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THE MODUS OPERANDI OF MEDICINES.

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THE manner in which medicinal substances produce their curative effects in a pathological condition of any organ or system of organs, is very little understood; the manner in which they produce their pathogenic effects in a state of health, is also involved in the obscurity of hypothesis. And although this knowledge may not be indispensable to the successful administration of medicines in the cure of diseases—yet in the practice of an art which professes to be founded upon deductions from the exact sciences, it is desirable, if possible, to trace the connection between every cause and its ultimate effect. The explanations given by authors of the *modus operandi* of therapeutical agents, falls far short of anything satisfactory; they are, at best, only what relate to their remote effects—with vague conjectures as to their immediate action on the tissues and fluids of the body; but they do not reach their ultimate action on or relation to their chemical elements.

If we admit that all changes whatever, which take place in the elementary constitution of matter, both organic and inorganic, are merely chemical transformations—we see that the practice of medicine proper is only the aggregate of a series of chemical experiments, and the physician a practical chemist. But it is insisted, that it is unnecessary to know precisely how medicines operate, so long as we know they produce respectively certain constant effects. This may, so far as practice is concerned, be true. But the very ignorance of the chemical knowledge which would teach us their *modus operandi*, is the cause of innumerable blunders, in compounding and prescribing all complex preparations. A large portion of the prescriptions made in practice, are chemically incompatible; so that a decomposition and re-union take place between two substances, and a third is formed, different from either of the other two. This new compound may be either inert or poisonous—and at least will produce effects different from what ought to be expected. In this way the physician is often deceived, when prescribing a new medicine, or an old one in some new combination. In this way, too, valuable medicines are sometimes prevented from producing their legitimate effects, and are therefore condemned. It is often the case that an

incompatible compound is mixed together by the scientific physician, as well as the nostrum monger, in defiance of all chemical laws, and still produces wonderful curative effects; for although there was a perfect discord of affinities, between all the ingredients, still some compound was produced which contained the power requisite, and which might have been prescribed more scientifically and with less trouble. It is an indisputable fact, that a good practitioner and a poor chemist, in the same person, is a compound quite as incompatible as any in the *materia medica*.

Since the blaze of light from modern chemistry has shone upon the old empirical system of therapeutics, it has swept it away like vapor before the sun-beam; and with our ignorance of applied chemistry, we are left almost without a substitute.

While a few practitioners are laboring to deduce the entire practice from chemical principles, and are thereby constantly making dangerous experiments and failures—others constantly reject all new remedies and improvements, and plod their way by the dim and doubtful light of past experience, so that the aggregate of empiricism in therapeutics is, perhaps, as great as at any past time. It remains for further researches to discover and establish the *modus operandi* of remedial agents, and to classify them according to their true chemical and physiological relations to the system.

There are *three modes*, according to authors, by which the general operations of medicines may be explained.

1st, It is said "they produce their effects by actual contact with one or more tissues." But let us go a little farther back, and inquire, how do they act by contact? If we can find what the immediate chemical relations between them and the tissues and fluids are, we shall then have a point from which we can pursue them, step by step, until we arrive at the most remote change produced. When an acid and an alkali are mixed together in solution, effervescence ensues—and what caused the effervescence? It is caused by the chemical union of the constituents of the compound. But how was this union produced? By chemical affinity. Again, what causes chemical affinity? Here we must resort to conjecture, and say, perhaps it is caused by cohesion, which is itself caused by a particular internal molecular arrangement of particles—or perhaps by the molecules of each being in opposite electrical states. But here the explanation ends, and we are still in the dark. And it is true of all investigation, that a limit is set, beyond which we can never pass. We may trace one effect to its legitimate cause, and this to some other cause more remote, which is, still, but the effect of some other cause more deeply hidden; and so on, until all beyond is conjecture, and we must link the chain of our reasoning to the throne of the great First Cause.

2d, It is said "medicines act by an impulse conveyed by the nerves, through an impression made somewhere else." This is a gratuitous assumption—for it is not proved that the impression is made elsewhere than on the nerves.

How do we know whether the primary impression is made upon the nerves themselves, or upon the tissues? The nerves, instead of serving as mere conductors of impressions, may have undergone some chemical,

physical or physiological change, by the impression of a medicine which may increase their power of generating or conducting impressions, or may destroy this power entirely. The supposition that medicines act through the medium of the nervous system, either primarily or secondarily, does not assist the explanation.

3d, "Medicines act by contiguous or continuous sympathy, or by that which is excited by mere continuity and proximity of parts." Now to say that medicines operate by sympathy, is merely to give a name to our ignorance; matter, as distinct from mind, or spirit, can have no sympathy for other matter. Sympathy is not a physical or chemical action between particles of *matter*—but a hypothetical term implying some metaphysical action or condition; some state or act of mind, which though manifested *through* matter, is not *itself* matter.

Pathogenetic or pathological, as well as physiological, effects, may be produced upon the body through the medium of the external senses, or by an act of memory merely: as the sight of blood causes fainting; that of food, salivary secretion; of an emetic, nausea; the sight of one in convulsions, may cause them in another; cries of distress produce pain in a by-stander; unexpected intelligence or misfortunes sometimes cause greyness, apoplexy, syncope or death. The explanation of the action of medicines within the system, and *not out of it*, is what we are to consider. But the explanation of these mental or physico-mental phenomena belongs to metaphysics or physiology, and not the *materia medica*; this branch of medicine, therefore, is not amenable for their explanation. No such therapeutical force as *sympathy* can be proved to exist in the system; and when a distant organ feels either the curative or pathogenetic effects of a medicine, it must be from direct chemical or physical action on one or more elements of some tissue or fluid, which is felt along the course of the tissue to the organ in question.

We have now given a synopsis of the *modus operandi* of all the medicines in the *materia medica*. We may now give briefly the explanation of authors in relation to the operation of a few of the leading classes of medicines.

Tonics produce an augmented action of the circulation, temporary strength, and, finally, fever—when taken into the system in a state of health; but this condition is followed, after a short time, by collapse and debility. In both healthy and diseased conditions, they tend to dry up the secretions and excretions, and thus act as astringents; in this way they arrest night sweating, diarrhœa, and other excessive discharges. Thus a re-action is produced upon the current of circulating fluid, which causes the tide to set back upon the system and prevent depletion from morbid action. In this way, also, arterial blood is economized for nutrition, while the *vis medicatrix nature* restores health.

Febrifuges are anti-periodics in their action, and to some extent are all tonics. They are supposed to terminate periodical diseases, by imparting temporary strength and stimulus to the system, which interrupts their paroxysm during a sufficient length of time for nature to accumulate lost vigor and restore normal action.

Nauseating medicines restrain hæmorrhage, by causing faintness,

which relaxes muscular tone and energy, and thus lessen the force of the circulation, and allow coagula to form at certain points and close bleeding vessels.

Purgatives operate mostly by stimulating the muscular coat of the intestines, and thus increasing peristaltic action. The purgative effect of mineral waters is supposed to depend on the large quantity of water which holds in solution small quantities of mineral salts; the same salts dissolved in any water have the same effect. They are supposed to operate by the stimulus of distension, so that, after all, their operation does not depend on their peculiar constituents or combination. Some salts have so strong an affinity for water that they absorb the fluids from the surface of the intestines by exosmosis, thus overcoming physiological action.

Narcotics are supposed to act by their sedative or depressing influence on the nervous system; or, in other words, they *operate by operating*.

Astringents are supposed to exert their secondary effect on the blood, or bloodvessels from which the secretions and excretions are produced.

Emetics are local irritants, which stimulate the mucous membrane or nerves of the stomach, and produce vomiting by reflex action. This explanation is involved and unsatisfactory. Authors say vomiting can only take place through the medium of the nervous system; that the action of the spinal, and other nervous centres, constitutes the proximate cause. How do we know whether vomiting is the cause or the effect of this disturbance of the nervous system? These explanations of the operations of medicaments are of the same kind and alike unscientific and unsatisfactory, with the system of pathology which makes every disease a unity.

If we were to sum up the teachings of authors on this subject, and make an abstract, it would amount to no more than the assertion that *all medicines* produce their characteristic effects by *stimulating* different organs or tissues of the body. They do not explain the ultimate relation between the medicines and any particular substance or tissue of the organism. They only give the aggregate of a series of chemical and mechanical processes which had occurred primary to them. Thus the totality of medicinal or pathogenetic effects are thrown together and explained in a single word, as purgation, emesis, stimulation, &c.

We shall now consider the manner in which all medicines must be primarily related to the different chemical elements of the body, and attempt to show that there are only *two ways* in which every article of food or medicine, whether solid, or liquid, or gaseous, must act when taken into the system. It will then be apparent, that what we call the specific operation of medicines, is not really any part of their *action*, but only the manifest consequences of preceding chemical action of their elements; that tonics do not *directly* impart tone to muscular fibre; that cathartics do not *directly* produce peristaltic action; that febrifuges do not cure by interrupting the febrile paroxysms, &c.

The only two modes in which any substance can act upon the system as a medicine, are by *chemical affinity* and *electricity*. Mechanical or physical effects often result from these, but are no part of the primary ac-

tion. These are the only means by which *elementary* changes take place in bodies, whether organic or inorganic. This will be more apparent when we consider the conditions necessary for the development of either of these forces.

Electrical action may be excited between two bodies, either wet or dry ; between gases, liquids and solids. Chemical affinities can only be brought into active play by high heat, eremacausis, or the presence of moisture. When two certain substances, both dry, are brought in contact, electricity may be excited ; when two certain substances, one or both moist, are brought in contact, electricity or chemical affinity must, one or both, be developed. Whenever this is the case, a change of elements must take place between the two bodies ; the old union is dissolved, and new ones are formed ; so that these elements have different relations to each other, and to all other elements. In the human system, a long series of chemical changes may follow this first separation and re-union, and part of these changes may be manifested as the effects of medicines.

One obstacle to our understanding the *modus operandi* of medicines is, that the changes which follow their passage into the system are concealed almost entirely from our view. The pain which would succeed the swallowing of sulphuric acid, for example, would indicate the action of some powerful agent on the stomach, without giving any clue to the changes which were taking place in consequence of the affinity between the acid and the organic elements with which it was in contact.

Another obstacle is, that the elementary composition of the fluids and tissues is not constant and invariable in quantity or quality. But the greatest difficulty, probably, consists in the mixed and complicated nature of medicinal substances ; and especially those from the vegetable kingdom. Those medicines which have the fewest elements, and are best known in their constitution, are most easily explained and understood in their action. The numerous elements in vegetable substances are all compatible and harmoniously united, during organic life, and all so combined as to allow the full development of the organism, the perfect performance of vital functions, and the consummation of its design. But when vitality closes, the juices evaporate, volatile matters escape, the organic elements undergo metamorphosis, and new compounds are formed ; so that the chemical character is different in the dead plant, its constitution variable, and the union of its elements unstable.

In consequence of this weakness of affinity between the elements of organic bodies, their equilibrium is easily overcome by any disturbing force, so that the chemical character of any vegetable medicine is no index to its operation. We cannot predict what changes it will undergo, and what new compounds will be formed, when it meets with acids, alkalies, salts or gases, in its course through the system.

Opium, for example, is a complex substance, among the elements of which are the alkaloids, morphia, narcotine, codeine, thebaine and narceine, besides tannin, extractive and coloring matter, &c. Some of these substances have a strong affinity for others, which are held in solution or a state of unstable combination, by the fluids of the system, so that we must commence with the first changes in order to trace the ope-

ration through all its deviations until it leaves the system, or is assimilated to its tissues.

Medicines whose compositions are isomeric, generally operate similarly. Morphia, codeia and solania, are almost isomeric; they all contain about the same proportions of carbon, hydrogen and oxygen, and only a trace of nitrogen. Their peculiar and similar operation may depend upon this condition, as they must be similarly related to the elements of the body. According to Liebig, opium, nux vomica and cinchona, are supposed to take a part in the "transformation of the old, or formation of the new brain and nervous matter." Again he says, the substance of the brain and nerves is produced from the elements of vegetable albumen, fibrine and caseine. He concludes, in relation to the operation of medicines, "they must take a direct share in the change of matter in the body, and exert an influence on the formation or quality of a secretion by the addition of their own elements."

The Galenical preparations, such as infusions, tinctures and soluble extracts, have the advantage of being more pure and of operating on the tissues with greater promptness.

But from the complex character, feeble union and wide range of affinities, of all organic compounds, it is impracticable, if not impossible, to trace their passage through the body and ascertain their ultimate effects on all parts and functions. The only way, then, to study the *modus operandi* of medicines, in accordance with chemical laws, is to use those of the most simple and well-known composition, such as acids, alkalies, oxides, salts, alcohol, ethers, and vegetable proximate principles.

Several forces, besides chemical affinity and electricity, are supposed to exert some influence in the operations of medicines; viz., vital principle, animal heat, magnetism, mental action, and idiosyncrasy. But we are as unacquainted with the nature of these forces, as with electricity, or any other; we see their effects merely, and this is simply about all we know of them. To turn the explanation on one of these terms, or another, is to change the formula merely, without developing any new idea or illuminating an old one.

In such investigations, we almost imperceptibly transcend the limit of purely physical principles, and find ourselves finally groping in the maze of metaphysical abstraction. So attenuated and nice is the dividing line between actual knowledge and speculation, that we are willing to couple the logical expression of a physical fact with a metaphysical consequence, and thus yield assent to a fallacy, rather than destroy the chain which binds together a beautiful theory.

Galvanic or electro-galvanic currents may be developed by the action of free acids, often present in the stomach, upon the mineral elements of salts and oxides, taken as medicines. These currents possess electro-positive and electro-negative power, and tend to decompose and revive elementary combinations. They may also cause decomposition in some of the tissues of the body, since their affinities are weak, and they all contain, in their normal state, more or less animal matter. In this way the action of medicines is modified in some cases to an important extent.

We shall now leave the general consideration of our subject, and pro-

ceed to the explanation of the *modus operandi* of a single substance—viz., alcohol—as an example illustrating our views. In this explanation, although imperfect, we think we have traced the connection of cause and effect farther than has before been done; we claim, also, that the explanation is nearly correct as far as it goes; and, finally, that the operation of all medicines, of known elements, can be equally well explained.

Operation of Alcohol.—It is a principle in natural philosophy, that all bodies, in passing from a rarer to a denser state, evolve heat. Alcohol is lighter and less dense than water. When it is taken into the stomach, it mingles with the gastric juice or whatever fluid the stomach contains, and which is much denser than itself; consequently when the union takes place, the alcohol becomes more dense, and the mixture gives off several degrees of latent caloric. This may account for the first calorific effects felt in the stomach. The heat thus generated stimulates arterial action, by its tendency to expand in volume the blood and other fluids and tissues. This expansion, while it augments the bulk of the circulating fluid, diminishes the calibre of the vessels, thus rendering necessary a greater velocity in the circulating fluids; this increased velocity increases the friction between the blood and the sides of the vessels, and consequently augments the heat. After being absorbed, it passes with the blood through the lungs, where a part of its oxygen undergoes combustion in the capillaries, and thus increases animal heat. Its carbon and a portion of its oxygen unite to form carbonic acid, which acts as a sedative on the brain and nervous system. Alcohol, by its power of coagulating the albumen of the blood, causes in this way obstruction to the capillary circulation, which is followed by swelling and obstruction to the next larger vessels; this soon causes congestion of various points, which congestion re-acts upon the larger vessels behind those congested points, causes them to become distended, and thus exerts an injurious pressure upon the nerves lying in their vicinity. When this congestion and consequent pressure extend to the brain and other nervous centres, sensation begins to diminish, motion becomes irregular or involuntary, the senses wandering or entirely lost, and apoplexy and sometimes death ensues. This is termed intoxication; and when it terminates in resolution, the functions are gradually restored, without serious organic injury to the system.

To recapitulate in conclusion, briefly: alcohol acts as a *stimulus*, by furnishing to the different tissues an increased supply of highly-oxygenated blood; and by the heat it produces by mixture with other fluids: as a *sedative*, by producing pressure upon the nervous system by congested vessels, and by causing the whole system to become surcharged with carbonic acid. That this is the mode in which this medicine operates, seems to be established by its pathogenetic effects, by the treatment necessary to cure these effects, by analogy, by post-mortem appearances, and, finally, by chemical principles.