underrate the valuable influence of medical empiricism, for to do so would be but heaping undeserved reproach on "the bridge that carried us over." One cannot call it an inheritance of "unalloyed blessedness," yet it certainly had its good side also.

p. 56 - Increase of temp. by Phos.
57 Diff between hypophos & phosphates