CHEMISTRY AND PHYSICS

IN RELATION TO

PHYSIOLOGY AND PATHOLOGY.

CHEMISTRY AND PHYSICS

IN RELATION TO

PHYSIOLOGY AND PATHOLOGY.

BY

BARON JUSTUS LIEBIG, M.D. F.R.S.

PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF GIESSEN; KNIGHT OF THE HESSIAN ORDER, AND OF THE IMPERIAL ORDER OF SAINT ANN; MEMBER OF THE ROYAL ACADEMY OF SCIENCES OF STOCKHOLM; CORRESPONDING MEMBER OF THE ROYAL ACADEMY OF SCIENCES OF BERLIN AND MUNICH; OF THE IMPERIAL CITY OF ST. PETERSBURGH; OF THE ROYAL INSTITUTION OF AMSTERDAM, ETC. ETC.

LONDON:
H. BAILLIERE, PUBLISHER,
219, REGENT STREET,
FOREIGN BOOKSELLER TO THE ROYAL COLLEGE OF SURGEONS AND THE ROYAL MEDICO-CHIRURGICAL SOCIETY.
PARIS: J. B. BAILLIERE, LIBRAIRE DE L'ACADEMIE ROYALE DE MEDECINE, RUE DE L'ECOLE DE MEDECINE.

1846.

LONDON:
Printed by Schulze and Co., 13, Poland Street.

CHEMISTRY AND PHYSICS

IN RELATION TO

PHYSIOLOGY AND PATHOLOGY.

DEVELOPMENT OF THE NATURAL SCIENCES.

The history of science teaches us, that every branch of physics comprised at its commencement nothing beyond a series of observations and experiments, which had no obvious connection with each other.

SPECIAL LAWS OF NATURE.

All advances in science were dependant upon the discovery of new facts, by which two or more previously observed experiments were made to bear upon each other. The first step gained was the deduction of *special* laws, which embraced in themselves the connection of a certain number of natural phenomena ; the next was the attainment of *general* laws, or what was the same thing, of certain expressions of the dependence or connection of a larger, or smaller series of experiments.

GENERAL LAWS OF NATURE.

Many branches of physics as mechanics, hydrostatics, optics, acoustics, the theory of heat, &c., have been elevated to the rank of abstract sciences, in consequence of their permitting all known cases of the phenomena of motion, air, sound, heat, &c., to be traced through a series of syllogisms to certain truths, or to a very small number of undoubted facts, which not only unite together those already known, but also those yet remaining to be discovered; so that a new isolated series of conclusions is not requisite to the explanation of new phenomena, or experiments.

If we can regard it as undoubted that not only the phenomena of inanimate nature, but also, those of animal and vegetable life are peculiar to themselves, stand in certain relations to each other, and depend upon certain causes ; and if further, it be true that it is only by a knowledge of these causes or conditions that we can gain a clear insight into the existence of organic processes, then must the investigation of the reciprocal dependence and the conditions of the phenomena of life, be regarded as the most important department of physiology.

The explanation of many natural phenomena, requires, in most cases, nothing more than an acquaintance with the relation of dependence in which they stand, one to the other.

The knowledge of these relations is attainable in every branch of natural investigation by the extension of experience, and by correctness of observation; and there can be no question that, at some future time, as chemistry loses the character of an experimental art, so will physiology be capable of ranking as a deductive science.

COURSE OF INVESTIGATION.

If it follow, according to the course of natural investigation, that general laws must be preceded by those that are merely special, and it be granted that a just conception of life cannot be acquired without a thorough knowledge of the organism in all its parts, both with reference to the functions of individual organs in themselves, and their mutual dependence, including the consideration of the relation of form to organic matter; then it will not be denied that we are still most widely removed from the possession of a general formula, embracing the comprehension of life, and the knowledge of the causes and connections existing in natural phenomena. So remote is this object, that there are many who still regard the probability, or even possibility of the attainment of such general laws in physiology, as purely chimerical; while most persons are unable to distinguish psychical from corporeal phenomena, or the idea of vital power from the form of living organs.

PRECONCEIVED VIEWS, AN IMPEDIMENT TO INVESTIGATION.

A man even of the most cultivated mind cannot wholly emancipate himself from the dominion of those laws, on which his powers of comprehension are dependant. If the daily experience of a prolonged period constantly show him two phenomena or facts, apparently closely connected together, if he learn that, for centuries, they have been considered inseparable, and if he have never, either by accident or design, been led to consider each individually, he becomes gradually incapable, in spite of the greatest exertion to the contrary, of considering them apart, until at length his mind refuses to admit the very assumption of any difference existing in the nature of the phenomena observed.

Innumerable instances testify that even the most accurate observers of their age have regarded certain facts or representations as impossible, simply because their power of comprehension was unable to receive them ; while their successors have not only comprehended them, but what is far more, have universally received them as incontestible truths.

Men of the clearest discernment, who were raised far above ordinary ideas, were yet unable to understand that the force of gravity acts with an upward instead of a downward tendency, or that the sun from its vast distance could exercise any influence upon the earth, or the earth upon the moon. Even the great Leibnitz rejected the Newtonian theory, because he could not regard it as possible that the planets could maintain a motion in a curved line around one common centre, without the agency of some continuously acting mechanism ; since according to him in the absence of a propelling power, the body must fly off at a tangent to its orbit.

Starting from the general proposition that a body can exercise no influence upon a point, with which it is not in contact, the Newtonian theory of gravitation was rejected ; and the fact now become familiar to the mere schoolboy, that the power of gravitation is active at boundless distances without any influencing material agent, appeared even to men of the noblest intellect to contain so great a contradiction, that rather than receive it, they maintained the probability of the strange, and unfounded creations of their own fancy.

There are many theories in mechanics and physics, which, although we know to have been regarded as the great discoveries of their age, and the results of the most patient and laborious investigations, appear to us now so true and obvious, that if we did not possess the history of their gradual development, it would seem incredible that a doubt of their truth could ever have been entertained by any individual in any age.

The simple position that a body once put in motion, could traverse space, for ever pursuing with unvarying velocity the same direction, appeared so opposite to common and evident experience that the recognition and establishment of its truth met for a long period with the greatest opposition.

That two chemico-active bodies can form a combination of definite unchangeable properties, through their union in indefinite or unlimited proportions, appears, even to our sound powers of comprehension to be untenable.

The comprehensive has, as we have shown, nothing to do with the apparent, but is dependant upon the condition of our mental development. If the uniting link that associates a fact with the usual course of our ideas be wanting, the fact itself will appear devoid of truth and comprehensibility. This is one of the greatest impediments that stands in the way of the application of chemistry to psychology, and of a simple consideration of chemical discoveries on the part of many physiologists ; and if to this be associated, as in pathology, the assumption of facts on experience, the correctness of which has no other foundation than the opinion of many centuries, and if, in these branches of science, the mode of arriving at conclusions and deductions be not changed, there is no hope as yet, that chemistry, with all her advances, will ever be able to render any essential aid to physiology and pathology ; while it is alike impossible for either of these sciences to attain to any scientific basis, without the co-operation of chemistry and physics. While no one doubts the necessity of this co-operation, there is little unity of sentiment regarding its practical application.

PHYSIOLOGY AS A DEDUCTIVE SCIENCE.

The opinion that every empirical science, including physiology, may in the course of time acquire the character of a deductive science seems to require no confirmation ; and it must be immaterial whether this position be attained by borrowing from other sciences : as for instance, in the case of astronomy, which owes its scientific basis to its partial incorporation with the theory of motion.

INVESTIGATION PURSUED ACCORDING TO PHYSIOLOGICAL LAWS.

If we bear in mind that, as no occurrence in the world, so also no phenomenon of nature either in the animal or vegetable kingdom, can appear without standing in relation to, or as the immediate result of another, that has preceded it; (as the present condition of a plant or animal is dependant upon certain pre-existing conditions;) it is clear, that if all the causes that affect one condition and their influence upon time and space, with their properties, are known to us, we shall be able to declare what other condition will succeed the former one. The expression of these conditions or relations, is what we term a natural law.

THE DIFFERENCE BETWEEN THE CHEMISTRY OF THE PRESENT DAY AND THAT OF AN EARLIER AGE.

No one who is conversant with the history of the development of chemistry, and of many other branches of physics will deny that the main reason of the advance of these sciences rests upon the gradually confirmed conviction that every natural phenomenon has more than one requirement, every effect more than one cause, and that it is the simple inquiry into the plurality of these conditions, and the separation of effects which distinguish the chemistry of the present day from that of former times. A speedy termination was put in the period of phlogosis to all research by assuming principles of dryness and humidity, heat and cold, combustibility, acidity, volatilization, &c.; ascribing a special essence to every property, the explanation of which was included in the simple description of the phenomenon.

The fluctuation in weight which bodies manifest on being submitted to chemical processes, was regarded as a property of matter similar to the effervescence of limestone, when acted upon by acids. There was a theory for the respective phenomena of combustion and calcination, although the relations of weight were not regarded as in the province of earlier chemistry. It was left to physiologists to explain how a body could have an increase of weight after losing one of its constituents; and further, how under any circumstance, a body can show a fluctuation in weight. The increase of weight in calcination was an accidental property, peculiar as it was supposed, together with many others, to metals.

POINT OF VIEW ASSUMED BY MANY PHYSIOLOGISTS OF THE PRESENT DAY.

Many physiologists and pathologists still regard the conception of vital processes and phenomena, from the same point of view as the phlogistics; they ascribe the effects of the nervous system to a nervous force; while vegetation, irritability, sensibility, action and reaction, simple effects of motion or resistance, causes of the formation and the change of form, which are included in the expression of typical forces, are all regarded as *entities*, and assume the place occupied in older chemistry by the essences.

CONFUSION OF EFFECT AND CAUSE.

The most common phenomena have been incorporated in the minds of many physiologists as actual capacities—properties—which they have falsely been led to explain by especial reasons, different from the others known; thus the terms endosmosis, and exosmosis have been applied to the return to a state of equilibrium of two fluids differing in their nature, or of two unequally dissolved substances, separated by an animal membrane; and thus we continue to treat names as if they were facts, embracing an explanation of the process, while this phenomenon is nothing more than a filtration, differing so far from other forms, that the permeation is dependant not upon pressure, but upon attraction, disposition, or affinity.

To this mode of observation was added the equally great error of conceiving that causes must be of a similar nature to their results, and that like must call forth like. Thus, the cause of combustion was thought to be something combustible, and the cause of acid, something acid; the caustic property of burnt lime was derived from a caustic, which suffered itself to be transferred from one body to the other, from the lime, for instance, to the so-called mild alkalies; the presence of a primitive alkali was pre-supposed in the alcalies; an *acidum universale* in acids; a primitive salt in salts; while analogous bodies were varieties of *one substance.*

FALSE EXPLANATION OF PHYSICAL PROPERTIES.

Many physical properties of bodies were explained by the physical character of their most minute parts; thus, for instance, a sharp taste was ascribed to sharp particles. Lemery's * view that the smallest atoms of an acid were lance-shaped, and that the atoms of alkalies were porous like a sponge, met with great approval, for it seemed to confirm their mutual power of neutralization; and the fact of ammonia precipitating gold in its solution was a convincing proof to the chemists of that day, of the capability they ascribed to ammonia of abrading the lance-like points of the atoms; it acted, to use Lemery's words, like the cudgel thrown by a boy against a nut tree laden with fruit.

* Lemery's opinions were first promulgated in his *Cours de Chimie,* published in 1675. An English translation entitled, *A course of Chymistry, containing an easy Method, &c.,* passed through four editions, the last bearing the date of 1720.

Thus certain substances which possess an astringent or cooling flavour, were supposed to exercise an astringent or cooling effect upon the living body; and any alcoholic drink, which may be termed strong according to the common mode of speech, was admitted as a tonic among other remedial agents.

It is an error to suppose that this mode of considering natural phenomena belongs to a very remote period, as will be seen from the following extracts drawn from Mulder's "Chemistry of vegetable and animal Physiology."* "We, therefore, rightly conclude," he observes, "that in sulphur, selenium, chromium, and manganese, similar forces exist; and thus we arrive at the idea that the chemical relations of these elements are not dependant upon their matter, but upon the analogous forces, by which their molecules are governed. Thus the idea of the matter of sulphur is associated with somewhat of the idea of force, and of the same force which operates in selenium also—which operates not only in forming combinations, but in contributing likewise to the formation of the whole character of the compound substances produced. We remark the effects of this force which exists in sulphur, selenium, &c., even in more

* "Versuche einer allgemeinen physiologischen Chemie." Braunschweig, 1844, p. 37, of the first edition.

complicated compounds than those to which we have referred."

The excellent investigations of Mitscherlich and Kopp upon isomorphism, have not been able, as we see, to eradicate this mode of observation.

EVERY PHENOMENON OF NATURE IS DEPENDANT ON MORE THAN ONE CAUSE.

The truth of a number of opinions or views, whether justly or unjustly, is liable to be doubted; but a phenomenon, an effect, cognizable to the sound senses of the most different persons, everywhere, and at all times, cannot be doubted, excepting inasmuch as the causes which bring about certain results may not be fully known. But this cause can never be supplied by the imagination, in the department of natural investigation; for we know that one and the same effect, as, for instance, a mechanical motion, a blister upon the skin, or the contraction of a muscle, may be brought about by different causes, and that one and the same cause may bring about a variety of effects.

CHEMICAL COMBINATION.

We know that the simple process of chemical combination is dependant upon at least three causes or conditions, which must stand in a certain relation to each other, if the combination is to be formed, and that affinity, the force of cohesion, and heat, have an equal share in the process.

DIFFERENT EFFECTS OF HEAT.

We know further that when a given quantity of heat expands a solid body, and forces its minutest parts to separate from each other, a double or triple quantity will entirely change the properties of the body, and that a further alteration occurs in these properties if the amount of heat that is communicated exceed a certain degree.

It is perfectly certain that expansion, liquefaction, and transition into the gaseous form are dependant upon causes, identical in their nature, but that the effects produced are by no means proportional to the causes; the reason of this has been justly sought in the reaction or resistance of some other cause, and our idea of the existence of the power of cohesion thus acquires a more scientific basis.

The same degree of heat, which is a condition of the combination of the oxygen of the air with mercury, produces the opposite effect—the decomposition of the oxide of mercury into mercury and oxygen, if the temperature be raised a few degrees.

By a simple process of oxidation we derive acetic acid from alcohol: we obtain this acid from the oxidation of salicylite of potash; we may also exhibit it from wood, sugar, and starch, by the mere application of heat and the exclusion of the oxygen of the atmosphere: in all these cases the product yielded is the same; but the conditions of its formation are extremely different.

THE SEPARATION OF VITAL EFFECTS, AND THE CHIEF REQUISITES THERETO.

If it be true that physiology can only attain to a scientific basis by the investigation of the plurality of conditions, on which the phenomena of life depend; and if it be granted that this can only be attained by a consideration and separation of vital effects, and the conditions to which they give rise; it is evident that since a number of causes have, or may have, an influence upon these effects, the physiologist ought to possess an intimate knowledge of all the forces and causes which may bring about changes of form and character in matter; since, without this, he would be unable to separate true effects from those which might be erroneously ascribed to the cause, and which, perhaps, have nothing in common with indications of gravity, affinity, &c.

CONTINUED DISREGARD OF THESE PRINCIPLES.

No one can deny that these principles are applied in the investigations of pathology at the present day, and the difference between the method of inquiry now pursued from that in use in the earlier stages of philosophical science is certainly very great, although the influence of the older system is not quite exterminated, at least as far as Germany is concerned. In spite of our acknowledgment of the accuracy of the principles of natural investigation, we are but too ready to throw off its shackles, and suffer our unfettered thoughts wherever the way is not clear, to erect a barrier of errors before the gates of knowledge. Favourite antitheses and paraphrases still play a chief part in all explanations, robbing common facts and conditions of the simplicity and perspicuity of which they are capable. The deficiency here rests not with the principles, but in the want of their due application.

EXAMPLES.

A few extracts from the writings of a distinguished pathologist of the present day will suffice to justify these remarks, and to show the influence that the older mode of investigation still exercises upon the present; they will also tend to demonstrate how impossible it is to arrive at correct conclusions by starting from indefinite ideas, and how small is the acquisition of scientific knowledge with reference to chemical and physical sciences, even in the most intellectual men.

INDEFINITE IDEAS OF IRRITABILITY AND IRRITANTS.

Many external causes, as the atmosphere, heat, electricity, magnetism, chemical agents, mechanical pressure, friction, &c., exercise certain effects upon the whole, or parts of the organism; in some cases these are similar, in others different.

These effects are dependant upon a certain number of those active causes, which exert either an external or internal influence upon the organism. The existence of these causes is capable of being defined and measured by the qualitative and quantitative difference in the effects produced by external causes which indicate a changed condition. The active forces in the organism are, accordingly, appreciable by the investigation of those effects which are qualitatively and quantitatively modified by every external cause. The method pursued by modern pathology is exactly the reverse of the principles advanced, as is proved by a few passages from the celebrated work of Henle, " On Pathological Investigations."* " Irritability is," according to Henle, " everything which, in acting upon organic matter, alters its form and composition, and consequently its function," p. 223. Far from regarding the separation of causes and their effects as the indispensable auxiliaries of knowledge, the author here, as we perceive, includes all imaginable causes of the changes in the form and properties of the organic body, under the term irritability; and, in the expo-

* Pathologische Untersuchungen, Berlin, 1840.

sition of conditions, this word plays the part of an entity, although this does not comprehend the mode of action of electricity, heat, light, magnetism, or chemical forces, but simply a small part of the action of each of these agents. We need only apply to the following, the definition given above by the author, to perceive how little science gains by such a method.

" Irritability alters the nervous fibre and its relations to the blood; but if it do not wholly decompose it, the metamorphosis of matter continues, and is perhaps even increased by the irritation, &c."

FALSE ANALOGIES.

No one after this will wonder to find, at p. 221 of the same work, an hypothesis regarding the mode of action of irritants, although there is not an allusion to the mode of action of any thing, or cause, which in acting upon organic matter changes its form and composition.

TYPICAL FORCE—AN INDEFINITE IDEA.

It cannot surely be correct to regard certain vital indications, (as, for instance, the development of the organism from the egg or germ, or the renewal of original forms,) as dependant on a certain typical power in the organism, since this expression is nothing but a mere verbal illustration.

Henle, at page 129 of his " Rationelle Pathologie," admits that the perpetual typical laws, which he has spoken of, are inadequate to explain how the salamander can regenerate a whole limb, while in the kindred frog regeneration is limited to a few tissues, as in the higher animals; and regards these indications as proving nothing more than the fact that they are such. To comprehend an explanation, pre-supposes a knowledge of the laws on which it depends, and the comprehension of the law is inseparable from the knowledge of qualitative or quantitative relations.

By way of rough illustration, we may compare the healthy organism in many respects to a large Transatlantic steam-boat; the latter consumes at every moment of its passage oxygen and fuel, which are again given off in the form of carbonic acid, water, soot, or smoke; it encloses sources of heat and power, which call forth motor effects, and minister to the wants of the crew, by preparing food for their use. If a sail be rent, there is one at hand to repair it; if a leak be sprung, the joiner is there to arrest the damage; while a number of men are ever active in keeping up the original condition of the vessel, and maintaining her speed; and so it is with the living body, which likewise has *its* smiths, and joiners, and other artificers. Let it then be our duty to study and recognize its mutual relations.

LIGHT CONSIDERED AS AN IRRITANT.

It is impossible to arrive at the comprehension of a subject, if, as is done by some pathologists, a term—such as an irritant—be made to include alike active causes, which change the form and composition of organic bodies, and such as light, sound, &c., which do not possess this capacity. Light is in itself a motor appearance, and as such is perceived by the eye, exciting in the optic nerve a motion which is transferred to the sensorium; the motion once begun is continued, as the tones of a flute are prolonged in the air, or a string in the piano produces tones. The impression of light is motion itself, but this motion calls forth no change in the form and composition of the eye or brain, unless new causes are superadded; and among such we may rank the labour of thought, by which the impression is converted to a conscious perception, awakening, in its turn, conceptions and ideas.

No one would seriously maintain that a piece of white paper could, by its reflected light, bring about a change in the form and composition of the brain, since an opposite effect must then necessarily be ascribed to a piece of black paper, from which no light is given forth; but the two combined, the black and white, when in the form of letters in a book, awaken the most manifold feelings, conceptions, and images; and it is by means of these, and not of light, that an influence is exercised upon the properties of the brain.

SOUND AS AN IRRITANT.

The observations which we have made regarding light, apply in every respect to sound; the vibrations of the air-wave are continued through the organs of hearing, and communicated to the auditory nerve. The motion imparted to the membrane of the tympanum alters its form and composition as little as those of the molecules, which have received a like motion from it. As the eye wearies in a picture gallery, although it receives less light in the same period than it would in the open air, so it is also with the ear.

FALSE IDEA OF REACTION.

The false ideas conveyed by a mere verbal term, give occasion to constant misconception. This is the case with the word reaction, which merely means an opposing agency, but is used in physiology in a very different sense. We say that the glands react upon an irritant, if the secreting power be increased by any external cause, as is perceptible in a number of the secretions at the time of applying an irritant. One peculiarity of organic bodies is, that the increased activity of the glands does not continue, even if the irritation be kept up; although it lies in the nature of things that the secretion must cease if there is no matter present capable of affording it, and that it will be again augmented in proportion to the new supply. The action of the irritant is not an action upon the glands, but upon the cause, which equally produces the secretion, so that, in consequence of the irritation, more matter is secreted at one period than at another.

Thus, in the tail of a lizard, a metamorphosis and renewal of its molecules is continually going on, and when the tail is cut off, and the cut surfaces are separated, the governing forces act against the separation of the parts by the knife, but no counter-action of vital force is exhibited upon the knife. The cut surface of the severed piece of tail is not renewed, but the one which is connected with the organism grows, not in consequence of a reaction, but owing to the continuance of the causes which effect the renewal. The body of the lizard is not integrally renewed, when nutrition is absent. If the tail grow again, the other parts of the body lose a corresponding weight and volume.

The organic body resembles other bodies in all its conditions; thus many effects which have been called forth continue, even when the causes which gave rise to them have ceased to act; others are balanced, if the active cause of the disturbance cease, because within the body itself there are forces or causes of resistance at work which uninterruptedly make themselves felt.

VERBAL EXPLANATION NO ADVANCE.

The very small amount of knowledge we have gained from that period of physiology, when it was looked upon as a mere natural philosophy, sufficiently proves that the most comprehensive description of a function of the organic body, as the process of respiration or digestion, or a condition of disease, is not sufficient to impart a knowledge of it, and that the most ingenious combinations contribute nothing to our advance, if they be not sustained by a close and accurate inquiry into facts already observed, and such as yet remain to be brought to light. The imaginative faculty alone does not justify us in losing sight of the original point of view, nor in assuming that a consecutive course of views and opinions is an advance in science, since such a mode of proceeding can only be compared to that of a man revolving in a circle, and seeking to gain the greater number of different points of view. Not that these are immaterial, for they indicate the direction in which we must apply our powers; but the mere *description* of a condition, as for instance, of a catarrh being an inflammation of the mucus membrane of the nose, must not be regarded as an explanation, or as the termination to our inquiry. A new expression for catarrh, as arising from some active injury to the cutaneous nerves, is no actual gain, but a mere ideal representation.

EXERCISE OF THE IMAGINATION WITH REFERENCE TO OBSERVATION.

The right use of our senses—as in the appreciation of the distance, or height, or circumference of a body—is acquired by experience and reflection, and so also is the right conception of a natural phenomenon ; and the reflection of it in all its purity, undimmed by the representations awakened during our perception of it, is the attribute of a well-trained mind. The botanist recognises at a glance the existence, and the varieties of the plants around him ; the painter sees a multitude of points which the unskilled eye cannot detect even after the most fixed attention. None of the experimental sciences demand this acuteness and exercise of the imaginative faculty more strongly than physiology and pathology ; and in few is it more rarely met with than in medicine. Hence arise the many contradictions in the comprehension of the simplest conditions, and the close succession of the most opposite modes of cure, and the constant appearance and speedily forgotten existence of numerous works on the unhealthiness of certain localities, on the nature of yellow fever, cholera, and the plague—works that have often been written by men, who never saw the place they describe, or a single case of any of the diseases they profess to treat of. In order to give validity to a theoretic view of chemistry and physics, it is indispensable that its truth be guaranteed by a series of practical investigations on the part of the writer. If this be wanting, the theory, although it may be the perfectly correct expression of a truth, will meet with little or no attention. It required the keen imaginative faculty of a Berzelius to save from utter disregard such a theory as that advanced by Richter* on chemical proportions, and to recognize the innate truth and existence of a common law of combinations amid a mass of false facts; among which, that single one, which forms the starting point for the table of equivalents—the non-existing carbonate of alumina—was sufficient to destroy all faith in the others.

* Richter's work entitled, "*Anfangsgründe der Stochyometrie, oder Messkunst chymischer Elemente.* (Elements of Stochyometry, or the Mathematics of the Chemical Elements), was published in 1792. Its object was a rigid analysis of the different salts, founded on the fact that when two salts decompose each other, the salts newly formed are neutral as well as those which have been decomposed. He endeavoured to determine the capacity of saturation of each acid and base, and to attach numbers to each, indicating the weights which mutually saturate each other.

ERROR ORIGINATES IN FALSE OBSERVATIONS AND COMBINATIONS.

Viewed with reference to natural inquiry, every erroneous mode of investigation depends upon the want of just observations, and the false conceptions we deduce from them ; and is further based upon the error of considering the simultaneous occurrence, and concurrence of two phenomena as the proof of the existence of a connection between them. In nature numerous phenomena occur, of which *one* may be inappreciable, if another given one fail, while again innumerable other phenomena may occur together, or simultaneously, without standing in any mutual relation to each other. The assumption of an erroneous connection of this kind, originates in all cases in a false mode of investigation; and thus the combination of two phenomena, only similar in some one particular relation, is always the result of incorrect observation.

OBSERVATION.

To see and perceive by the senses is a condition of observation, but sight and perception do not characterise observation.

Observation is not limited to seeing the thing itself, but likewise the parts of which it is composed; thus a good observer must perceive and seek to become conscious of the mutual connection existing between the several parts among themselves, and considered with reference to the whole.

EXAMPLES OF ERRONEOUS OBSERVATIONS—THE SUPPOSED INFLUENCE OF THE MOON UPON THE FORMATION OF DEW.

One of the most familiar illustrations of erroneous observation, is the influence ascribed to the moon in reference to the cold felt in moonlight nights, and to the formation of dew and hoar-frost, while the moon in these cases is a mere spectator of their formation.

In a work, in other respects very good, published at Dresden last year, on the influence of the moon upon the earth, the following passage occurs :

THE INFLUENCE OF THE ATMOSPHERE UPON EVAPORATION.

"In the absence of an atmosphere we cannot conceive the existence of water, or any similar fluid in a liquid form. If our globe were suddenly deprived of air, its rivers and seas must evaporate, and the whole earth would in a short time dry up as we see exemplified on a small scale by experiments under the air pump." Here, as we see, a connection between the atmosphere and evaporation is presupposed, which does not exist in nature. Without an atmosphere it is true no clouds would be formed, liquid water would not be converted into vesicles of vapour, and aqueous vapour would not rise to so great a height; but the atmosphere has no effect upon evaporation, and an equal quantity of aqueous vapour is produced under the receiver of the air-pump, whether or not the air be exhausted.

DILUTION OF THE OXYGEN OF THE ATMOSPHERE BY NITROGEN.

We find in many physiological works the view advanced, that the nitrogen of the atmosphere contributes to the dilution of the oxygen, and the modification of its action upon the organism; whilst in fact the quantity of oxygen in a given space would not in any respect be changed, were we to assume that the nitrogen had suddenly been removed from the earth. Two gases varying in their nature exercise a certain pressure upon the human body and the surface, with which it is brought in contact; but the particles of the *one* gas do not compress those of the *other*. If we take two bottles, one filled with nitrogen, and the other exhausted, and bring them in contact by a glass tube, the nitrogen will distribute itself through both vials; if again both bottles are of equal volume, both will contain an equal amount of the gas, and the same thing happens when one vial instead of being exhausted is filled with oxygen at an equal pressure; the nitrogen will distribute itself in the bottle as if no oxygen were present—the action of oxygen similar to that of nitrogen.

THE POWER OF THE SUN IN ATTRACTING WATER.

The fact of the impracticability of working some mines in the height of summer, owing to the veins or shafts being filled with water, has led naturalists to ascribe to the beams of the sun a power of attracting water, which, according to them is to be naturally explained by the action of the sun in drying up the soil, whence hollow spaces are formed which are again filled from below by capillary action. We know that a connection between the sun and the water takes place within the mine, but this simply depends upon the drying up of the brooks in summer; as the pumps which are destined to draw away daily an equal quantity of water, are impeded in their action by the stoppage of supply from these sources.

An analogous explanation may be given of the connection between the immoderate use of spirituous liquors and self-combustion, since it is most probable that none but drunkards would be likely to fall into the fire, and be thus consumed.

THE IDEA OF BOERHAVE ON THE ORIGIN OF ALKALIS IN PLANTS.

The false ideas concerning vital and material forces, which at this moment separate by an unfathomable abyss, the department of physiology from that of chemistry, arise entirely from the absence of *true*, and the presence of *erroneous* views: thus the ideas entertained in the eighteenth century of the occurrence of alkalies in plants, may be placed side by side with those entertained in pathology at the present day concerning the growth of a crystal, and the nutrition of an organic being. According to Boerhave the alkali belonged neither to the sap nor to the individual parts of the plant, but was a product of the process of combustion; and he represented to his hearers that decayed wood yielded no alkali which was as little a constituent of the plant as the glass, which many plants give on incineration.

FALSE COMPARISON BETWEEN THE COHESIVE FORCE OF CRYSTALLIZATION AND THE ORGANIC FORCE.

"Crystals like cells," so says Henle in his (Rationelle Pathologie),* "are restricted even under the most favourable conditions to a final limit of growth, although the former are less narrowly circumscribed than the latter. Crystals associate themselves together like cells in aggregate bodies, reminding us by their arborescent arrangement of the elementary parts in the higher plants. Material and vital bodies offer a certain measurable degree of resistance to external influences, but accommodate themselves to circum-

* Part. I. p. 101.

stances, even changing their forms occasionally. The most remarkable point of similarity between crystals and organized beings, is shown after injury from external influences. Crystals like organic bodies have the power of regenerating lost parts more or less fully. In both, the force which formed the body continues at work, independently of the matter which it has survived, or replaced. Thus if a crystal from which the angles have been cut off be laid in a fluid whence it may draw a substance analogous in composition to itself, it will increase generally, but more especially in the direction of the part where it was injured, so that the regular figure is first restored, just as an injured animal will, before all else, regenerate any lost part as far as typical laws permit regeneration in his individual case."

However true it may be that augmentation in the mass of an organic body be occasioned by the force of attraction, there is no resemblance externally between the growth of a crystal and the formation of an organism. The form of the membrane is not affected by the physical form of the atom, as it is in crystals, for instance, in a crystal of alum, consisting of an aggregate of particles of alum, where each individual crystal has a form precisely similar to that of the aggregate body. The cell is a whole within itself, and not an aggregate of smaller cells.

EXPLANATION.

Crystals have not, like cells, a limit of growth: the increase of size in the crystal is not occasioned by a cause acting from within in an outward direction, as in living organisms, but by the force of attraction upon the surface. This force is active at every point of the outer surface, while the molecules below take no part in the growth, and may even be removed without depriving the superficies of their capacity to increase. The new planes which are formed on truncating the angles of a crystal, exercise no stronger attraction on the molecules of the surrounding medium, than do the other planes; and they do not in any special manner perfect themselves.

By cutting off an angle from an octohedron we obtain a cubic superficies of the crystal, bounded by four converging octohedric planes; in a crystallizing fluid the body increases in three dimensions; the four superficies become longer and broader, and, in consequence of their elongation and convergency, the angle is restored, even when the cubic superficies has been incrusted. But when one angle is struck off a cubic crystal of alum, and the crystal be thus truncated, it does not increase, in the mother liquid, in a greater degree towards the truncated angle than towards any of the other sides; the original cube-like figure is not restored, because the force of attraction of one individual portion of a cubic plane is not greater than the attractive force of an equally large portion of any one of the other six superficies of the outer surface.

A crystal which grows in a saturated solution, always increases on one side *especially*, that is, on the surface directed towards the bottom of the vessel, owing to this plane being always in contact with those particles of the saline solution, which have the greatest specific weight, and are most copiously charged with the crystallizing matter. There are also cases in which, in consequence of the difference of temperature of the upper surface and the bottom of the vessel, the crystal increases most in a downward direction, while the upper parts lose their form.

COMPARISON OF THE PARASITE THEORY WITH THE CHEMICAL THEORY OF CONTAGION, MIASMA, AND PUTREFACTION.

The source of the most frequent errors in judging of a condition of disease, originates in regarding things that frequently occur simultaneously, as necessarily exercising a mutual influence on each other; looking upon the one as the cause of the other. For the comprehension of diseased conditions and the choice of means to remove them, there is no view which is more deficient in a scientific basis than that of identifying miasma and contagion with living organisms, as parasites, fungi, and infusoria; and regarding them as being developed and increased in the healthy body, where they thus induce a condition which may terminate in death.

A glance at the principles of the parasite and chemical theories, will suffice to show the respective merits of each.

But if, in the following remarks, I attempt to lay before my readers, by means of a series of facts, certain processes of the living organism, together with their relation to certain phenomena, observed in inanimate nature, I do it much less with the desire of advancing any new views regarding the nature and substance of contagion and miasma, or bringing forward the question of fermentation and putrefaction, than of drawing the attention of naturalists to a cause which, although hitherto ill-observed, is one that prevails generally, wherever a change occurs in the form and property of matter, or wherever combination and decomposition are going on. And if proof be adduced, that this cause exercises a decided and referable influence upon the indication and direction of the forces of cohesion and affinity, its undeniable share in the actions of vital force will be the less questioned, since vital force belongs to the same category as chemical forces, as far as the former manifests its activity only by direct contact, or at immeasurably small distances.

INFLUENCE OF MECHANICAL MOTION ON CRYSTALLIZATION.

Every one knows that water freezes at all temperatures below 32° F., and that during the act of freezing the temperature remains at 32° F.; nevertheless, water may be cooled as low as 5° F., without becoming solid, if the fluid be in a state of perfect rest. The least disturbance is sufficient to effect congelation.

INFLUENCE OF MECHANICAL MOTION ON CRYSTALLIZING SOLUTIONS OF SALTS.

The same conditions affect a number of solutions of salts, dissolved by heat; if cooled in a state of perfect rest they do not precipitate any salts, and no separation occurs between the water and the dissolved salt, while the least disturbance—a particle of dust or a grain of salt thrown into the water—will induce the molecules thus disturbed to crystallize, and when once crystallization has begun, it is continued throughout the whole mass.

INFLUENCE OF MECHANICAL MOTION ON SULPHURET OF MERCURY, IODIDE OF MERCURY, AND IRON.

By constant shaking and friction, the black amorphous sulphuret of mercury is converted into crystalline cinnabar, while the rough iron, whose parts are irregularly deposited, becomes crystalline on being hammered. On rubbing a portion of lemon coloured iodide of mercury, it passes into a new state of crystallization, and becomes scarlet.

From these facts it is shown that a mechanical motion exercises an influence upon the indication of the force which governs the condition of the body, and this motion is continued to its smallest molecules; for the formation of crystals it is necessary that they should be turned towards the direction in which the force of attraction is the strongest; it is, therefore, clear that atoms can be put in motion in fluids, as well as in solid bodies, by a stroke or blow, by friction, or by some other mechanical cause. The causes do not, however, exercise a certain influence on the indication of the cohesive power alone, but also upon the chemical affinity.

INFLUENCE OF MECHANICAL MOTION ON THE INDICATION OF CHEMICAL AFFINITY.

In a weak solution of chloride of potassium, tartaric acid does not deposit any precipitate: but mere shaking, or the friction of the inner wall of the vessel with a glass rod instantly causes a deposit of crystals of bitartrate of potash. The fulminates of silver and mercury explode with the greatest violence on the application of a blow, or of friction; the same is the case with Berthollet's fulminate of silver, with picrate of lead, and many other compounds. It is clear that in these cases the blow or friction, or more correctly, the motion, is imparted to the atoms of these combinations; that the direction of their attraction is thereby changed, and that, consequently, new products are formed. Fulminate of silver contains cyanic acid. By the blow or friction, a new mode of arrangement is brought about; a part of the carbon develops itself, and combines with the oxygen, forming carbonic acid; nitrogen develops itself with the carbonic acid, and explosion is the result of the sudden transition to the gaseous form. The colourless fluid styrole becomes solid and hard through the influence of a purely mechanical motion. *(Sullivan.)*

HEAT SIMILAR TO THE ACTION OF A MECHANICAL FORCE.

A number of bodies are decomposed by heat, and in these cases its action is perfectly similar to that of a mechanical force. Heat acts like a wedge driven in between the atoms. If between two atoms the resistance, which the chemical force that held them together, has opposed to the entrance of the wedge be less than the force which separated them, the atoms fall asunder, and decomposition is the result. Oxide of mercury is resolved into oxygen and the metal. Heat acts in the same manner on bodies composed of more than two elements. At a certain temperature the fulminates of silver and mercury, Berthollet's fulminate, and picrate of lead explode. Heat alters the original mode of arrangement of the atoms, and, consequently, the equilibrium of their mutual attraction; under its action they are then deposited in the directions to which their attraction is the strongest. The formation of new products rests upon the establishment of a new state of equilibrium, and they suffer no further change as long as they continue exposed to the same degree of heat; but if the temperature be raised, a new disturbance occurs, and, consequently, a new state of equilibrium, and a new mode of arrangement of the elements. On being exposed to a faint red heat, acetic acid is decomposed into carbonic acid and acetone; the carbonic acid contains two-thirds of the oxygen, while the acetone contains all the hydrogen of the acetic acid; at a higher temperature the acetone is decomposed into a compound of carbon which contains oxygen, and into an oleaginous hydro-carburet. Exposed to a temperature of 392° F., the styrole becomes solid and hard, loses its fluid character, and passes into a form resembling the most beautiful crystal glass.

INFLUENCE OF THE CONDITION OF CHEMICAL ACTIVITY.

It has been observed that platinum does not decompose nitric acid, and that it is neither oxidized or dissolved by this acid. A compound of platinum and silver dissolves, however, easily in nitric acid.

INFLUENCE OF THE CONDITION OF CHEMICAL ACTIVITY UPON THE CAPACITY OF BODIES TO ENTER INTO COMBINATIONS.

Metallic copper does not decompose water, when boiled with sulphuric acid; certain compounds of zinc, copper, and nickel dissolve, however, easily in sulphuric acid, with a development of hydrogen. In certain relations, compounds of these three metals will not dissolve in sulphuric acid, but if a trace of nitric acid be present, oxidation begins, which is then continued without further co-operation of the nitric acid. The solution of the platinum and copper follows in both cases against the electrical laws; heat or other causes, which might increase the affinity, have no share in the process.

INFLUENCE OF THE SAME CONDITION UPON THE CAPACITY OF BODIES TO SUFFER DECOMPOSITION.

If, further, binoxide of hydrogen be brought in contact with hyper-oxide of lead or hyper-oxide of silver, the decomposition of the former is accelerated, as by many solid bodies, and it is resolved, with effervescence, into oxygen and water ; but the molecules of both metallic oxides undergo a like decomposition when in contact with the decomposing parts of the binoxide of hydrogen ; oxide of silver is resolved into oxygen and the metal, hyper-oxide of lead into oxygen and oxide of lead. Both oxides behave as if they had been exposed to a faint red heat.

It follows, from these appearances, that the condition of the combination or decomposition of a body, or of its change of place or motion, may exercise an influence upon the molecules of many other combinations brought in contact with it ; they pass into the same condition ; their elements are in a like manner separated, and they thus gain the power, which they did not possess in themselves, of entering into a combination.

The decomposition of the second body naturally proves that the resistance of the force, which strives to hold the atoms together in their original mode of arrangement, must be less than the force of that activity which affects it.

INFLUENCE OF A SIMILAR CONDITION UPON ORGANIC SUBSTANCES.

The property possessed by any substance in combination or decomposition, to call forth in other bodies of similar or dissimilar nature in contact with it, a condition of form and character like its own, belongs, in a much higher degree, to organic bodies than to inorganic substances.

DECAYED WOOD.

Decayed wood brought in contact with that which is sound, changes gradually the sound body, under similar conditions, to a state of decomposition.

RELATION OF UREA AND HIPPURIC ACID IN URINE.

In fresh urine, if there is a complete exclusion of oxygen, no change of the urea, or of the hippuric acid contained in it occur ; on exposure to the air, another substance, occurring in urine in consequence of the oxygen being taken up, suffers a change in form and properties, which is communicated to the urea and the hippuric acid. Urea is decomposed into carbonic acid and ammonia, and in the place of the hippuric acid which disappears, benzoic acid is found.

INFLUENCE OF THE PUTREFACTION OF WOOD ON THE OXIDATION OF HYDROGEN.

Decayed wood takes up oxygen from the air, and gives out an equal volume of carbonic acid.

If hydrogen be added to the air, it becomes oxidized with the wood, and acquires the property of combining, at the ordinary temperature, with the oxygen.

Under similar circumstances the vapour of alcohol absorbs oxygen, and becomes changed into acetic acid.

THE FIBRIN OF THE BLOOD AND YEAST ACT SIMILARLY TOWARDS BINOXIDE OF HYDROGEN.

Fresh fibrin stands in the same relation to air as damp wood, passing equally into a state of decomposition ; if, in this condition, it be decomposed by binoxide of hydrogen, the latter is immediately resolved into oxygen and hydrogen ; but if the fibrin be heated to boiling, this accelerating action ceases entirely. Yeast behaves in a like manner, occasioning an immediate decomposition of the constituents of the binoxide of hydrogen ; but if it be previously heated to boiling, the action ceases.—(*Schlossberger.*)

RELATION OF COMBINED ORGANIC ATOMS AMONGST THEMSELVES.

These properties are in the highest degree appreciable in complex organic atoms. The larger the number of individual elements and atoms, which have associated themselves into a group of atoms of definite properties, and the more various the directions of their attractions, the smaller in the same relation must the force be which attracts together every two or three of the minutest molecules of the group: they offer a slight resistance to the causes—whether heat or chemical affinities—which effect a change in their form and properties; and are as easily changed and decomposed as other substances of simple combination.

PUTREFACTION.

The constituents of plants and animals into which sulphur and oxygen enter are formed of compound organic atoms; from the moment they are separated from the body, and come in contact with the air, they pass into a state of decomposition, which, once begun, continues even after the air is excluded. The colourless sections of a potato, turnip, or apple, soon become discoloured and brown on exposure to the air.

In all these substances, the presence of a certain quantity of water, by which the minutest parts receive mobility, is a necessary requirement, in order that on a transient contact with the air a change of form and properties, and a breaking up into new products may be called forth; both of which continue until not a particle of the original body remains. This process has been familiarly designated by the term putrefaction.

AFFINITY NOT THE CAUSE OF PUTREFACTION.

Experience teaches us further, that a number of substances brought in contact with these putrefying sulphurous and oxygenous matters, when in the act of putrefaction, in like manner change their properties; in the act of decomposing, their elements group themselves into new products, in the composition of which there are, in most cases, none of the elements of the putrefying substances taken up. From all these phenomena it is clear that the decomposition of the second body is not effected in consequence of an indication of affinity, since the idea of affinity is inseparable from the idea of combination.

DECOMPOSITION OF AMYGDALIN AND ASPARAGIN BY PUTREFYING SUBSTANCES.

In contact with the nitrogenous constituent of germinating barley (diastase) asparagin is resolved into succinic acid and ammonia; amygdalin resolves itself with the nitrogenous constituent of sweet almonds (emulsine) into prussic acid, oil of bitter almonds and sugar; salicin into saligenin and sugar.

THE CONVERSION OF STARCH INTO SUGAR.

Potatoes and the flour of the cereal grasses contain no sugar. The mere contact with water is sufficient, in consequence of the change that is thence effected in the sulphurous and nitrogenous constituents, to bring about a conversion of the starch into sugar.

THE SAME EFFECT PRODUCED BY ANIMAL MEMBRANE.

Animal membrane, when moistened with water, causes sugar of milk and grape-sugar to pass into lactic acid ; a similar property is possessed by the gluten of the cereal grasses, by animal casein, and by diastase.

FERMENTATION AND ITS PROPERTIES.

The property of an organic body to pass into the same state of putrefying decomposition as the body with which it is brought in contact, is termed the process of fermentation.

DIFFERENT DEGREES OF PUTREFACTION, AND THEIR INFLUENCE UPON FERMENTATION.

If it be true that the change of form and property in the fermenting body be dependant upon those which are effected in the putrefying body, or in the agent of fermentation ; if the new order of deposition of the atoms of the one body, be influenced by the direction in which the parts of the other arrange themselves ; if finally the fermenting body behave, as if it were a part or constituent of the agent of fermentation, it is clear that the mode of separation in the one must change with that of the other body ; the fermenting body must yield other products if the disunion, or the chemical condition of motion change the agent of fermentation. Innumerable experiments testify to the correctness of these conclusions.

MILK OF ALMONDS AND SUGAR.

When the milk of almonds, which in its fresh state exercises no influence upon sugar, is left for a short period of time, it ceases to act upon amygdalin ; and if in this condition sugar be added, the latter begins to ferment, and separates into alcohol and carbonic acid. If the almond milk be left still longer, it converts the sugar into lactic acid. A similar property is possessed by diastase, which, when fresh, converts starch into sugar ; but after a period of eight days, it loses this action, and gives rise to fermentation.

CASEIN AND SUGAR.

In the first period of its putrefaction the casein of milk converts the sugar of milk and grape-sugar into lactic acid; at a higher temperature the sugar of grapes passes into alcohol and carbonic acid ; and if the formation of free acids be hindered by the addition of an alcaline base, the casein in the last stage of its metamorphosis, occasions a decomposition of the saccharine atoms into carbonic acid, butyric acid and hydrogen.

ANIMAL MEMBRANE AND SUGAR.

Animal membrane behaves in the same manner. At first it effects a change of the starch into sugar, then of the sugar into lactic acid, and subsequently of the sugar into carbonic acid and alcohol.

THE INFLUENCE OF A HIGHER TEMPERATURE UPON FERMENTATION.

The same sugar of beet-root, which ferments at an ordinary temperature, and is decomposed into alcohol and carbonic acid, yields, on raising the temperature of the juice without the addition of any foreign substance, mannite, lactic acid, gum, carbonic acid and hydrogen.

FOUSEL OIL FROM SUGAR.

The same sugar yields, on changing again the conditions of its fermentation, butyric acid ; it is decomposed, in the fermenting molasses of beet-root sugar into water, carbonic acid and hydrated oxide of amyle (fousel oil.)

SEPARATION OF THE SUGAR, SIMILAR TO THAT OF ACETIC ACID OCCASIONED BY THE ACTION OF HEAT.

Milk sugar and sugar of grapes contain the same elements as lactic acid, and combined in the same relative proportions.

The products which appear on the fermentation of sugar of grapes contain precisely the same elements as an atom of sugar. Its decomposition is a simple separation, or transposition of its atoms, as is seen in acetic acid on the application of a higher degree of temperature. The carbonic acid contains two-thirds of the oxygen: the alcohol all the hydrogen of the atom of sugar.

THE PROPERTY OF CAUSING FERMENTATION IS COMMON TO ALL COMPOUND ORGANIC ATOMS.

If we take into consideration that the capacity of producing putrefaction or fermentation is common to bodies of the most various forms of composition; that blood, meat, cheese, membranes, cells, saliva, diastase, milk of almonds, &c., gain this property as soon as, by the chemical action of oxygen, a disturbance of the state of equilibrium has been excited in the attraction of their elements, it would seem that all doubt of the true cause, by which these phenomena are brought about, must vanish.

CAUSES OF THE CHANGE OF FORM AND PROPERTY OF MATTER.

A change of place or position in the most minute particles of a number of compound substances, and their decomposition, or conversion into new products may be called forth by chemical action, by heat, or electricity; and it may also be occasioned by a transference of some condition of motion, or by contact with a body, the particles of which are undergoing a change of place.

CONTINUANCE OF THE DECOMPOSITION.

If, from any external cause—by contact with oxygen, &c.—the condition of equilibrium in the attractive force of the elements of one of these compound atoms be disturbed, the result is the establishment of a new condition of equilibrium. The motion imparted to the first molecule is transferred to the second, the third, &c., of the parts of similar nature, extending even to all dissimilar particles, and to all other substances, if the force which held together their elements in their original form and character be less than that acting upon them with an opposite tendency. Want of power to maintain an original condition is want of power of resistance. Every body which is capable of offering this degree of resistance, hinders putrefaction and fermentation in most cases by entering into a chemical combination with the body susceptible of either of these conditions ; and the power of maintaining the original mode of arrangement is strengthened by every new accession of the force of attraction. To the force which maintains the condition of the first body, is added a second attraction which must be overcome before the elements of the first can change their locality or size.

ANTISEPTIC SUBSTANCES.

Amongst the substances which counteract putrefaction and fermentation we must mention before others, sulphurous and arsenious acids ; further, many mineral acids, metallic salts, empyreumatic substances, volatile oils, alcohol, and common salt.

These substances exercise a very unequal influence upon putrid matter. Alcohol and common salt in certain quantities arrest putrefaction, and consequently the process of fermentation, by removing from the putrid body a certain quantity of water, which is a necessary requirement for this change. Sulphurous acid, which is capable of entering into combination with all organic matters generally, and therefore with all bodies susceptible of putrefaction, hinders this process on the same principles.

RELATION OF ARSENIOUS ACID TO MEMBRANES.

Arsenious acid does not exert the smallest influence upon the fermentation of sugar in the juices of plants, or upon the action of yeast on sugar :—(*Schlossberger.*) Neither does it affect the putrefaction of the blood, but its action on membranes and the membranous structures is unquestionable. Whilst a bladder, or a bit of membrane covered with water is thoroughly decomposed and liquefied, giving off, in the course of six weeks or less, a most offensive stench, another piece of membrane or bladder likewise in contact with water will remain unchanged and without smell, if arsenious acid have been added to the fluid; the explanation of this difference is, that the gelatinous tissue enters into combination with the arsenious acid in the same manner as skin combines with tannic acid.

By means of a knowledge of the causes of the origin and extension of putrefaction in organic atoms, we are able to give a simple reply to the question of the nature of many forms of contagion and miasma, as the following remarks will show.

EXTENSION OF THE PROCESSES OF PUTREFACTION AND FERMENTATION IN THE LIVING ANIMAL BODY.

It still remains a question with many, whether there are facts to prove that the condition of decomposition or putrefaction of a substance be propagated to parts or constituents of the living body, and whether by contact with the putrefying substance, a condition will be induced in the parts of the human body, similar to that at work in the molecules of the putrid matter. We think there can be no hesitation in answering this inquiry in the affirmative.

FACTS.

It is a fact that the dead body often passes into such a state of decomposition while in the anatomical theatre that the blood of the living body is affected by it; the slightest puncture with a knife that has been used in dissection induces a dangerous or even fatal termination. The facts observed by Magendie that vomiting, lassitude, and even, after a prolonged period, death have been induced, by applying blood that is in a state of putrefaction, cerebral substance, bile, and putrefying pus to fresh wounds, have never yet been contradicted.

It is a fact that the use of many articles of food, as ham, sausages, &c., in certain stages of their decomposition, induce the most dangerous conditions of disease in the healthy body, and not unfrequently are the cause of death.

WHAT IS TO BE UNDERSTOOD BY THE TERM "PRODUCTS OF DISEASE."

These facts prove that an animal substance in the act of decomposition may induce a process of disease in the bodies of healthy individuals, and that this condition can be transferred to their organs and constituent parts. But as the products of disease can be only understood to mean parts and conditions of the living body in a condition of change in their form and properties, it is clear that as long as this condition remains imperfect, disease may be transferred to a second, or third individual, &c.

ANTISEPTIC SUBSTANCES RETARD THE EXTENSION OF CONTAGION AND MIASMA.

If now we take into consideration further, that all those substances or causes which destroy the propagating tendency of contagion and miasma, are at the same time requirements for the removal of all processes of putrefaction and fermentation—if daily experience show that, empyreumatic substances, as pyroligneous acid for instance, which most strongly counteract decomposition, are the means of changing entirely the process of disease in wounds suppurating unhealthily, and if further free or combined ammonia (the almost invariable product of putrefactive processes) be found during many contagious diseases, as for instance, typhus in the surrounding atmosphere, and in the urine and fæces; it surely then seems impossible to entertain a doubt concerning the cause of the origin and further propagation of a number of contagious diseases.

PUTREFACTIVE PROCESSES AS CAUSES OF CONTAGIOUS DISEASES.

General experience has at length shown us that "the origin of epidemic diseases can often be traced to the putrefaction of a number of animal and vegetable substances; that miasmatic diseases become epidemic where there is constant decomposition of organic matter in marshy, damp districts. And that they also develop themselves epidemically under similar circumstances after inundations; besides, in other places where a large number of people are assembled together with little change of air—as in ships, prisons, and besieged places, &c.;* further on at page 57, the same author observes that "we can never prognosticate the origin of epidemic disease with more certainty, than when a marshy flat has been dried up by continued heat, or when excessive heat follows extensive inundation."

CONCLUSIONS.

Here our deduction is fully justified according to the rule of natural inquiry, that in all cases where a process of putrefaction has preceded the first indications of disease, or where disease can be communicated by solid, fluid, or gaseous products, and where no more immediate cause can be adduced, the substances or matter in the act of decomposition must be looked upon as the most probable cause of disease.

* Henle, Untersuchungen, p. 52.

POWER OF INFECTION—IN WHAT IT CONSISTS.

The requirement for the capacity of infecting a second individual, is the presence in the body of the latter of a substance which can oppose no resistance either in itself, or through the vital energy in the organism to the causes affecting a change of form and property. If this substance were a necessary constituent of the body, disease must be transferable to all individuals; if only an accidental constituent, those persons alone would be infected in whom this substance was present in sufficient quantity, and of the characteristic nature. The termination of disease is only a destruction and removal of this matter; it is a re-establishment of the condition of equilibrium of those causes in the organism which regulate its normal functions, and which had been temporarily suspended.

A CHALLENGE TO INVESTIGATION.

Practical medicine will soon decide whether this view be correct or not; and it will then be shown whether there is any actual connection between the relation of arsenious acid to animal membranes out of the body, and their action in certain fevers; and between the relation of mercurial compounds to animal substances, and their action in contagious diseases.

If this so-called chemical view do not serve as a guide and director to the physician, after a careful study of the processes of putrefaction of simple and compound bodies, and of the materials or causes by which these processes are altered, hindered, or accelerated; and if a comparison of this with other analogous processes in the human organism, be not the means of enlarging his views upon disease, and raising to a more scientific basis his knowledge of the remedial agents to be employed; then, indeed, it were of no avail to endeavour to support this theory. Its simplicity has stood much in the way of its being generally received; for at the very time that every physician or physiologist does not hesitate to ascribe the most striking changes in vital processes to bad nutriment, want of fresh air, or the continuous use of salted food, &c.—whilst no one feels any scruple in assigning a scarcely appreciable difference of temperature as the cause of inflammation, fever, and death—one of the most important causes of a change of form and properties is disregarded, as exercising no influence upon the organic vital process.

Here is a theory strengthened by a firmly linked chain of numerous and most evident facts, to which a critical investigation is denied, although there is nothing that can be advanced against it save its comprehensibility. But it is precisely on this latter character that the difference rests, which is observed in the result of various methods of physical investigation. Although every pathologist and physiologist is fully convinced that no organic process can be explained without the co-operation of chemical and physical forces, every theory which has hitherto been based upon such causes has been invariably doubted and rejected.

If we compare the so-called chemical theory with the principles of the parasite theory, we cannot comprehend how intellectual men, and the most practised observers, can defend and lend their sanction to views which the experience of each succeeding day must refute.

THE PARASITE THEORY.

The principles of the parasite-theory may be referred to two facts, viz., to the propagation of the itch, and to a disease appearing in silk-worms, called *muscardine*.

THE ITCH.

The itch is an inflammation of the skin, occasioned by the irritation of a kind of mite (acarus scabiei, sarcoptes humanus*), which lives upon the skin, or, more correctly speaking, burrows within it. For the communication of the itch continuous

* An excellent account of this insect, and of the other parasites infesting the human body is given in Vogel's Pathological Anatomy. See Dr. Day's translation, p. 419.

vicinity is necessary, and that especially at night, as the itch-mite is a nocturnal depredator. The fact of the itch-mite being the vehicle of the contagious character of the itch, is proved by the following facts: inoculation with the pus of itch-pustules does not engender the itch, any more than the application of the crusts of scabious pustules upon the arm. Secondly, the disease is healed by rubbing off the mites with brick-dust; and it can only be propagated by the impregnated female animalcule. The itch may continue until it induces general permanent disease, which in these cases becomes established, and cannot be spontaneously cured.

THE ITCH A CONTAGIOUS DISEASE PROPAGATED BY AN ANIMAL.

Contagion of the itch is, according to this theory, an animal with a mandibular apparatus, which lays eggs; we term it fixed contagion, because it cannot fly, and its eggs cannot be transported by atmospheric influence.

If it be proved that the itch may be propagated by animals, it requires neither a chemical nor any other theory to explain the communication of the disease; and it becomes evident that all conditions which are similar to the itch belong to this class, where observation shows approximating or like causes, for the communication and extension of the disease.

CONTAGIOUS DISEASES NOT COMMUNICATED BY ANIMALCULES.

If now it be asked, what results have been obtained from investigation into these and other similar causes of infectious diseases, we may answer, that in the contagion of small-pox, the plague, syphilis, scarlatina, measles, typhus, yellow fever, dysentery, hydrophobia, &c. the most attentive observations have not been able to trace any animalcules or organic entities to which the means of propagating the disease could be ascribed.

PARASITES IN BODIES OF THE HIGHER CLASSES OF ANIMALS.

We have already observed, that there are a number of insects which can alone be developed and propagated in the body or under the skin of the higher animals, and that they may, in many cases, induce disease, and even death ; and it will, therefore, be perfectly clear that the itch-mite belongs to this class of diseases, since the size of the animalcule can make no difference in the explanation.

There are, accordingly, diseases occasioned by animalcules, parasites, which develop themselves in the bodies of other animals, and thrive at the cost of some of their constituent parts ; and they cannot be mistaken for other diseases, where such causes do not prevail, whatever resemblances there may be in external indications. It is possible that further observations may attest the fact, that some or other of the contagious diseases belong to the class dependant upon parasites; until, however, such a fact be established, we must, according to the rules of natural investigation, avoid assuming it. It is the province of scientific enquiry to discover the especial causes by which they have been induced, the simple question concerning which will lead the way to an explanation of the subject.

That infection in contagious diseases is dependant upon an organic being, and that the itch must be regarded as a type of contagious diseases, were facts which it was endeavoured to ground upon the deduction of like effects springing from like causes.* A similar mode of reasoning has, for centuries, impeded the advance of the natural sciences, and even continues at the present day to lead to many errors.

The pure miasmatic diseases, and their so-called miasma, have not as yet been laid open to investigation in reference to their origin and the manner of their extension, and on that account no explanation has hitherto been attempted, either by a

* Henle, Zeitschrift, 2 Bd. p. 305,

chemical or parasite-theory. The parasite-theory has designated *muscardine* as the type of those miasmatic contagious diseases which arise from matter derived either from the air or from the diseased body.

MUSCARDINE.

Muscardine is a disease of the silk-worm, occasioned by a fungus. The germ of the fungus, when introduced into the body of the worm, grows in eating its way into the interior, and after the death of the animal it penetrates the skin, when the surface soon appears covered with a forest of fungi, which by degrees dry up, and are converted into dust; this is raised and scattered in the air by the slightest motion of the body on which the fungus grows. Good nutrition, and perfect health and strength increase the capacity for infection; and thus, in a colony of silk-worms, the finest and largest are always the most affected by the disease.

PARASITES IN ANIMALS AND PLANTS.

Similar parasites have been observed on diseased fish, in infusoria, and in hen's eggs; and it is clear that these observations confirm a series of facts regarding the animal organism which often occur in the vegetable world, proving that disease and death are frequently induced by parasites, which live exclusively upon the constituent parts of other bodies; as yet, however, no connection has been drawn between these facts and the origin and propagation of miasmatic contagious diseases; and if it be allowable to designate a fungus, or its spores, by the term contagion, it is clear—since the size of the fungus makes no difference in our mode of considering it—that some sources of contagion attain to a length of six or eight inches, this being the size of the fungus, *Sphœria Robertii*, which develops itself in the body of the New Zealand grub, and occasions its death.

FALSE VIEWS OF THE CAUSES OF PUTREFACTION ARE THE FOUNDATION OF THE PARASITE-THEORY.

A view of the cause of fermentation and putrefaction, which is thoroughly false in its principles, has hitherto served as the main support of the parasite-theory. Its adherents regard putrefaction as a decomposition of organic beings, by infusoria and fungi, and every putrefying body as a sort of rampart of infusoria, or a plantation of fungi; and thus, according to this view, wherever organic bodies pass into putrefaction to any extent, the whole atmosphere must be filled with the germs of the contagion, and become the cause of disease.

FUNGI AND INFUSORIA DO NOT OCCASION PUTREFACTION.

It has not escaped the advocates of the parasite-theory, that a close connection exists between putrefaction, contagion, and miasma; although they avoid entering upon an explanation of the mode of comprehending the connection of these phenomena, and their mutual dependence upon each other. This connection would be established, if it were proved that infusoria or fungi, induced putrefaction or fermentation; that by them and their process of digestion and respiration, sugar is resolved into equal volumes of carbonic acid gas, and vapour of alcohol; and that the following conversions are brought about, viz., urea into carbonate of ammonia; salicin into sugar and saligenin; sulphate of protoxide of iron into sulphuret of iron; sulphate of lime into sulphuret of calcium; sulphate of soda into sulphuret of sodium; blue indigo into white indigo; starch into sugar; sugar into lactic acid; amygdalin into prussic acid, bitter oil of almonds, and sugar.

The following remarks will show how thoroughly untenable are these views.

OPPOSITION BETWEEN PUTREFACTION AND THE PROCESS OF LIFE.

The constituents of vegetable and animal structures have arisen under the dominion of an active cause of change in the form and properties of organisms; and this is vital force, which decides the direction of attraction, and opposes the force of cohesion, heat, and electricity, destroying the influence of every cause that hinders the association of atoms in combinations of a higher order without the organism. In compositions of such various nature as the organic atoms, these other forces occasion a change of form and condition, when the vital force after death no longer opposes their action. The same leaf, or the same grape which possessed the capacity of giving off pure oxygen to the atmosphere, submits to the chemical action of the oxygen from the moment of its separation from the organism, and its being brought in contact with the air.

No organism—no portion of an animal or plant is capable, after the extinction of vital energy, of resisting the chemical action which air and humidity exercise upon it, and its elements fall back under the unlimited dominion of chemical force. Fermentation and putrefaction are the stages of its retrograde development, presenting less perfect combinations, until at length the organic atoms, in consequence of continuously acting unorganic forces, return to their simple original forms, in which they may serve for the development and nutriment of new generations.

FUNGI AND INFUSORIA ARE SUBJECTED TO PUTREFACTION, FERMENTATION, AND DESTRUCTION.

Fungi and infusoria are organic beings with constituent parts of the same composite nature as those of the higher orders of vegetables and animals, and we observe the same phenomena in their bodies after death, as those which accompany the disappearance of all organisms, and find them in a state of putrefaction, fermentation, and corruption; how then is it possible to regard fungi and infusoria as the causes of these processes, when they themselves become putrid, fermented, and corrupt, leaving nothing but their inorganic skeletons?

FUNGI AND INFUSORIA ARE THE ATTENDANTS, BUT NOT THE ORIGINATORS OF THE PROCESS OF PUTREFACTION.

No one will deny that fungi and infusoria are found in a great number of putrefying and corrupting substances; but the frequency of their appearance cannot possibly be adduced as a motive for regarding them as the causes, instead of the attendants of these conditions. Fungi and infusoria are shown by nature, in reference to their nutriment and development, to be organic atoms, which have ceased to be parts or constituents of living organisms, and, in most cases, they do not appear until putrefaction be established, or is complete, and the process of corruption has begun. It cannot be doubted that all processes and their respective products are changed by their presence, for by means of their process of nutriment and respiration, they accelerate solution, limiting its baneful influence upon the surrounding parts to the shortest possible period of time.

FUNGI AND INFUSORIA HASTEN THE PROCESS OF PUTREFACTION AND CORRUPTION.

If the process of putrefaction be terminated by the return of the elements of organic beings into carbonic acid, and carbonate of ammonia, it is clear that the period necessary to effect this conversion must be most perceptibly curtailed if the putrefying agent be a plantation of infusoria, millions of whom are busily engaged in leading the constituent parts of the body into a state of decomposition by means of their respiratory and digestive processes.

BY THIS MEANS THEY BECOME THE ENEMIES OF THE PROCESS OF PUTREFACTION.

It can no longer be doubted that nature has assigned to the infusoria the important part of being the enemies and opponents of all contagion and miasma; since the most incontrovertible facts have shown that the green and red infusoria are during their life, and the process of their propagation, sources of the purest oxygen.

In a similar manner fungi check putrefaction by converting to their own nutriment, the sulphurous and nitrogenous constituents of vegetables—the actual originators of corruption ; and thus further, the general transition into the final products of corruption.

THE NATURE OF YEAST.

The views which the adherents of the parasite theory have formed as to the cause of putrefaction, mainly rest upon observations which have been made upon the formation of the yeast in the fermentation of wine and beer ; but the investigations into the nature of the yeast are not yet closed, and it is to be presumed that the microscopic observations already made will be strengthened by further inquiry, and every doubt concerning its vegetable nature be thus set aside ; yet even in this case the explanation regarding the separation of sugar into alcohol and carbonic acid, would admit of no other expression than that assumed by the chemical theory.

RELATION OF THE YEAST IN SOLUTIONS OF SUGAR, IN GRAPE JUICE, AND BEER WORT.

It is a perfectly well-known fact that in spirituous fermentation, the elements of the sugar of grapes without any loss of weight, and those of the sugar of cane with an increase of weight, are given back in the form of carbonic acid and alcohol. We cannot here, according to our usual conceptions, speak of the conversion of the atoms of sugar to the nutritive and respiratory processes of an organic being. The weight of the yeast increases in the fermentation of the juice of the grape and beer-wort ; but if we put the yeast in a solution of pure sugar and water, although the fermentation is equally produced, the yeast in this case instead of gaining, loses a portion of its weight ; and by continuous contact of the same yeast with fresh sugar and water, it by degrees entirely loses the power of fermenting, while its weight constantly diminishes. In this case, as we see, one and the same action must be derived from two directly opposite causes, to one of which is ascribed the capacity for increase, and to the other the reverse of propagation. If we assume that the nutritive and respiratory processes of the fungi are dependant upon sulphurous and nitrogenous substances contained in their elements, and that the fermentation of sugar is an accidental phenomenon, accompanying the developing process of an organic being, then it is quite incomprehensible whence it arises that the fungi are not reproduced in a fluid, where there is present this chief requirement to their propagation, while they gain in weight as soon as sugar, the accidental attendant of this vital process, is added. If, for instance, in the juice of the grape, sugar be decomposed, and there is no free access of air, the remainder of the dissolved sulphurous and nitrogenous substances will remain dissolved in the juice for years without undergoing any change; if sugar be then added, the fermentation begins again, and yeast is again separated; when the sugar is decomposed, its separation ceases, beginning again only on a new addition of sugar; and this continues until the fluid contains an excess of sugar.

THE FORMATION OF YEAST, ALCOHOL, AND CARBONIC ACID ARE MUTUALLY DEPENDANT UPON EACH OTHER.

From these facts we evidently obtain a reciprocal relation of dependence, as required by chemical theory, between the form and properties of the sulphurous and nitrogenous body which is converted into yeast, and the new forms and properties contained in the atom of sugar; and it is clear that the condition in which the elements of the former stand during their association with the yeast, and their falling asunder into other products, is the cause of the manner in which the sugar separates. No organic beings or animals similar to fungi, have ever been observed in any other form of separation of sugar, as, for instance, in its transition into lactic acid by means of an animal membrane, or in its transition into mannit, gum, butyric acid, acetic acid, &c.; nor in any other process of putrefaction or fermentation, have organic beings been perceived, which appearing invariably in the same forms, control the nature of the products.

VIBRIONES IN THE URINE.

In many cases the presence of vibriones is detected in the urine during its state of putrefaction, while in other cases, when the urine putrefies, it is impossible to discover any organized being, and if the absence of vegetable or animal organisms is certain in one single case, where fresh urine has been decomposed by the putrefying white deposit which occurs in a state of putrefaction, the fact is perfectly sufficient to remove every doubt of the true cause of the putrefaction.

FUNGI CONTAIN SUGAR.

If further we show that, in all hitherto examined fungi, analysis has yielded a quantity of sugar, which during the process of life did not pass into alcohol and carbonic acid, but that, in the same fungi, spirituous fermentation occurs immediately after their death, and from the moment when a change in their colour and properties is perceived, every analogy is wanting to justify our regarding the vital process of these plants as the cause of fermentation. The action must rather be ascribed to the reverse of a vital process.*

* Schlossberger, Annalen der Pharmacie, Vol. LII. p. 117.

CHANGE IN THE PROCESS OF PUTREFACTION IN HEATED AIR.

We may consider it as proved by the most admirable experiments, that the process of putrefaction in meat and many other animal substances assumes a totally different form, when these substances have been preserved in vessels containing heated air, and when consequently there can be no co-operation of infusoria; yet these animal substances by no means, under these circumstances, maintain their original condition; they change their colour and composition, and if the water necessary to the complete decomposition of the meat be present, it dissolves after a certain period into a most offensive mass.* We need only recal to mind the relations of fresh urine in order to perceive that in many of these animal substances a constantly renewed afflux of oxygen is a requirement for their putrefaction; that on the exclusion of oxygen, the urea does not pass into carbonate of ammonia, and that, enclosed in a vessel, these

* De Saussure in his beautiful investigations observed the fact that hydrogen at a glowing heat obtained by the decomposition of aqueous vapour by means of iron, and in contact with putrefying or decayed animal substances entered into no combination with oxygen; while at the ordinary temperature, pure hydrogen was easily condensed under these circumstances. This deserves attention in an inquiry into the influence of heated air upon the process of putrefaction. Possibly the decomposition of infusoria and the germs of fungi may not be the only cause of the change in this process.

substances convert the oxygen into carbonic acid, and that with the removal of the oxygen, the whole process is arrested, or at all events changed.

The adherents of the parasite theory assume, that by the passing contact of sugar of grapes with the air, (without which fermentation could not begin) the germs of the yeast plant which are present everywhere in the air, find access to a soil which affords them the necessary requirements for their fruitful development; but they do not explain the reason why the brewer is obliged to add yeast in order to turn his wort to a state of fermentation; and why these same germs, if they really were in the air, should not develope themselves in a soil so congenial to the requirements of their life and propagation. They entirely forget that the fermentation of the sugar of grapes begins with a chemical action, that a measureable quantity of oxygen is taken up from the air, that the juice becomes turbid and discoloured, and that fermentation only begins after the occurrence of a precipitate; they do not consider that fermentation diminishes instead of increasing with the additional quantity of oxygen; and that under certain conditions when the matter capable of taking up oxygen has become insoluble, fermentation no longer goes on in the juice.*

* Two cubic centimeters of must, three millimeters thick and thirty millim. in diameter, in contact with twenty cubic centim. of oxygen

Before all these relations have been thoroughly examined, it would be contrary to all sober inquiry to consider the vital process of an animal or plant as the cause of any process of fermentation or putrefaction; and in all cases where the presence of organic beings is not to be shown on investigation in the contagion of a miasmatic-contagious disease, the hypothesis of these bodies having or taking any share in the process of disease must be rejected as altogether unsound.

TWO SIMULTANEOUSLY OCCURRING PHENOMENA ARE FREQUENTLY HELD TO BE A CAUSE, AND ITS EFFECT.

Another no less grave error in the mode of considering and deciding upon a question, is to look upon two different phenomena, which are effects of one and the same cause, as mutually dependant upon each other, and regarding the description of the one phenomenon as an explanation or definition of the other.

EXAMPLES.

This is the case, for instance, with the explanation which is given of fever, of crises, &c. A few examples of similarly false combinations, which

do not pass into a state of fermentation; while a similar stratum without the addition of oxygen occasions a considerable development of carbonic acid.—De Saussure in the Jahrbuch für Chemie, vol. LXIV, pp. 47—51.

daily occur in life, will best exhibit what is here alluded to.

A STORM REGARDED AS THE CAUSE OF UNUSUAL CHANGES IN THE STATE OF THE BAROMETER.

Nothing is more common than the opinion which ascribes to storms the effect of making the mercury fall in the barometer.

Storms are effects of a difference of temperature, or of some other causes of interrupted equilibrium of the pressure of the atmosphere. A change of the pressure of the atmosphere exhibits itself by its influence upon the rise and fall of a column of mercury, which is of equal weight with a column of air of the same diameter. The barometer and the storm do not stand in any immediate relation to each other; the storm exercises no influence upon the barometer, and the two are only combined by their mutual dependence upon one cause. And in precisely the same manner the fall of the barometer is connected with the occurrence of rain.

SYMPTOMS OF FEVER MUST NOT BE REGARDED AS THE CAUSES FROM WHENCE IT ARISES.

The false ideas which many pathologists have formed to themselves of the cause of fever belong to this class of errors regarding the *causa efficiens*, and to the confusion of ideas concerning effect and cause.

HENLE'S EXPLANATION OF FEVER.

"Although I am far from thinking," says Henle,* "that I am able to settle the controversy regarding the question of the existence of essential fevers, I yet believe I may contribute something that shall enable the contending parties first to understand themselves better, and next their opponents. It follows that as febrile symptoms are the consequences of an alteration in the central organ, so this alteration is the proximate cause of the febrile symptoms ; and as the fever depends upon these symptoms, upon the complication of the change of temperature, motion of the blood, of thirst and lassitude, this alteration must be the proximate cause of the fever—in fact the fever itself."

Setting aside that these three positions are not consecutive links of one conclusion, since each one says the same as the other two—we cannot in accordance with the rules of natural investigation —so long as the causal connection of the febrile symptoms and the alteration in the spinal cord be not explained—regard the febrile symptoms as anything more than indications of the changed condition of the spinal cord. To the symptoms of fever which are externally perceptible, must be added the scientific investigation of a new indica-

* Untersuchungen, p. 240.

tion of disease. The alteration in the central organs is a fact perceived, or to be perceived by the senses, but not a cause.

WHAT COURSE MUST BE PURSUED IN THE INVESTIGATION OF THE CAUSE OF FEVER.

If it be assumed that this alteration is always and unalterably accompanied by febrile symptoms, the knowledge and explanation of the cause of fever must include the recognition of the connection of the three constantly recurring indications of fever—that is, the subjective feeling of indisposition, the alterations in circulation and respiration, and the changed phenomena of heat, which characterize the febrile condition, as well as the relation of their mutual dependence.

If we exclude from investigation, as inexplicable phenomena, the subjective indications, the feelings of indisposition, and of heat and cold, it still remains to trace the connection existing between the alteration of the spinal cord, the accelerated movements of the blood and the respiratory apparatus, and the altered phenomena of heat. Before we can obtain any explanation of this, we must arrive at a conception of motion, and seek the source of a moving force and heat in the animal body. If we would trace the cause of fever according to the physical method, and consider that by the co-operation of many, or let us say of two causes, a certain amount of force is engendered in the heart itself, by which the circulation of the blood is affected; then the motion will be regular or normal, if the number of the beats of the heart be equal in every minute, and when the force is thus divided over equal periods.

POINT OF VIEW OF THE INVESTIGATION.

If this same amount of force, in consequence of the disturbed relation of the two causes, which have their seat in the heart, at one time increases and at another diminishes, the pulsations of the heart will be at one time quicker, and at another slower. The force engendered is in this case not proportionate to the term of its consumption. It is clear that, on the supposition of this force being engendered in the heart, the alteration in the spinal cord can exercise no other influence upon the change in the phenomena of motion, or upon the accelerating or retarding of the heart's action, than that, in consequence of its condition, it may oppose, in some manner or other a smaller resistance to motion at one period than at another. The causes of the effects of motion do not exist in the heart alone; they are distributed in every part of the organism, in the spinal cord, as well as in every individual muscular fibre.

ENQUIRY INTO THE CONNEXION OF THE SPINAL CORD WITH THE EFFECTS OF MOTION.

We may conjecture that the movement of the heart, as well as that of all other parts of the organism, the motion of the intestines, and the voluntary motions, proceed from the spinal cord, and it is evident that a change in the condition or character of this organ must be followed by a change in all the phenomena of motion. The same must happen when any part of the nerves, standing in connection with the spinal cord, and with the circulatory apparatus, &c., suffers a change of condition or properties, and this changed activity must exercise a retrograde influence upon the spinal cord and the apparatus of motion. The laws of the propagation or communication of motion, are everywhere the same, whatever causes may have called them forth.

The cause of motion in a mill, the rotatory motion of the stone, the bolting of the flour, &c., are not occasioned by the wheel, for that is a portion of the mill itself. It is quite certain that an irregularity in the working of the mill may be occasioned by the removal of a few of the wings of the wheel, by which the pressure of the water on these parts ceases; it may also, however, be occasioned by the breaking off of the cogs of one of the other wheels of the mill, when an irregularity of motion will be perceived not only in this wheel, but in every other part of the wheel.

REGULAR AND IRREGULAR MOTIONS.

If now the organism engender a certain amount of force in a given time, the motions will be regular if the force proceed from the spinal cord; irregular if one apparatus have more force than another. If subsequently the motions of the blood and respiration be accelerated, the consequence will be weakness in the limbs, or a disturbance of the digestive functions. The extra force which the heart receives in the acceleration of its action, cannot be applied to the other apparatus of motion.

After establishing the connexion between the spinal cord and the effects of motion, the relations of the latter to the phenomena of animal heat must next be discussed.

RELATION OF THE PHENOMENA OF ANIMAL HEAT TO THOSE OF MOTION.

Observation shows that the irregularity of the phenomena of motion is accompanied by a change in the phenomena of heat; in many cases the subjective and objective phenomena of heat rise and fall with the acceleration or retardation of the indications of motion; in other cases again both do not recur simultaneously in the same relations.

But the phenomena of motion become more regular by the equalization of the indications of heat; and if the former are restored to a normal state, the latter will show a proportionate degree of irregularity. If, now, it can be shown that the effect of motion (speed) does not call forth heat (as, for instance, by friction,) it naturally follows that heat and the phenomena of motion stand in no nearer connection with each other than the storm with the abnormal rise and fall of the mercury in the barometer, and that, consequently, the causes which have influenced the one series of phenomena are simultaneous conditions of the other series. If the amount of evolved heat in a given time stand in a definite relation to the number of blood-corpuscles which have passed through the capillaries in the same time, the source of heat must be sought in certain states of the blood-corpuscles, or of the blood and the capillaries.

RELATION OF THE PHENOMENA OF HEAT TO THE OXYGEN OF THE AIR.

Since it is proved, by investigation, that the condition of the blood, by which it may become a source of heat, consists in its power of taking up oxygen, and since the oxygen thus taken up in a given time stands in a definite relation to the number of inspirations within the same period, irregular effects of heat must be dependant upon the respiratory motions, the contractions of the heart, and *one external cause*—and this is, the chemical action of oxygen. As the relation of these three factors to each other is altered, the phenomena of heat must in like manner change; and when in certain parts of the organism the capacity of entering into combination with the oxygen increases from any superadded cause, more heat will be evolved in that one part than in others. When, in accordance with this, the motion of the circulation and respiration is accelerated, then will also the amount of oxygen and liberated heat be increased, which is in accordance with the beautiful law established by Vierordt. If the respiratory and circulatory motions are accelerated in unequal relations, the subjective, or objective feeling of warmth is changed. When all these relations are examined and obtained, we shall not only be able to explain the individual symptoms of the fever, and, consequently, the disease itself, but we shall then also be enabled to trace all to a final and sole cause (the cause of disease.) This is the course of natural enquiry.

ERRONEOUS CONCLUSIONS DRAWN FROM BRINGING ONE CAUSE TOO PROMINENTLY FORWARD.

Erroneous combinations of conclusions of another kind are formed, when in the explanation of a natural phenomenon we only keep in view one of the many causes on which it is dependant, ascribing to it an active importance which it does not possess in and for itself, but merely receives from the presence of other causes. Thus, for instance, Schleiden bases his theory partly upon an untenable atomism, partly upon false mechanical principles, when he says, in his "Elements of Scientific Botany,"* "that fermentation and putrefaction are the effects of the communication of a motion, and that the amount of the motion will be measured by the product of the mass into the velocity. One part of diastase is said to extend its decomposing power over 1000 parts of starch (but this is an error, since, according to Guerrin Varry, one portion of diastase acting upon 60 of starch, gives only 10.3 of sugar. The relation of 16 of starch to 1 of diastase, gives only 14 of sugar.) We must, therefore, assume in an atom of diastase a velocity 1000 times greater than would be necessary for the decomposition of an equal weight of starch. Here we see that a gigantic edifice of crowded hypotheses has been erected upon the most untenable basis, in order to support a false opinion. On the other hand, the objection started as to the impossibility of one body at rest setting another in motion, borrowed from the atomic method of explanation, is likewise physi-

* Grundzüge der Wissenschaftlichen Botanik, 1845, p. 282.

cally false; since gravitation, magnetism, and electrical attraction are nothing but mere examples of motion being imparted by one body at rest to another."

CORRECTION OF SCHLEIDEN'S VIEW.

As to what regards diastase, and its action upon starch, Schleiden has forgotten to take into consideration the time which is necessary to effect the conversion into sugar. The view which he contests, does not presuppose that the molecules of the diastase possess a greater velocity, but that the surrounding deposition of the molecule of starch had gone on while the motion in the diastase molecule still continued, and, consequently, before a state of equilibrium had been established in the latter. Nothing is to be understood by a communication of motion, but that the molecules of starch are kept in contact with the molecules of the diastase, as if they were parts or constituents of it. The action of the diastase in a limited time depends, therefore, upon the number of the molecules of starch that can come in contact with the molecules of the diastase in the same period of time. The number of the molecules of diastase affect the time and the process of its conversion into sugar; the action disappears with the presence of diastase, and by a double or triple quantity of diastase the time of the conversion is shortened, or a larger quantity of starch is converted into sugar.

THE MEANS BY WHICH MOTION OCCURS.

As to the view advanced regarding gravitation and electricity, as instances of the motion of one body through another at rest, we must take into consideration that a body at rest may pass into a condition of motion in two essentially different modes.

FIRST: BY THE COMMUNICATION OF A MOVING MASS.

1. By the communication of the moving mass of a body already in motion, as by means of a blow—for instance, the action of the hammer on the nail, of water on the mill wheel, or wind upon the sail.

SECONDLY: BY AN ATTRACTIVE OR REPULSIVE FORCE.

2. By the action of an attractive or repulsive force, which is interposed between two bodies. In this the action is always mutual, and the speed obtained inversely proportionate to the masses moved.

CHEMICAL PROCESSES, AS PHENOMENA OF MOTION, BELONG TO THE SECOND KIND.

As one must consider chemical processes as phenomena of motion, it is not to be doubted that all such processes as can be explained by the formation of new compounds belong to the second class of phenomena of motion, while the attractive force of the constituents, or their chemical affinity, calls forth the change of place and property (that is the motion) of matter. After the establishment of the combination, motion ceases, as when the falling stone has reached the ground, and the iron filings the pole of the magnet.

PUTREFACTION AND FERMENTATION BELONG TO THE FIRST ORDER OF PHENOMENA OF MOTION.

But when a body which is undergoing decomposition, that is, whose parts are in a state of change of place and of motion, converts another body into a similar condition; and if observation have shown that all other known causes, excepting one alone, must be excluded from any participation in the change, or decomposition of the second body; and if it be proved that this one cause (communication of motion, friction, a blow, &c.), have a decided share in the formation and decomposition of a number of combinations, this one cause must be regarded as the final acting one, especially, if the views gained in the theory of motion, be applicable to chemical actions. The recognition of this last, and only cause, is therefore not a mere word that has been substituted for the term "catalytic force;" but the expression of an idea, which is strictly the opposite to that of a catalytic body. From the facts advanced in (2) p. 84, the erroneous conclusion is drawn that gravitation, magnetism, &c., are examples of the motion of one body through another at rest.

THE FORCE OF GRAVITATION GIVES NO RISE IN ITSELF TO MOTION.

A clock is kept in motion by the weight but cannot draw it up by itself, and the heat of the sun has as little share as gravitation in the action of a mill-wheel. The water which impels the mill-wheel was previously vapour—the vapour was fluid water.

The water underwent evaporation; the vapour, on the abstraction of heat, became again aqueous, and this liquid water falls by the action of gravitation, and continues to fall until, as in the clock, resistance arrests its motion.

WANT OF CORRECTNESS IN EXPRESSION, THE CAUSE OF ERRONEOUS CONCLUSIONS AND MISUNDERSTANDINGS.

Besides the erroneous conclusions and methods of investigation which are comprised in this one clause, there is yet one individual fault to be added, which prevails amongst many physiologists, and which can be explained only on the plea of carelessness. This failing is to regard things or phenomena, that have been perceived by the senses, as representing conclusions of the mind, which brings along with it this great disadvantage, that in order to esteem a fact as true, these naturalists require to have ocular demonstration of known causes which cannot be perceived by the senses.

From this it may arise that chemists, in spite of a superabundance of the most evident facts, are frequently unable to convince physicians of the simplest truths.

EXAMPLES.

Examples of this assertion can be found in every physiological work, and I will give a few illustrations from one of the most recent treatises. Valentin says,* " We perceive on dividing the facial nerve that the muscles of the face on the corresponding side are paralysed as far as the will is concerned. We thence justly conclude that the effects of our will are communicated by means of the facial nerve to the muscles of expression.

" We find after injury of the trunk, or the branch of the fifth pair of nerves supplying the eye, that secondary inflammation, suppuration,

* Manual of Physiology, Brunswick, 1844.

and even further, destruction of the globe of the eye are occasioned ; and conclude, therefore, that the integrity of the above-named nerves is necessary to the normal condition of the eye."

Further on at page 3, we find as follows: "I know that the walls of the arteries are elastic, and I may, therefore, at once conclude that they distend to a certain extent as soon as they have been filled with blood ; and that on the yielding of the pressure they return to their original circumference," that is to say, they are elastic.

POINT OF CONTACT BETWEEN PHYSIOLOGY AND CHEMISTRY.

I have shown in the above, how much the difference in the way of viewing things, adds to the difficulty of arriving at an understanding between physiologists and chemists ; and I will now endeavour to consider more particularly the point of contact, at which physiology and chemistry ought to meet in order that they may mutually assist each other.

DEVIATION OF CHEMICAL AND MECHANICAL LAWS FROM THE LAWS WHICH GOVERN VITAL PHENOMENA.

If we endeavour to make use of illustrations derived from the knowledge of mechanical forces, in the enquiry of vital or chemical phenomena, we immediately observe that the laws which govern the former, differ in many respects from those on which the peculiarities of chemical or vital combinations are dependant.

RELATION OF THE PROPERTIES OF ELEMENTS TO THE PROPERTIES OF THEIR COMBINATIONS.

A chemical combination of two bodies, possesses properties which are entirely different from those of its several constituents. The chemical force of the new body, the power of entering into new combinations, or bringing about decomposition, is not the sum of the chemical forces of its elements. We are entirely unable, by tracing backwards, from the properties of a muscular fibre, to decide concerning those of carbon, hydrogen, nitrogen, and its other elements; and yet nothing can be more true than that certain relations remain permanent between the properties of the elements, and those of their combinations.

Cinnabar is a metallic sulphuret, which possesses totally different properties from sulphuret of lead on sulphuret of zinc. It cannot be doubted that their difference is dependant upon the fact of mercury being combined in the first, lead in the second, and zinc in the third, with sulphur; and that the properties of the mercury, lead, and zinc must have an entirely definite and definable share in the difference of the properties of their combinations, since the latter are evidently dependant upon the difference. We see this the most clearly in the isomorphous substances ; sulphuret of lead is scarcely in appearance to be distinguished from seleniuret of lead, sulphate of alumina and ammonia, from sulphate of alumina and potash, selenate of soda, from sulphate of soda. The relations which exist between the chemical and physical properties of the elements have remained constant in many of these combinations ; and in those, where there is a deviation in colour, solubility, &c., one property, namely, physical form, remains constant. The same or a similar relation is doubtlessly attainable between the properties of all elements and their combinations, and all the efforts of chemistry have been directed to the discoveries of these constant relations. An investigation of this kind is the only way in which chemistry can attain to natural laws, and it is only by the same means that physiology, if it is to rise to the rank of a natural investigation, can gain a scientific basis.

THE CHEMICAL FORCES OF THE ELEMENTS HAVE A SHARE IN THE VITAL PROPERTIES.

We cannot, certainly, as yet follow out any physical property by means of the laws, or properties of the elements ; but still there can be no question that a knowledge of such properties is to be gained from laws, which arise, when these elements have been, in a certain measure, arranged. When these elements have combined to form an animal or vegetable substance, when they have attained to physiological or vital properties, then the chemical forces, which have given them their original properties are no more destroyed or removed, than the cohesive power of the atoms of sulphur is destroyed when we melt a portion of that substance. There has only been another cause superadded—heat—which has removed the effect of the cohesive force, or the connection, rendering its action no longer perceptible. The new condition, that of fluidity, is one of equilibrium between two antagonising causes, an effect in which both have an equal share.

In vegetable and animal substances, the elements obey mechanical and chemical laws, if their action be not removed by resistances, which must be regarded as the indications of new laws, that govern the parts of the organism.

THE RELATIONS BETWEEN CHEMICAL AND VITAL EFFECTS MUST BE INVESTIGATED.

If by the connection of many causes, new laws and phenomena are brought forward, which have no resemblance with the actions of individual causes in themselves, the effects of the latter stand in an immediate relation to those of the new phenomena, and these are the relations which must be sought and investigated.

When we have gained a clear conception of these, we shall be able to decide concerning a number of unknown facts or phenomena, as in the case of isomorphous substances, without further observation.

THE RELATION OF THE WEIGHTS OF THE ELEMENTS TO CHEMICAL COMBINATIONS.

A purely scientific character has been imparted to chemistry by the knowledge of the fact, that the property of weight in all chemical combinations is constant, and that in whatever manner the elements may be composed, the weight of the combination is equal to the sum of the weight of its elements. The knowledge of chemical proportions has led to our being able to predetermine all possible combinations of a body, but it could not explain the apparent exceptions of bodies, which, according to experience, united not in constant, but in every conceivable proportions. It is by the consideration of another property—the relation of external form to composition—that we have not only been enabled to give an explanation of these deviations, but have also gained a far clearer conception of the cause of the constant relations of combination.

THE UNIVERSALITY OF LAWS OF MUTUAL DEPENDANCE IN NATURAL PHENOMENA.

The advances made in all branches of natural investigation, in the physical sciences, as well as in physiology, rest upon the conviction that similar laws, based upon conditions in the properties of bodies reciprocally depending upon each other, may be obtained.

THE WAY TO ATTAIN TO A KNOWLEDGE OF THE RELATIONS OF DEPENDENCE.

There is no other method in natural investigation by which we can arrive at a knowledge of the relations in which the properties of bodies stand to each other, than by first seeking to learn these properties themselves, and next, the cases in which they vary. It is a law of nature, that the deviations in a property are, without exception, accompanied by entirely similar changes in another property; and it is perfectly clear, that the knowledge of the laws of these deviations, will place us in a position to decide concerning the one property, without any further observation of the other. The knowledge of the one, will lead to the explanation of the other.

A few examples will be sufficient to prove the truth of these statements.

EXAMPLES OF THE LAWS OF DEPENDENCE—PRESSURE AND THE BOILING-POINT.

It is known that every fluid passes into a state of ebullition under the same circumstances, and at unvarying degrees of temperature; this is so constant, that we designate the boiling-point as a characteristic property of fluids.

One of the conditions of the constant temperature at which air bubbles are formed in the interior of these fluids, is external pressure ; the boiling-point varies with this pressure in all fluids, according to an especial law, increasing or diminishing with the increase or diminution of the pressure. Every boiling-point of temperature has a corresponding and definite pressure, and every pressure a definite temperature. It is known that an acquaintance with the law of the mutual dependence of the boiling-point of the water, and the pressure of the atmosphere has led to our being able, by means of the thermometer, to decide altitudes above the level of the sea, and thus to measure one property by deviations in the other.

THE BOILING-POINT.

The relation in which the boiling-point of fluids stands to their properties is less known. Pyroligneous spirit, alcohol, and the fousel oil of potato spirit are three fluids, possessing very different boiling-points. Pyroligneous spirit boils at 138° F., alcohol at 172° F., fousel oil at 274° F. The comparison of these three boiling-points shows that the boiling-point of alcohol is 34° higher than that of pyroligneous spirit ($138° + 34° = 172°$), while that of fousel oil is four times 34° degrees higher ($138° + 4 \times 34° = 274°$). Each of these three fluids yields an acid upon oxidation under like circumstances: pyroligneous spirit gives formic acid; alcohol, acetic acid; fousel oil, valerianic acid. Of these three acids, each has its own boiling-point: formic acid boils at 210° F., acetic acid at 249° F., and valerianic acid at 347° F. If we compare these three points, we find that they stand in the same relation to each other, as do the boiling points of the fluids from which these acids have been obtained. The boiling point of acetic acid is 34° degrees higher than that of formic acid, while the boiling point of valerianic acid is four times 34° higher.

A similar deviation in one property shows, as we have remarked, a similar deviation in another. The property to be considered here, is the composition. If we compare the composition of the six several bodies (of the three acids, and the three fluids,) from which they originate by the influence of oxygen, we find as follows: the composition of the pyroligneous spirit is designated by the formula, $C_2\ H_4\ O_2$; that of spirits of wine by $C_4\ H_6\ O_2$; that of fousel oil by $C_{10}\ H_{12}\ O_2$.

If now we designate by R, a quantity of carbon and hydrogen, which belongs to the formula C H., (like equivalents) we see immediately, that the composition of alcohol can be expressed by that of pyroligneous spirit +2 R.

Pyroligneous spirit. Alcohol.

$$C_2\,H_4\,O_2+C_2\,H_2 \;=\; C_4\,H_6\,O_2.$$

While the composition of fousel oil may be expressed by that of pyroligneous spirit + 8 R.

Pyroligneous spirit. Fousel oil.

$$C_2\,H_4\,O_2+C_8\,H_8 \;=\; C_{12}\,H_{12}\,O_2.$$

The formula of formic acid is $C_2\,H_2\,O_4$, that of acetic acid $C_4\,H_4\,O_4$, that of valerianic acid $C_{10}\,H_{10}\,O_4$. We easily perceive that the formula of the acetic acid can be expressed by that of formic acid + 2 R, the formula of valerianic acid by that of formic acid + 8 R. In accordance with these experiments, a boiling point increased 34° F. corresponds with the occurrence or excess of 2 equiv. of carbon and 2 equiv. of hydrogen, or of 2 R. It may be seen that the relation between this group is constant, and that a conjecture concerning their composition may be made from the knowledge of the boiling point. The boiling point of the formate of oxide of methyle is 96° F., that of formate of oxide of aethyle, 130° F., the difference between the two, 34°. From this it might be conjectured that the composition of the latter differs from the former about $C_2\,H_2$ or 2 R, and such is the case. The formula for formate of oxide of methyle is $C_4\,H_4\,O_4$, that of the corresponding compound of aethyle $C_6\,H_6\,O_4$, and therefore about $C_2\,H_2$ higher. Thus butyric acid boils at 311° F., and its boiling point is, therefore, about three times 34° higher than that of formic acid. The comparison of their formulæ shows that butyric acid may be looked upon as formic acid + 6 R. Toluidine and aniline are two organic bases, both so far different in their composition, that aniline contains C_2 H_2, or 2 R more than toluidine. The comparison of their boiling points shows that the boiling point of aniline is 34° higher.

THE LAW OF THE RELATIONS OF DEPENDENCE IS DISTINCT FROM THE CAUSES BY WHICH THESE PHENOMENA ARE EFFECTED.

No one will deny, from these examples, the existence of a natural law for this group, nor can any one doubt that the qualities of a body stand in a definite relation to its composition, and that a change in a quality corresponds with a similar deviation in its quantitative relations. It must be especially noticed here, that the knowledge of this natural law is quite independent of the actual cause, or of the conditions which, taken together, effect the constant boiling point, for we are as ignorant of what relates to the boiling point, as we are concerning the conception of life.

THE BOILING POINT, THE SPECIFIC GRAVITY, AND THE COMPOSITION OF A BODY STAND IN RELATIONS OF DEPENDENCE TO EACH OTHER.

In the above examples we have only touched upon one of the relations of the quality and composition of bodies, there being as many of these relations as the body has properties. A law has been obtained for a large group of chemico-organic combinations, by which, from the knowledge of the boiling point, and the composition of the body, it has been established how many pounds a cubic foot of the combination weighs, and that the property of the specific gravity, and consequently of the pressure which the body exerts on equal spaces, stand in a definite relation to two others, which are changed as it likewise is changed.

SPECIFIC HEAT AND ATOMIC WEIGHT.

A similar relation of dependance has been established in reference to the amount of heat which different bodies need in order to rise to the same temperature, and their equivalent weights. It is a well known fact, that different bodies receive a different amount of heat at the same temperature. Equal weights of sulphur, iron, and lead, heated to the boiling point of water, when brought in contact with ice melt a certain quantity of it, but the amount of water produced under these circumstances is very different.

If the quantity of heat were equal in the three bodies, the weight of melted ice must amount to the same in all, but the unequal effect which is here observed proves the want of uniformity in the active cause. Sulphur melts six and a half times as much ice as lead, while iron melts four times as much. It is perfectly clear, that when we heat sulphur, iron, and lead at the same difference of temperature, say for example, from (60 to 400) with the same spirit lamp, we should have to consume half an ounce of spirit to heat lead, three ounces and a quarter of an ounce for the same quantity of sulphur, and nearly two ounces for an equal weight of iron.

These differences in the amount of heat required to raise equal weights of different bodies to the same degree of temperature, and which are peculiar to each, are termed their *specific heats.* From the knowledge of the unequal amount of heat, which bodies of equal weights contain, at a similar degree of temperature, we obtain an invaluable rule of proportion, by which we are able to reckon the weights of sulphur, lead, and iron, which contain a like quantity of heat; thus for instance, 16 parts of sulphur will melt as much ice as 28 parts of iron, and 104 of lead, at equal temperatures. These numbers are the same as the combining weights or the equivalent numbers. Like equivalents of these and many other bodies take up a similar amount of heat in order to raise themselves to an equal temperature, and if we consider the equivalents as the relative weights of atoms, it is clear that the amount of heat, which each atom takes up, or gives off under similar conditions, is the same for every atom, and when expressed in numbers, is inversely proportionate to the weights of the atoms.

It certainly is a singular result that the amount of ice which a body melts, should have served in many cases to define and establish the relations of weight, in which this body combines with others.

SPECIFIC HEAT AND TONE OF GASES.

It may appear still more singular to many that this property, in aeriform bodies, of taking up and giving off heat, stands in a definite relation to the tone produced by blowing gas through a pipe or flute. This is so truly the case that a celebrated naturalist, Dulong, was able to compute by the irregularity of tone, the amount of heat which in a constant volume the gases give out on pressure, and take up on expansion. In order to obtain a clear insight into this remarkable connection, we must recal to mind, the beautiful idea of La Place, concerning the connection of the specific heat of a gas, with its power of propagating sound. It is known that Newton, and many mathematicians since his time, have in vain sought to establish a formula to guide us in the observation of the velocity of sound. The formula that was calculated, closely approximated to the result of observation, but there was always an inexplicable difference. As now propagation of sound takes place by means of the vibrations of the elastic molecules of the atmosphere, in consequence of pressure, and subsequent expansion, and as on pressing together the air, heat is liberated, while, on the expansion of the atmosphere, heat is absorbed, La Place conjectured that this phenomenon must have an influence upon conducting the sound; and it was proved, that by making a correction for the specific heat of the air, the formula of the mathematician was free from all errors, and was an accurate expression of the velocity observed.

If now we compute the velocity of sound according to the Newtonian formula (that is, without reference to the specific heat of the air) and if we compare it with the formula of La Place, a difference will be perceived between the two in the length of space, which a sound-wave is computed to traverse in a second. This difference arises from the specific heat of the air—from the amount of heat which, on the propagation of the sound, is liberated from the molecules of air set in motion. It is clear that this difference in the velocity of propagating sound in other gases, which with equal volumes, contain and give out on pressure, more or less heat than the air, must be greater or less than that of the atmosphere; and it is, therefore, easy to perceive how the numbers, which express these unequal velocities in the propagation of sound in different gases, afford us at the same time a standard by which to measure the unequal quantity of heat which they contain.

As now the heighth or depth of the tone depends upon the number of vibrations of a sound-wave in a second, that is, upon the velocity with which a motion once impressed propagates itself, and we know that in all gases the velocity of the propagation of a sound-wave is directly proportionate to the number of vibrations of the tones that are called forth thereby, we perceive how, by the unequal heighth of the tone which is brought out by means of a pipe from different gases, (that is by ascertaining how much more one gas contains than another) we are able to find the specific heat of the gas. Acoustics owe the rank they hold at the present time to the great discovery, that musical harmony —each tone that touches the heart, attuning it to joy, or animating it to courage—is the symptom of a definite and definable number of oscillations of the molecules of the propagating medium, and a sign of all that can be determined according to the laws of undulations of this motion. A number of facts referring to tones might be drawn from the theory of undulation, while empirical truths have led to a corresponding knowledge of the properties of vibrating bodies, which were previously quite unknown.

It is asserted of a celebrated Viennese violin maker, that he was accustomed to select the wood for his violins, by making choice of those trees, which, on his striking them with a hammer, returned a certain sound, known to himself alone. This may be a mere fable; but there can be no doubt, that he knew the importance of selecting boards for the upper and lower parts of his instruments, which should make the same number of oscillations in a second, and that this property depended upon the thickness of the boards used.

ELECTRICITY AND MAGNETISM, MAGNETISM AND HEAT, MAGNETISM AND CHEMICAL FORCE.

If finally we consider that the electrical current passing through a metal wire stands in a peculiar relation to the magnetic properties which it receives; and if we remember that, by the magnetic needle the minutest differences of radiated heat may be detected, that the quantity of electricity in motion is expressible in numbers by means of the same electrical needle, and can be measured in cubic inches of hydrogen, and by metallic weights, and that finally when we see how the causes or forces, from which the properties of bodies and their capacities to make an impression upon our senses stand in a relation of mutual dependence to each other we cannot doubt that the vital properties are equally dependant with all others upon these laws, and that the chemical and physical properties of the elements, with their form and method of arrangement, play an appreciated and appreciable part amongst the phenomena of life.

VITAL PROPERTIES ARE NO EXCEPTION TO A LAW OF NATURE.

It doubtless arises from the method they have adopted, that many physiologists and pathologists are led to look upon vital properties as in some degree exceptions to a great natural law; for how else can we explain the fact of their not regarding the number and grouping of those elements from which the parts of the organism have been composed as a physical property affording indispensable assistance towards the attainment of an insight into vital phenomena ; how else can we explain their not taking into account, in the treatment of disease, the elementary composition of the means of cure, and the properties depending upon them, on which their action rests. The mere knowledge of a formula is not of course sufficient for this object, but it is necessary to the investigation of the laws of the relations in which the composition and form of nutrition, or of the secretions stand to the *nutritive* process ; or the composition of remedial agents to the effects which they exercise upon the organism.

ANATOMY MOST ESSENTIAL.

It is certain that all advances of the physiology of plants and animals, from the age of Aristotle to the most recent times, have been facilitated by the progress made in the study of anatomy. As he must remain in the dark concerning distillation, who has seen nothing connected with the process but the still, the fire, and the worm, from whence the spirit flows, so will it be impossible to gain an insight into any process without a correct knowledge of the apparatus used. How much more then is this the case with the human organism, which is a complex apparatus, requiring a most accurate knowledge of the structure of individual parts, before one can venture to form a judgment of the signification of the functions of the whole.—(*Schleiden.*)

We must not, however, forget that anatomy alone, from the days of Aristotle to Leuwenhoek's time, has thrown but a partial light upon the laws of the phenomena of life, as the knowledge of the apparatus of distillation does not instruct us alone concerning its uses ; so in many processes, as in distillation, he who understands the nature of fire, the laws of the diffusion of heat, and of evaporation, the construction of the still, and the products of distillation, knows infinitely more of the process of distillation than the smith himself who made the apparatus. Each new discovery in anatomy has added acuteness, exactitude, and extent to its descriptions; unwearied investigation has almost penetrated to the inmost cell, from whence a new road of enquiry must be opened.

ANATOMY NOT ALONE SUFFICIENT.

If, however, as many think, the further advance of physiology is alone dependant upon the perfecting of our knowledge of the anatomical structure of organisms, chemistry can then in no way assist physiology, since its department is not to consider the form, but to establish the condition and relations of forms to their elements, and their methods of arrangement.

By a knowledge of the anatomical structure and relations of the body, anatomy alone is aided, and even by the most accurate investigation into the phenomena of motion in bodies, we shall never learn anything concerning the reasons and laws which govern them. An acquaintance with the mode and direction of motion can alone contribute to our knowledge.

WHAT MUST BE SUPERADDED.

If anatomical knowledge is to serve for the solution of a physiological question, something else must necessarily be added; and the first thing, surely, is to investigate the matter from which this form was made, the forces and properties co-operating with those of life, and the knowledge of the origin of matter and of the changes which are experienced, before those relations can be learnt, in which all constituents of the organism, the fluid as well as the solid, stand to each other. Many physiologists deem that the important questions which chemistry has solved upon this subject, only enrich herself, although all these results take as low and subordinate a place in chemistry as those that have been acquired by the analysis of minerals and mineral waters.

CHEMISTRY ALONE IS NOT SUFFICIENT.

Another fundamental error entertained by others is, that one may attain to an explanation of vital phenomena by chemical and physical forces alone, or in combination with anatomy; it is, indeed, scarcely to be supposed that the chemist should be able merely by the knowledge of chemical forces to explain the existence in the living body of new laws and new causes, or that the physiologist, setting aside the action of chemical, or purely physical forces, should endeavour to account for every process by the aid of the laws of inorganic nature.

The latter view is the ultimate consequence of a reaction from the previously entertained views. In a period of philosophical physiology not very remote from the present day, every thing was explained by vital force. This theory was next wholly rejected, and the possibility assumed of our being able to trace all vital processes back to physical and chemical causes. "In the living body," thus wrote physiologists forty years since, "there are different laws at work from those which govern inorganic nature. All the processes of the living organism are of a peculiar character."

In the present day many physiologists, on the contrary, regard these various processes as similar in character. The evil of both these theories is, that neither then, or now, has any attempt been made to establish, or even to investigate the deviations occurring in the effects of vital force, and in the action of inorganic force, or to determine their similarity and differences.

The deductions drawn were not based upon a knowledge of the difference, or similarity of their mutual relations, but upon ignorance of these characteristics.

WHAT IS MEANT BY CHEMICAL FORCE.

Those philosophers who regard vital processes as effects of inorganic forces, entirely forget that the expression *chemical force* means nothing more than the *quantitative* character of different vital indications, and the qualities dependant upon these quantities. The false view taken of the influence of chemistry in explaining vital phenomena arises from one of two erroneous estimates of the science, either depreciating its effects unjustly, or entertaining too exaggerated an idea of its importance.

RELATIONS OF DEPENDANCE CANNOT BE ESTABLISHED BY A NUMERICAL SYSTEM.

If a definite connection exist, or be discovered between two facts, it does not fall within the province of chemistry to prove the connection, but simply to trace out and express its numerical character.

No relation can be established between two facts by means of numbers if that relation does not exist; and hence the importance of the numerical system.

NUMBERS ARE ONLY EXPRESSIONS OF THE RELATIONS OF DEPENDENCE.

Bitter oil of almonds and benzoic acid are, considering their occurrence and properties, two totally different organic combinations.

A few years since, no mutual relation was even suspected to exist between the two; but now it is known that oil of bitter almonds becomes solid and crystalline in the air, and that the resulting body is identical in its properties and composition with benzoic acid. The relation between these two bodies is undeniable after this experiment. Observation shows, that in the transition of oil of bitter almonds into benzoic acid, oxygen is taken up from the air, and an analysis of the two firmly established the conversion numerically, and thus explained it, as far as it would admit of explanation.

In a similar manner, by the study of the changes which the oxygen exercises upon fousel oil from potato spirit, a definite relation was discovered between this body and valerianic acid, and it was established by numbers, that one bore the same relation to the other, as alcohol to acetic acid.

CHEMICAL RELATIONS BETWEEN UREA, URIC ACID, ALLANTOIN, AND OXALIC ACID.

The urine of man contains urea, and frequently uric acid: while the urine of some animals is deficient in uric acid, and that of others in urea. The quantity of urea in the urine diminishes with the increase of uric acid; the urine of the fœtus of the cow contains allantoin, while in the urine of man, oxalic acid is scarcely ever absent. A change in certain vital processes of the organism, is accompanied by a corresponding change in the nature, quantity, and character of the combinations, which are secreted by the kidneys. It then remains for chemists to express, quantitatively, the relations in which these bodies are observed to stand to each other, and to the processes in the organism.

THE METHOD PURSUED BY CHEMISTRY TO EXPRESS THESE RELATIONS.

Chemistry first tests, by analysis, the quantitative signification of the terms urea, uric acid, allantoin, and oxalic acid; by this, however, no reciprocal relation is established between them, and it is only by an investigation into the changes which the combinations of those bodies, that have a share in the formation or change in the organism, suffer under the influence of oxygen and water, that a definite and undeniable connection can be numerically established. By the addition of oxygen to uric acid, three products are separated, viz: allantoin, urea, and oxalic acid. By a greater addition of oxygen, uric acid passes into urea and carbonic acid. Allantoin appears as an urate of urea. The comparison of the relations discovered by chemists, in the transition of uric acid into urea, with those which accompany the same process in the organism, has led to the conclusion that the requirements (in this case being an addition of oxygen) are in both cases either similar, or they deviate from each other. And these deviations furnish a new starting point for investigations, which lead to the explanation of the process.

Urea and uric acid are products of the changes which the nitrogenous constituents of the blood suffer, under the influence of water and oxygen.

The nitrogenous constituents of the blood are, in their composition, identical with the nitrogenous constituents of nutrition. The relations of the latter to uric acid, and to urea and the oxygen of the air and the elements of water are expressed in Chemistry by formulæ, which explain them as far as they can be applied.

WHAT IS MEANT BY CHEMICAL FORMULÆ.

It must be evident, even to the unlearned that the difference in the properties of two bodies, is either dependant upon a different arrangement of the elements of which they consist, or upon a quantitative variety in their composition. Chemical formulæ are expressions of the different methods of arrangement, the *quantitative* differences which attend the *qualitative.* Chemistry, even at the present day, cannot by the most careful analysis establish with certainty the composition of an organic body, if its quantitative relation cannot be gained from a second, which has already been ascertained without any doubt ; without such aid the formulæ for the oil of bitter almonds and fousel oil could not have been obtained, and if the relation of dependence between two bodies cannot be ascertained by direct observation, the chemist is obliged to find it by his analytic art ; this he does by separating the body into two or more products, investigating those which he obtains from the action of oxygen, chlorine, alkalies, or acids; and by the aid of these he succeeds finally in obtaining one or more products, the composition of which he is acquainted with, and whose formulæ he consequently knows. To the formulæ for these products, he joins that of the body which he has analysed. The sum of the whole is thus obtained by aid of the knowledge of one, several, or all the parts of which the aggregate consists. Thus if the number of equivalents of the carbon, hydrogen, and oxygen, which appertain to a molecule of sugar, are not definable by analysis; and if the skill of the chemist affords no guarantee for the correctness of his analysis of salicine or amygdaline; the analysis may be tested by the fact, that sugar combines with oxide of lead; and resolving itself into carbonic acid and alcohol by fermentation offers two combinations, the formulæ of which are known; amygdaline resolves itself into prussic acid, oil of bitter almonds, and sugar. Salicine into sugar and saligenine.

IMPORTANCE OF FORMULÆ.

It is clear that when the weight of a body, and that of one or two, or all the products resulting therefrom be known, we may determine the number and relation of one, or two, or all its elements, —that is to say we can obtain their formulæ; and thus the result of the analysis can be verified and corroborated.

REASONS FOR THE CHEMIST TO STUDY THE PRODUCTS OF DECOMPOSITION OF A BODY.

The importance of formulæ to chemistry is clear when considered from the following point of view. A correct formula expresses the quantitative relations in which one body stands to one, two, or more bodies.

The formula for sugar expresses the whole sum of those of its elements, which combine with an equivalent of oxide of lead, and it shows the quantity of carbonic acid and alcohol, into which it resolves itself by fermentation. This will lead us to understand why chemists are often compelled to divide into numerous products the matter, whose composition they wish to establish, and wherefore they study combinations. These are all checks upon his analyses. No formula deserves implicit confidence, if the body whose composition is to be expressed have not been subjected to this operation.

MISUSE OF FORMULÆ.

While some modern physiologists forgot that the knowledge of the relations of two phenomena must precede their expression in numbers, the formulæ of chemists degenerated in their hands into sense-less forms of jugglery. Instead of the expression of a genuine relation of dependence, they sought to establish by numbers, relations which either did not exist in nature, or never had been observed. This property, however, does not appertain to numbers.*

HOPES.

The time will come, although perhaps the present generation will barely live to see it, when a numerical expression for chemical formulæ shall have been obtained for the measurement of all the normal

* "Microscopic anatomy shows that in the composition of the brain and spinal cord, there is a mixture of grey and white matter, and that albumen and oil occur together in these organs. Instead of availing themselves of this anatomical fact, chemists have analysed the fat as a whole, that is to say, they have investigated an unknown mixture of albumen and fat. By this means they obtained a peculiar, apparently nitrogenous fatty acid, to which the term *cerebric acid* has been applied, and have sought to establish on theoretical grounds, the anomaly of a nitrogenous fat.

But by a simple chemical deduction, based on Mulder's formula for protein, it is easy to show that we only obtain that which might be naturally expected, namely an evidence that cerebric acid is a mixture of albumen, fat, and phosphorus.

For 1 at. cerebric acid = $P\ C_{178}\ H_{170}\ N_{2 \cdot 5}\ O_{38 \cdot 36}$

and

½ at. protein	=		C_{20}	$H_{15 \cdot 5}$	$N_{2 \cdot 5}$	O_6
14·36 at. fat	=		C_{158}	$H_{136 \cdot 5}$		$O_{14 \cdot 36}$
18 at. water	=			H_{18}		O_{18}
1 at. phosphorus	=	P				
		P	C_{178}	H_{170}	$N_{2 \cdot 5}$	$O_{38 \cdot 36}$

Hence this apparent anomaly in reference to the composition of the brain disappears."—Valentin's Lehrbuch, Vol. I. p. 174.

energies of the organism, and of the deviations in the functions of individual parts by means of the corresponding deviations in the composition of the matter of which these parts consist, or of the products to which they give rise. We shall thus obtain a better means of quantitatively considering the effects which are induced by causes of disease, or by remedial agents, and of more clearly and accurately observing the conditions of vital phenomena. Then, indeed, it will be deemed impossible that there ever was a time, when the share taken by chemistry in the acquirement of this knowledge could be disputed, and when a doubt could be entertained concerning the way and means by which this assistance has been afforded.

THE END.

LONDON:
Printed by Schulze & Co., 13, Poland Street.

H. G. OLLENDORFF.

A New Method of Learning to Read, Write and Speak, the German Language in Six Months. Translated from the Fifth French Edition. By G. J. Bertinchamp, A.B. Second Edition, Revised and Considerably Improved, by James D. Haas. 12mo. Bound. 1844. 9*s*.

ALSO:

A Key to the Exercises. 12mo. Bound. 1844. 4*s*. 6*d*.

WORKS ON ANATOMY AND MEDICINE.

J. CRUVEILHIER AND C. BONAMY.

Atlas of the Descriptive Anatomy of the Human Body. By J. Cruveilhier, Professor of Anatomy to the Faculty of Medicine, Paris. With Explanation by C. Bonamy. Containing 82 4to. Plates of Osteology, Syndemology, and Myology. London, 1844. Plain, £3; coloured, £5. 15*s*.

ROBERT, E. GRANT, M.D. F.R.S. L. & E.

General View of the Distribution of Extinct Animals. By Robert E. Grant, M.D. F.R.S. L. & E. Professor of Comparative Anatomy, in the University College, London. In the "British Annual," 1839. 18mo. London, 1839. 3*s*. 6*d*.

On the Principles of Classification as applied to the Primary Divisions of the Animal Kingdom. In the "British Annual," 1838. 18mo. Illustrated with 28 Woodcuts. London, 1838. 3*s*. 6*d*.

Outlines of Comparative Anatomy. 8vo. Illustrated with 148 Woodcuts. London, 1835—41. In boards, £1. 8*s*.—Part VII. with Title-page 1*s*. 6*d*.

MARSHALL HALL, M.D. F.R.S. L. & E.

On the Diseases and Derangements of the Nervous System, in their Primary Forms, and in their Modifications by Age, Sex, Constitution, Hereditary Predisposition, Excesses, General Disorder, and Organic Disease. By Marshall Hall, M.D. F.R.S. L. & E. 8vo. with 8 Plates, engraved. London, 1841. 15*s*.

* *As an Appendix to the above Work.*

On the Mutual Relations between Anatomy, Physiology, Pathology, Therapeutics, and the Practice of Medicine; being the Gulstonian Lectures for 1842. 8vo. with 2 coloured Plates and 1 plain. London, 1842. 5*s*.

New Memoir on the Nervous System, True Spinal Marrow, and its Anatomy, Physiology, Pathology, and Therapeutics. 4to. with 5 engraved Plates. London, 1843. £1.

W. C. HUFELAND, M.D.

Manual of the Practice of Medicine, the Result of Fifty Years' Experience. By W. C. Hufeland, Physician to the late King of Prussia, Professor in the University of Berlin. Translated from the Sixth German Edition, by C. Bruchhausen and R. Nelson. 8vo. bound, London, 1844. 15*s*.

GERBER AND G. GULLIVER.

Elements of the General and Minute Anatomy of Man and the Mammalia. Chiefly after Original Researches. By Professor Gerber. To which is added an Appendix, comprising Researches on the Anatomy of the Blood, Chyle, Lymph, Thymous Fluid, Tubercle, and additions by C. Gulliver. In 1 vol. 8vo. Text, and an Atlas of 34 Plates, engraved by L. Aldous. 2 vols. 8vo. 1842. Cloth boards. £1. 4*s.*

ROBERT LEE, M.D. F.R.S.

The Anatomy of the Nerves of the Uterus. By Robert Lee, M.D. F.R.S. folio, with 2 engraved plates. London, 1841. 8*s.*

R. T. H. LAENNEC.

A Treatise on the Mediate Auscultation, and on Diseases of the Lungs and Heart. By R. T. H. Laennec, Professor to the College of France and to the Faculty of Medicine of Paris. With Notes and Additions of M. Laennec, and of M. Andral, Professor to the Faculty of Medicine, Paris. Translated from the last edition by a Member of the College of Physicians. Edited by Theophilus Herbert, M.D., with Practical Notes, condensed from the Lectures of F. H. Ramadge, M.D., Oxon. 8vo. with plates. London, 1846. 18*s.*

W. C. L. MARTIN, ESQ.

A General Introduction to the Natural History of the Mammiferous Animals: with a particular View of the Physical History of Man, and the more closely allied Genera of the Order "Quadrumana," or Monkeys. Illustrated with 296 Anatomical, Osteological, and other Engravings on Wood, and 12 full-plate Representations of Animals, drawn by W. Harvey. 1 vol. 8vo. London, 1841. 16*s.*

RICHARD OWEN, F.R.S.

Odontography; or, a Treatise on the Comparative Anatomy of the Teeth: their Physiological Relations, Mode of Development, and Microscopical Structure in the Vertebrate Animals. By Richard Owen, F.R.S. Correspondent of the Royal Academy of Sciences, Paris and Berlin: Hunterian Professor to the Royal College of Surgeons, London. This splendid Work is now completed, 2 vols. royal 8vo. containing 168 Plates, half bound russia. London, 1840—45. £6. 6*s.*

A few copies of the Plates on India paper, 2 vols. 4to. £10. 10*s.*

J. LEBAUDY, M.D.

The Anatomy of the Regions interested in the Surgical Operations performed upon the Human Body, with Occasional Views of the Pathological Conditions, which render the interference of the Surgeon necessary, in a Series of 24 Plates, the Size of Life. By J. Lebaudy. Folio. London, 1835. £1. 4*s.*

Prof. J. SYME, F.R.S.E.

Principles of Surgery. By J. Syme, Professor of Clinical Surgery to the University of Edinburgh. Third edition, much enlarged, and illustrated with 14 Plates on India paper, and 64 woodcuts. 1 vol. 8vo. London, 1842. £1. 1*s*.

VOGEL & DAY.

Pathological Anatomy. By Vogel, Professor of Anatomy in the University of Göttingen. Translated with the Author's sanction, and Edited by Dr. Day, 1 vol. 8vo. illustrated by 6 coloured and 4 plain plates. London, 1846. 16*s*.

JAMES WARDROP, M.D.

On Blood-Letting, an Account of the Curative Effects of the abstraction of Blood; with Rules for employing both local and general Blood-Letting in the treatment of Diseases. 12mo. London, 1835. 4*s*.

ROBERT WILLIS, M.D.

Illustrations of Cutaneous Disease: a Series of Delineations of the Affections of the Skin, in their more interesting and frequent Forms: with a Practical Summary of their Symptoms, Diagnosis, and Treatment, including appropriate Formulæ. By Robert Willis, M.D. Member of the Royal College of Physicians. The Drawings are after Nature, and Lithographed by Arch. Henning. These Illustrations are comprised in 94 Plates, folio. The Drawings are Originals, carefully coloured. Bound in cloth, lettered, London, 1842. 6*l*.

On the Treatment of Stone in the Bladder, by Medical and Mechanical Means. 8vo. London, 1843. 5*s*.

ROBERT WILLIAMS, M.D.

Elements of Medicine: Morbid Poisons. By Robert Williams, M.D. Physician to St. Thomas's Hospital, 2 vols. 8vo. London, 1836—1841. £1. 8*s*. 6*d*.

——————— Vol. 2. Separately. 1841. 18*s*.

FRANCIS B. COURTENAY, ESQ.

On the Pathology and Cure of Stricture in the Urethra. Illustrating, by a selection from numerous interesting facts and cases, the Origin, Progress, and History of this Disease, in all its Phases, and embracing every variety of Morbid Contraction to which the Urethra is liable, together with an account of the mode of Treatment successfully adopted in each case, and Cure of every species of Urethral Stricture. Third Edition. 8vo. London, 1845. 5*s*.

Practical Observations on the Chronic Enlargement of the Prostrate Gland in Old People, with Mode of Treatment. Containing numerous cases and plates. 8vo. in boards. London, 1839. 7*s*. 6*d*.

A. B. GRANVILLE, M.D. F.R.S.

KISSINGEN, its Sources and Resources, with Observations on their use and efficacy in the Treatment of Diseases. By A. B. Granville, M.D. F.R.S. 1 vol. 12mo. London, 1846. 5*s.*

D. SPILLAN, M.D.

THESAURUS MEDICAMINUM; or the Medical Prescriber's Vade-Mecum; containing all the Medicinal Substances of the Pharmacopœia, arranged according to their Therapeutic Action, with the most elegant method of prescribing each; to which are subjoined a Table of Incompatible Substances, and Directions for the Treatment of Poisoning. By D. Spillan, M.D. 18mo. London, 1842. 3*s.*

MICHAEL RYAN, M.D.

THE PHILOSOPHY OF MARRIAGE, in its Social, Moral, and Physical Relations; with an Account of the Diseases of the Genito-Urinary Organs, with the Physiology of Generation in the Vegetable and Animal Kingdoms. Fourth edition, very much improved. By M. Ryan, M.D. 1 vol. 12mo. London, 1843. 6*s.*

G. F. RICHARDSON, ESQ.

GEOLOGY FOR BEGINNERS; comprising a Familiar Exposition of the Elements of Geology and its Associate Sciences—Mineralogy, Fossil Conchology, Fossil Botany, and Paleontology. By G. F. Richardson, F.G.S. Second Edition, with 251 Woodcuts. Post 8vo. 1843. 10*s.* 6*d.*

J. MADDOX, M.D.

PRACTICAL OBSERVATIONS on the efficacy of Medicated Inhalations in the Treatment of Pulmonary Consumption. By Dr. Maddox. 8vo. with a coloured plate, 2nd edition. London, 1845. 5*s.* 6*d.*

SIR W. J. HOOKER.

ICONES PLANTARUM; New Series. Vols. I—III, containing each 100 Plates with explanations. By Sir W. J. Hooker, Director of the Royal Botanical Gardens, Kew. 8vo. cloth. London, 1842—44. £1. 8*s.* each vol.—Vol. IV. Part I. 14*s.* London, 1845.

THE LONDON JOURNAL OF BOTANY. Vols. I—IV, with 24 Plates each, boards, 1842—45. £1. 10*s.* each vol.

Also published monthly, with 2 *plates. Price* 2*s.* 6*d.*

NOTES on the Botany of the Antarctic Voyage conducted by Capt. James Clark Ross, R.N. F.R.S., in H.M.SS. *Erebus* and *Terror;* with Observations on the Tussac Grass of the Falkland Islands. 8vo. with 2 coloured Plates. London, 1843. 4*s.*

JAMES WILSON.

PRACTICE OF THE WATER CURE, with authenticated Evidence of its Efficacy and Safety. Part I., containing seventy authenticated Cases, the Opinions of English Medical Practitioners, a Sketch of the History and Progress of the Water Cure, and an Account of the Processes used in the Treatment. 8vo. London, 1844. 1*s.* 6*d.*

PROFESSOR KÆMTZ.

A Complete Course of Meteorology. By Kæmtz, Professor of Physics at the University of Halle. With Notes by Ch. Martins, and an Appendix by L. Lalanne. Translated, with Additions, by C. V. Walker, Editor of the "Electrical Magazine." 1 vol. post 8vo. (pp. 624), with 15 Plates, cloth boards. 1845. 12*s*. 6*d*.

THOMAS THOMSON, M.D. F.R.S. L. & E.

Chemistry of Organic Bodies—Vegetables. By Thomas Thomson, M.D. F.R.S. L. & E. Regius Professor of Chemistry in the University of Glasgow, Corresponding Member of the Royal Academy of Paris. 1 large vol. 8vo. of 1092 pages. London, 1838. Boards, 1*l*. 4*s*.

Heat and Electricity. Second Edition, 1 vol. 8vo. illustrated with wood-cuts. London, 1839. 15*s*.

WORKS ON HOMŒOPATHY.

J. BELLUOMINI, M.D.

Scarlatina and its Treatment on Homœopathic principles, By J. Belluomini, M.D. 8vo. London, 1843. 1*s*.

BŒNNINGHAUSEN.

The Homœopathic Treatment of Intermittent Fevers. By Bœnninghausen. 8vo. New York, 1845. 2*s*. 6*d*.

British Journal of Homœopathy. Edited by Drs. Drysdale, Russel, and Black. Nos. 1 to 17. Price each 4*s*. London, 1843—46. Published quarterly.

P. F. CURIE, M.D.

Annals of the London Homœopathic Dispensary. 1 vol. 8vo. 20 Nos. 1841—42. 15*s*.

Practice of Homœopathy. 1 vol. 8vo. London, 1838. 6*s*.

Principles of Homœopathy. 1 vol. 8vo. London, 1837. 5*s*.

Domestic Homœopathy. Third Edit. 12mo. London, 1844. 5*s*.

See Jahr.

CURTIS AND LILLIE.

An Epitome of Homœopathetic Practice. Compiled chiefly from Jahr, Ruckert, Beauvais, Bönninghausen. 12mo. New York, 1843. 5*s*.

J. GUNTHER, ESQ.

New Manual of Homœopathic Veterinary Medicine. Containing the Horse, the Ox, the Sheep, the Dog, and other domestic animals. Translated from the German, with notes by J. Austin. 1 vol. post 8vo. London, 1846.

HARRIS DUNSFORD, M.D.

The Practical advantages of Homœopathy, illustrated by numerous Cases. By H. Dunsford, M.D. Dedicated by permission to Her Majesty Queen Adelaide. 1 vol. 8vo. boards. 1841. 8*s.*

The Pathogenetic Effects of some of the principal Homœopathic Remedies. By H. Dunsford, M.D. 8vo. London, 1838. 9*s.*

REV. T. R. EVEREST.

A Popular View of Homœopathy, exhibiting the Present State of the Science. By the Rev. T. R. Everest. 2d edit. amended and much enlarged. 8vo. London, 1836. 6*s.*

SAMUEL HAHNEMANN, M.D.

The Chronic Diseases, their Specific Nature and Homœopathic Treatment By S. Hahnemann. Translated and Edited by Charles J. Hempel, M.D. 5 vols. 8vo. New York, 1846. £2.

Organon of Homœopathic Medicine. Second American, from the British Translation of the Fourth German Edition. 8vo. cloth. New York, 1843. 10*s.* 6*d.*

Matiera Medica Pura. By Samuel Hahnemann. Translated and Edited by Charles J. Hempel, M.D. 2 vols. 8vo. New York, 1846. 16*s.*

Exposition de la Doctrine Médicale Homéopathique ou Organon de l'Art de Guérir. Par Leon Simon. 3ème Edition. 8vo. Paris, 1845. 8*s.*

Doctrine et Traitement Homéopathique des Maladies Chroniques. Traduit de l'Allemand, par Jourdan, M.D. 3 vols. 8vo. Paris, 1846. £1. 3*s.*

Traite de Matière Médicale, ou de l'action pure des Médicamens Homéopathiques. Traduit de l'Allemand, par Jourdan, M.D. 3 vols. 8vo. Paris, 1834. £1 4*s.*

G. H. G. JAHR.

New Manual of Homœopathic Medicine. By G. H. G. Jahr. From the third original edition, with Notes and Preface by Dr. P. Curie and Dr. Laurie. In 2 vols. post 8vo. £1 8*s.*

See Curie.

Short Elementary Treatise upon Homœopathy and its Practice, with some of the most important effects of Ten of the Principal Homœopathic Remedies. By G. H. G. Jahr. Translated by Boyard, M.D. 18mo. London, 1846. 2*s.* 6*d.*

New Homœopathic Pharmacopœia and Posology, or the Preparation of Homœopathic Medicines. 8vo. Philadelphia, 1842. 12*s.*

J. RUOFF, M.D.

Repertory of Homœopathic Medicine Nosologically arranged. Translated from the German by A. H. O'Kie, M.D. with additions by G. Humphrey, M.D. 2nd Edition. 12mo. New York, 1845. 7*s.*

S. SIMPSON, M.D.

A Practical View of Homœopathy with Cases. By S. Simpson, M.D. 8vo. London, 1836. 10*s.* 6*d.*

C. HERING, M.D.

The Homœopathist or Domestic Physician. By Charles Hering, M.D. (Philadelphia, U.S.) 2d Edition. 12mo. London, 1845. 7*s.*