PART I.

OF THE GENERAL PRINCIPLES OF PHARMACEUTIC CHEMISTRY.

PHARMACEUTIC CHEMISTRY is that branch of chemical science which investigates the composition of bodies, and considers their mutual chemical relations, so far as these are connected with their medicinal properties and applications. It connects the doctrines of Materia Medica and Pharmacy, and forms a proper introduction to the study of each; an exposition of its principles being necessary in delivering the history of the articles of the Materia Medica, and being not less indispensable in explaining the operations of Pharmacy. It includes two subjects, *first*, the analysis of bodies, so far as relates to the enumeration of their constituent principles; and, *secondly*, the general operations to which they are subjected in their preparation as remedies.

CHAP. I.

OF THE CHEMICAL ANALYSIS OF THE ARTICLES OF THE MATERIA MEDICA.

THE ultimate object of chemical investigations, is to discover the composition of bodies; and the result of these investigations is the reducing them into two classes, those which are Simple, and those which are Compound. The former are such as consist of parts perfectly alike; the most minute particles into which a simple body can be resolved, retaining all its essential properties, and being similar to each other. Compound substances can, on the contrary, be resolved into parts different in their qualities from each other, and from the compound which they had formed.

It is from the union of simple substances that compounds are produced. When two simple bodies are placed in contact, under certain circumstances, an attraction is often exerted by the particles of the one to those of the other: they unite and form a compound, having peculiar properties. These compounds are farther capable of combining with other simple bodies, or with each other, which gives rise to a series of bodies still more extensive; and these again are capable of new combinations, or of such intimate mixtures with each other, as to form many peculiar substances. There are thus produced, from a few simple substances, all the products of nature, and all those which are the results of the operations of art.

It is the province of Chemistry to trace these combinations; to determine whether bodies are simple or compound, and, if compound, to ascertain the number of their constituent principles, the proportions, and the modes in which they are combined.

The general process by which these objects are attained, is termed, in the language of Chemistry, Analysis. It is merely the separation of a compound body into its constituent parts, and is effected either by the agency of heat, or by the exertion of a superior attraction.

The analysis from the application of heat, differs according to the composition of the body analysed. If a compound, consisting of two simple substances, be exposed to heat, it in many cases happens that the mutual attraction by which its principles were united ceases, and a decomposition or separation of these principles takes place. This is an example of pure analysis; no change being produced, but merely the separation of the component parts of the compound, so that each is obtained in its original state.

An analysis more complicated is that where several substances are combined together, in such a manner that their attractions are reciprocally balanced, and one compound is formed. When a compound of this kind is exposed to a high temperature, this balance is frequently subverted, and the compound is decomposed. But its constituent principles, instead of passing off pure, enter into new combinations with each other, and form other compounds, each of which may be collected, and in its turn analysed. It is in this manner that vegetable and animal substances are acted on by heat: the products afforded by their analysis are not such as pre-existed in them, but are compounds formed during the decomposition, from new combinations of their ultimate constituent principles. This is what is named False or Complicated Analysis.

Chemical Analysis is also effected by the exertion of a superior attraction. If a compound be placed successively with different substances in situations favourable to the operation of chemical action, one or other of these substances may exert a superior attraction to one or other of its component parts; a decomposition will be produced, and from the products the constituent principles of the compound as well as their proportions may be determined.

As compound substances can combine together so as to form a new compound, it is obvious, that this compound may be resolved either into the immediate principles from the union of which it has been formed, or into those of which these consist. It is necessary, therefore, that these should be distinguished. The former are accordingly named the Proximate Principles of a compound; the latter the Ultimate Principles. The proximate principles are of course compounds; the ultimate principles are the elements of these compounds; and the results of analysis are extremely different, according as one or other of these is obtained.

When by analysis the constituent principles of a body have been obtained, they may often be combined again, so as to reproduce the substance analysed. This operation is named Chemical Synthesis; and when it can be effected, is the surest proof of the accuracy of the analysis.

In analysing the various products of nature, we arrive ultimately at substances which we are unable to decompose, and which are therefore regarded as simple. The absolute simplicity of these is not indeed established; for our inability to decompose them may not arise from this, but from the imperfections of our modes of analysis; and it is even probable, that all the substances which are yet known to us may be compounds, and that a more refined chemistry may discover their composition. Until this be accomplished, however, they are regarded as simple, and they are so with regard at least to our knowledge of them. As the ultimate principles, therefore, of all analysis, they are first to be considered in proceeding to the general analysis of the articles of the Materia Medica.

Of these bodies, OXYGEN is the most important. There is no simple substance which exerts an attraction to so many others, or which gives rise to such important compounds. With a few exceptions, indeed, all the productions of nature are either capable of combining, or are already combined with this principle, and the development of its agencies constitutes the most extensive and important part of chemical science.

Oxygen always exists in the gaseous state: when it enters indeed into combination with other substances, it often becomes concrete; but its properties are at the same time changed, and its descriptive characters are therefore taken from it as it exists in the aërial form. Like other gases it is invisible and elastic; its specific gravity is rather greater than that of atmospheric air; it is absorbed by water, but in a very small proportion.

The distinguishing properties of oxygen gas are those of supporting respiration and combustion. An animal lives much longer in this air than it does in any other; and combustion in it is more vivid and durable. It is the only air indeed, which, strictly speaking, can support either of these processes; other aëriform fluids doing so only from the oxygen they contain.

Its capacity of supporting combustion is more particularly to be assumed as its characteristic chemical property; combustion being nothing but the combination of oxygen with combustible bodies, accompanied with the emission of heat and light. It also frequently, however, enters into combination without the phenomena of combustion being apparent, more especially when the absorption of it takes place slowly, or when it is transferred from a compound in which it exists to another substance. The combination of a body with oxygen is termed Oxygenation, or Oxidation. The products of this combination have either certain common properties, belonging to a class of chemical agents long distinguished by the appellation of Acids; or they are destitute of these properties, and they are then denominated Oxides.

Oxygen forms one-fourth part of atmospheric air; and it is principally on its agency that the many chemical changes produced in bodies by that air depend. Combined with another elastic fluid, hydrogen, in the proportion of 85 parts to 15, it forms water, the substance which has the most extensive operation in promoting chemical action by the fluidity it communicates, and which more directly produces many important chemical changes, by affording oxygen to bodies. This element exists as a constituent principle of all acids, and communicates to them their energy of action. It has more lately been established, that it is also an ingredient in the composition of the alkalis and earths, and that it is therefore the principle of alkalinity as well as of acidity. With all the metals it combines in different proportions, communicating to them a greater susceptibility of chemical action, and greater activity in their relation to the living system; and it exists as a constituent part of nearly all the vegetable and animal products. Hence no principle is more extensively diffused, and none has a more marked influence in the combinations into which it enters.

The elastic fluid which, along with oxygen gas, composes atmospheric air, is named AZOTE or NITROGEN. Its chemical agency is less powerful, nor does it possess any very remarkable property by which it can be characterized; hence it is distinguished rather by negative qualities. It is lighter than oxygen gas, is incapable of supporting combustion or respiration, is scarcely sensibly absorbed by water, and is not combustible in the strict sense of the term; for although it combines with oxygen, the combination is not rapid; it does not, after it has commenced, proceed of itself, and it is not attended with any sensible emission of heat or light.

Nitrogen gas forms three-fourths of atmospheric air, the remaining fourth part being oxygen gas. In more intimate combination with oxygen, and in that proportion in which they are mutually saturated, it forms a very powerful acid, the nitric acid; and in lower degrees of oxygenation it forms compound gases which have no acid powers. With hydrogen, and probably a portion of oxygen, it forms ammonia, one of the alkalis; it exists in some vegetable substances, and is a constituent principle of nearly all the varieties of animal matter. This substance had been usually regarded as simple. The recent researches which have arisen from the application of galvanic electricity to chemistry, have established some singular facts with regard to it; whence the conjecture has been formed that it is a compound, and, in particular, that it is connected in chemical constitution with hydrogen: but the subject is still involved in such obscurity as to preclude any certain conclusion.

Atmospheric Air, of which oxygen and nitrogen are the essential constituent parts, has merely the aggregate properties of these two gases, their combination being so slight that no new powers are acquired from it;

and, as the oxygen is the more energetic ingredient, the chemical agencies of this air depend chiefly on the operation of this principle. It yields oxygen to a number of substances, with more or less rapidity, and thus changes their chemical constitution. It sometimes acts too by communicating humidity; and in a few cases, by affording an elastic fluid, carbonic acid gas, which is diffused through it in small proportion. Its nitrogen exerts no active power, but apparently serves merely to dilute, and thus to moderate the action of the oxygen gas.

Hydrogen is another elastic fluid, which in the system of modern chemistry has been regarded as elementary, and the importance of which, as a principle opposed to oxygen in its chemical powers, recent discoveries appear to establish. In its aërial form, in which form only it can be obtained uncombined, it is the lightest of all the elastic fluids, and the lightest substance therefore whose gravity we can ascertain. It is distinguished farther by its high inflammability; it burns whenever an ignited body is approached to it in contact with atmospheric air, and explodes if previously mixed with the air. The product of its combustion is water, which is therefore considered as a compound of it with oxygen. Combined with nitrogen, it forms ammonia: with the primary inflammables, sulphur carbon and phosphorus, it forms compound gases: it dissolves even some of the metals, and it is an abundant ingredient in vegetable and animal substances.

Water, of which hydrogen is the base, is a substance extremely peculiar in its chemical relations. Its power of combination is extensive, there being few substances on which it does not act, or with which it does not combine; yet in these combinations no energetic action is displayed; it in general scarcely produces any alteration of properties; and hence its most important operation is the communicating that state of fluidity to bodies which is in general necessary to their mutual chemical actions. It is more peculiarly the solvent of all saline substances, and of the greater number of the earths; and it dissolves many of the vegetable and animal products. When it communicates oxygen, it produces more important changes. Several of the metals are slowly oxidated by it; and when they are dissolved by acids, it often acts by affording to them that oxygen which is necessary to the solution. Vegetable and animal substances often suffer chemical changes from the oxygen which water imparts, as well as from the fluidity it communicates favouring the re-action of their constituent parts; and in their decomposition at elevated temperatures, the elements of the water they contain enter into the composition of the products which these decompositions afford.

There are three substances formerly supposed to be simple, distinguished by the property of inflammability, and hence named Simple Inflammables, which exist as constituent principles of a number of natural products. These are carbon, sulphur, and phosphorus. Recent discoveries appear to favour the conclusion, that the inflammable matter of each of them has not yet been obtained perfectly pure; but that in the state in which they are presented to us, it is combined with a small portion of oxygen, and perhaps of hydrogen; and some analogies even lead to the conjecture, that the ultimate bases are metallic. In this compound state, however, they are destitute of the metallic splendour, opacity, and specific gravity, and are connected chiefly by the common property of inflammability. When united with oxygen, they form acids.

Carbon. The ultimate base to which the name of carbon ought to be appropriated is probably still unknown to us; but there are several substances of which it constitutes the greater part, and of course in which it exists in a state more or less pure. Wood charcoal in burning is almost entirely consumed, forming with the oxygen with which it combines a peculiar elastic fluid, carbonic acid, and leaving only a small residuum of earthy, saline, and metallic substances. As a discriminating appellation of the pure inflammable matter which thus combines with oxygen, the term Carbon was introduced, and it denoted therefore simply this matter free from the other substances mixed with it in charcoal, and apparently not essential to its constitution. It was afterwards discovered, that the Diamond, which was known to be a combustible body, affords in burning precisely the same product as charcoal, and hence therefore consists of the same inflammable matter. Different opinions were advanced with regard to the difference between charcoal and diamond; but from galvanic experiments it appears, that in charcoal the inflammable base is combined with a little hydrogen, in diamond with a very minute proportion of oxygen. In the substance named Plumbago, it is united with a small quantity of iron; it has not therefore been obtained entirely insulated; but it is to this inflammable base common to all these substances, and composing nearly the whole of their weight, that the term carbon is understood to be appropriated.

Carbon, besides existing as an element in the composition of many mineral substances, is an abundant ingredient in the products of the vegetable and animal systems. Not being volatile, it forms the principal part of the residual mass when these are decomposed by heat; and it is by this decomposition of vegetable matter, especially of the wood of plants, that it is obtained in the form of charcoal. With oxygen, combined in different proportions, it forms two elastic fluids, carbonic oxide, and carbonic acid. With hydrogen and oxygen, in different proportions, it forms various inflammable gases. Alkohol, or pure ardent spirit, which is the product from saccharine matter by fermentation, is a similar compound; and ether, which is formed from alkohol by the action of acids upon it, is of the same composition with a larger proportion of hydrogen. Lastly, this ternary combination of carbon, hydrogen, and oxygen, in various proportions and modes of combination, appears to constitute the principal varieties of vegetable matter.

Sulphur is found in nature principally as a constituent part of mineral bodies. It exists combined with many of the metals; and combined with oxygen, forming sulphuric acid, it enters into the composition of a number of saline and earthy compounds. It is highly inflammable; in burning it combines with oxygen, principally in that proportion which forms an elastic fluid, highly pungent and suffocating, sulphurous acid. With a larger proportion of oxygen, it forms a dense inodorous liquid acid, sulphuric acid. With hydrogen, it forms an inflammable gas, sulphuretted hydrogen, which exists in nature impregnating water in the sulphurous mineral waters; and this compound, either alone, or with an additional proportion of hydrogen, forming what is named super-sulphuretted hydrogen, enters into combination with alkalis, earths and metallic oxides, forming several important pharmaceutic preparations. Lastly, sulphur exists as a constituent part of animal substances: hence sulphuretted hydrogen is generally evolved in the decomposition of these by heat or putrefaction: it has also been detected in the composition of a few vegetables. This inflammable substance appears, from galvanic experiments, to consist of a peculiar base, not yet obtained insulated, combined with small proportions of hydrogen and oxygen; and it is probably this base which enters into the preceding combinations.

PHOSPHORUS, like sulphur, is found chiefly as an ingredient of animal matter. Combined with oxygen, in the state of an acid, it also exists in several of the natural compounds of the mineral kingdom. It is of a soft consistence like wax, semi-transparent, and of a white or yellowish colour; it is so highly inflammable that it burns spontaneously when exposed to the air. It combines with two proportions of oxygen, forming two acids, the phosphorous and the phosphoric. With hydrogen it forms a gas highly inflammable; and it unites with sulphur and with the metals. It too contains minute quantities of oxygen and hydrogen, and its simple base is therefore unknown.

The class of METALS is an extensive one, the substances to which this name is appropriated being numerous, and the number being still farther augmented, if the lately discovered bases of the alkalis and earths are to be regarded as metallic. The physical properties, characteristic of the metals, are opacity, great lustre, density, and tenacity under the two modifications of ductility and malleability. These are possessed in different degrees by the different metals, and if the bases of the alkalis and earths are to be admitted as metals, the property of density cannot be considered as distinctive, as some of these are even lighter than water. With regard to chemical properties, the metals are fusible, in general not volatile except at very intense heats; they are capable of combining with oxygen, with hydrogen, sulphur, carbon, and phosphorus, with each other, and when oxidated are capable of uniting with acids, alkalis, and earths.

Of these combinations, that with oxygen is the most important; and in relation to the object of this outline, the only one requiring any farther observations. This combination is effected in various modes. When heated in contact with the air, they attract its oxygen:

if the temperature be very highly elevated, as in that produced in the galvanic circuit, they display during this oxidation the phenomena of combustion; even if the temperature is less elevated, several of them burn more or less rapidly; but the greater number are oxidated more slowly, and without any sensible extrication of light. Several metals are slowly oxidated by water, or by the joint action of air and water at natural temperatures. And all of them can be oxidated by acids, the acid either directly imparting oxygen to the metal, or enabling it to attract this principle from the water which is present.

The compounds of metals with oxygen belong in general to the order of oxides. They are destitute of the physical properties of the metals, and have an earthy like appearance. Two or three metals acquire, in their highest state of oxygenation, acid powers.

In combining with oxygen, different metals unite with very different quantities of it. Each of them combines too with different proportions of oxygen, giving rise to the production, from the same metal of oxides having very different properties. These proportions have been supposed to be determinate, but there is every reason to believe that they are not so, except from the operation of external circumstances connected with the oxidation; that the natural tendency of the law regulating these combinations, is to unite the metal with the oxygen, in quantities indefinite, from the *minimum* to the *maximum*, and that uniform and determinate proportions are established in particular cases, only by causes foreign to the reciprocal attraction whence the combination results,—a circumstance of much importance, as is to be afterwards pointed out, with regard to the pharmaceutical processes on the metals.

When the metals are combined with oxygen, they become capable of combining with the acids, and they then acquire greater activity and power of chemical action. This previous oxidation of a metal is always necessary to its combination with an acid, and hence, when acids act on metals, they first impart to them oxygen, or enable them to attract oxygen from the water, or sometimes from the air, and then combine with the oxide that is formed. As the same metal is capable of existing in different states of oxidation, so by combining in these states with the same acid it forms very different compounds; and these compounds are farther diversified by the different proportions of acid combined in them.

Metals are rendered active on the living system, principally by being thus combined with oxygen, or farther combined with acids. In their metallic state, they seldom produce any sensible effect; and any effect they do produce appears to arise from their being chemically acted on by the gastric fluids. When oxidated, they become much more active; and still more so when the oxide is combined with an acid. And even the degree of oxygenation considerably influences their powers; so that from the same metal preparations of very different degrees of medicinal activity may be obtained, though all agreeing in the kind of action they exert.

It would be foreign to the object of this sketch to give the description of the individual metals: it is sufficient to have stated with regard to them these general facts. Few of them exist as common ingredients in the composition of natural substances, with the exception of iron.

A class of substances, possessing certain common properties, the ultimate principles of the various compounds, not metallic or inflammable, which occur in the mineral kingdom, had been distinguished by the appellation of EARTHS. An analogy had often been observed to exist between these substances and metallic oxides; and the conjecture had even been advanced, that they are of similar constitution, or consist of metallic bases combined with oxygen. By a train of investigation, originating in very different analogies, the composition of the earths has been established, and their bases discovered to be substances previously unknown, and possessing general properties, so nearly allied to those of metals, as to be sufficient perhaps to justify the placing them in that class; yet still so far different as to afford some reason for regarding them at least as a peculiar order.

The Primary or Simple Earths, as they are named, to distinguish them from the various earthy aggregates which exist in nature, have been described as substances insipid, insoluble in water, fixed, and nearly infusible by heat, uninflammable, and capable of combining with acids, so as to neutralize the acid properties. All these characters are not equally appropriate; for there are several of the earths which have a pungent taste, and are soluble in water to a considerable extent, and all of them may be fused by very intense heats.

The principal earths are Silex, Argil, Magnesia, Lime, Barytes, and Strontites; Zircon, Glucine and Ittria, having more doubtful claims to be ranked in this class, or existing in such minute quantities as to be comparatively unimportant.

Silex is an abundant ingredient, not only in mineral substances, but is frequently contained in vegetable products, and forms part of the earthy residuum of their decomposition. It is tasteless, nearly infusible and insoluble in water, and is peculiarly distinguished by its inertness, and comparatively limited range of combination; among the acids it combines only with the fluoric, and even scarcely neutralizes its properties. It unites with the fixed alkalis, and by fusion with the other earths and the metallic oxides.

Argil is insipid, soft to the touch, infusible, insoluble in water, and particularly distinguished by forming with that fluid a ductile plastic mass, which hardens and contracts considerably when heated. With the acids it forms compounds, which have generally a sweetish styptic taste, and which possess, to a certain extent, the property of astringency.

Magnesia exists in the form of a very light white powder, smooth and impalpable; infusible, insoluble in water, and not forming with it a coherent paste; it has a slightly bitter taste, changes the more delicate vegetable blue colours to a green, and combines with acids, forming compounds, in general very soluble, and having a bitter taste. In its pure form it is medicinally employed as an antacid, and its saline compounds have in general a cathartic power.

Lime, or Calcareous Earth, displays still greater energy of action. It is so far soluble in water, as to communicate to the solution a very harsh styptic taste, and the power of changing the vegetable colours to a green. Being usually obtained by the decomposition of limestone, chalk, or marble, by heat, it is in the form of a hard mass; but when it imbibes water, either directly or from exposure to the atmosphere, it splits, and falls down into a white powder perfectly dry. It is infusible. Combined with the acids, it neutralizes their properties. Its action is considerable on the animal system. Directly applied to animal matter, it acts chemically, producing decomposition, and thus operating as an escharotic. Given in solution, it exerts an astringent and tonic power, which power is also displayed in several of its saline combinations; and by its chemical agency it acts as an antacid, and, as has been supposed, likewise as a lithontriptic. Its base has been obtained, though not perhaps perfectly insulated; it has the metallic lustre, and appears to be highly inflammable.

Barytes surpasses lime in energy of chemical action. Like it, when in a solid mass, it absorbs water rapidly, and falls into a dry white powder; its taste is harsh and caustic: when water is combined with it, it fuses by a heat comparatively moderate; but when this is dissipated, the heat requires to be raised to a much higher point. It is more soluble in water than any of the earths, cold water dissolving a twenty-fifth of its weight, and boiling water even more than half its weight; this latter solution depositing, as it cools, transparent prismatic crystals. Its solution changes the vegetable colours to a green. This earth combines with the acids, and appears to exert to them very powerful attractions, as it decomposes their compounds with the other earths and the alkalis,—a circumstance probably owing, however, rather to the insolubility of the compounds it forms, than to any superior force of attraction. It exerts affinities to the other earths, and combines also with sulphur and phosphorus. Of all the earths, it is the one which acts most powerfully on the living system. Even in small quantities, it occasions unpleasant symptoms, and its preparations prove poisonous to animals. From this quality, and from another, the great specific gravity of several of its saline combinations, particularly the native sulphate and carbonate, barytes was often more peculiarly supposed to be of a metallic nature. Its decomposition has been effected by the application of galvanism, and a base obtained from it, of a metallic appearance, having the colour of silver, considerably heavier than water, fusible at a heat below redness, not volatile, inflammable, and reproducing barytes when combined with oxygen.

Strontites, the last of these earths, bears a close resemblance to barytes in many of its properties. Like it, it has a pungent acrid taste, is soluble in water, crystallizable from its saturated solution by cooling, changes the vegetable colours to a green, combines with the acids, and decomposes a number of the compounds which they form with the other alkalis and earths. Its native compounds too have a considerable specific gravity. It is, however, much less soluble in water than barytes; it requires nearly 200 parts of cold water to dissolve it, though boiling water dissolves it in much larger quantity. Barytes decomposes its salts. It is not poisonous, nor does it appear to exert any marked action on the living system. A characteristic property of it is that of its salts causing inflammable bodies to burn with a blood red flame.

Following the series from the metallic oxides through the earths, we arrive at the ALKALIS. These possess the chemical property common to the whole, and most characteristic, that of combining with acids, neutralizing the acid properties, and forming compounds, analogous in general properties to those formed by the earths and metallic oxides with the acids. But they display still more energy in their chemical actions than the earths, and are more remote in their qualities, from the oxides of the common metals. Their taste is extremely harsh and acrid; they are highly caustic; abundantly soluble in water; exerting indeed such an attraction to it as to imbibe it from the atmosphere, or attract it from other bodies: they are fusible by a moderate heat, and by a stronger heat are volatilized; they change the vegetable blue and purple colours to a green, the yellow to a brown, and they combine with oils, rendering them diffusible or soluble in water. These properties belong to two of the alkalis which are naturally concrete, potash and soda. A third, ammonia, exists when uncombined as a permanent gas, but it is instantly condensed by water, and absorbed by it in large quantity, and the general properties of it not connected with its peculiar form are the same.

One of the most splendid discoveries of Modern Chemistry is that of the composition of the Alkalis. Ammonia had been known to be formed from the combination of hydrogen with nitrogen, and analogy suggested to Chemists the conclusion, that the two fixed alkalis are of similar constitution, containing either of these elements as a common principle; and thus led them aside from the analogy suggested by their connection with the metallic oxides in neutralizing the acid properties, from which it might have been inferred, that they and the earths are compounds of metals with oxygen. Mr Davy, availing himself of the powerful instrument of chemical analysis which galvanism affords, submitted potash and soda to its action, and succeeded in effecting their decomposition. Their bases are substances extremely peculiar; they have the metallic lustre, opacity and tenacity, but not the property formerly considered as characteristic of metals, that of great specific gravity, as they are even lighter than water; they are very fusible and volatile, and pass through these changes of form, as well as different states of cohesion, in a very limited range of temperature; they are also highly inflammable; combined with oxygen, they form these alkalis; and, if these bases are to be admitted as metallic, the analogy in chemical constitution is established between the alkalis, earths, and metallic oxides.

Potash, or, as it ought to be named, (in conformity to the rule of giving a similar termination to the names of substances belonging to the same order), Potassa, is obtained from the incineration of vegetables, especially from the wood; the saline matter remaining after the wood has been burnt, consists principally of this alkali, in combination with carbonic acid, being freed from the impurities by lixiviation; this acid is abstracted by the action of lime, the alkali is obtained in solution, and, by evaporation, can be obtained in a solid state. It is of a white colour, crystallizable, fusible, and volatile at a higher heat; abundantly soluble in water, soluble also in alkohol, powerfully caustic, and possessed of all the alkaline properties in a high degree. There is some uncertainty, whether it exist in the vegetable matter from which it is procured in the state in which it is obtained, or whether its base is a constituent principle of that matter, and is oxygenated during the combustion: one reason for admitting the latter opinion, at least in part, is, that the alkali cannot be extracted in so large a quantity by any other process as by burning.

Potassium, as the base of potash has been named, is at the temperature of 32° a solid substance, hard and brittle, of a white colour, opaque, and with the lustre of polished silver; at 50° it becomes soft and malleable; at 60° it is in the form of small globules, somewhat consistent; at 70° it becomes more mobile and liquid; and at 100, it is completely so. It requires a temperature near to a red heat to volatilize it. It is lighter than water, or even than alkohol or ether. It is highly inflammable, when heated to its vaporific point, burning with intense heat and vivid light; at lower temperatures it combines more slowly with oxygen; it passes through various stages of oxidation to the maximum, when it forms the alkali, being then combined with oxygen in the proportion of 85 to 15. Such is the strength of its affinity to this principle, that it takes it rapidly from water, and from all the acids. It combines with the primary inflammables, and with the metals.

Soda, or Mineral Alkali as it has been denominated, in contradistinction to the other alkali, which has been distinguished by the epithet of vegetable, exists as a constituent principle of several saline mineral substances, but it is usually extracted from the combustion of marine plants. It is afforded by the combustion, combined with carbonic acid, and associated with various other saline substances, and is obtained pure by the same general process as that applied to potash. Whether it pre-exist in sea plants, or whether these, in common with land vegetables, afford potash in burning, which decomposes the muriate of soda with which they are impregnated from their situation, so as to afford soda, has not been well determined. In its physical properties this alkali bears a considerable resemblance to the other. It is solid and white, crystallizable, though with difficulty, from its watery solution; extremely acrid and caustic, fusible and volatile from heat, having a strong attraction to water, changing the vegetable colours to a green, and possessing all the alkaline properties. From potash it is principally distinguished by the very different compounds it forms.

Sodium, the base of soda, is white and opaque, and has the lustre and appearance of silver; is soft and malleable; is somewhat lighter than water; it is less fusible than potassium, not losing its cohesion at a lower temperature than 120°, and requiring for its perfect fusion a heat of 180; it is also less volatile. When heated to ignition, it burns vividly; at lower temperatures it absorbs oxygen without undergoing combustion; it abstracts oxygen from water, and from the acids, frequently with inflammation. It appears to be susceptible of various degrees of oxidation; at the maximum when the proportion of oxygen is about 21 to 79, it forms soda. It acts on the inflammables and the metals nearly as potassium does.

Ammonia. This alkali has usually been denominated volatile, from its volatility compared with the others, even when it is combined with water, being considerable. In its insulated state it exists as a permanently elastic fluid; its odour is extremely pungent; water absorbs it in very large quantity, and this solution forms what is named Liquid Ammonia. Its volatility, or tendency to assume the elastic form, and its comparative dilution, lessen the energy of its action; and hence, though possessed of the general alkaline properties, it appears weaker than the others in the affinities it exerts. Its composition was supposed to have been established, nitrogen and hydrogen appearing, both from analytic and synthetic experiments, to be its constituent principles. When the composition of the fixed alkalis was discovered, and they were proved to be oxides, analogy evidently suggested the conjecture, that oxygen would probably also exist in ammonia; and Mr Davy, from some experiments, concluded, that this is the case, though these have not been fully confirmed by subsequent experiments. The analogy in the chemical constitution of ammonia to that of the fixed alkalis, has however been established by the important discovery, that it affords metallic matter; Berzelius and Pontin, Swedish chemists, having found, that when the alkali is placed at the negative wire in the galvanic circuit in contact with quicksilver, the quicksilver increases in bulk, becomes thick, and at length a soft solid,—changes perfectly similar to what are produced in it by the addition of metallic matter, and which can scarcely be conceived to arise from any other cause. The matter producing these effects in the experiment, must have been derived from decomposition of the ammonia; and it is accordingly found, that when this substance receives oxygen, either from the air or from water, ammonia is reproduced. Either hydrogen or nitrogen must therefore be of a metallic nature, combined probably with a portion of oxygen; and it is not improbable that both these gases may be modifications of the same base. The analogy in constitution has thus been rendered complete, with regard to the three alkalis, and they, as well as the earths, are connected by a series with the oxides of what are more strictly denominated metals,—one of the most perfect examples of generalization which the science of Chemistry affords.

The last important class of chemical agents is that of Acids. The characteristic acid properties are a sour taste, the power of changing the blue, purple, and green colours of vegetables to a red, and that of combining with the alkalis, earths, and metallic oxides, forming compounds, in which, when the combination is established in the due proportion, the properties of the acid, and of the base with which it is united, are equally neutralized. The more powerful acids have a considerable degree of causticity; they have a strong attraction to water, and they act with energy on inflammable and metallic substances.

All the acids are compounds of oxygen, and this element is therefore regarded as the principle of acidity. This truth was established by Lavoisier, with regard to a number of the acids, and extended by analogy to a few which had not been decomposed. It has been confirmed, with regard to these, by more recent investigations. The bases of the acids are either inflammable or metallic. The production of acidity is usually the result of their full oxygenation, and in some cases the base combines with two proportions of oxygen, forming two acids, different in their properties from each other.

On these facts, with regard to the chemical constitution of the acids, their nomenclature is founded. The base being specific with regard to each acid, while the oxygen is common to them, it is from the name of the former that the name of the acid is derived; and, by a variation in the termination of this name, the different acids which may be formed from the base, by a difference in the degree of oxygenation, are distinguished; the name terminating in the syllable *ic*, when the acid is that which contains the larger proportion of oxygen, and in the syllable *ous* when it contains the smaller proportion. Thus sulphur forms two acids, by combining with two proportions of oxygen; the term sulphur is the radical whence the names of these are derived, and according to the above principle, the one is denominated the sulphuric, the other the sulphurous acid. Where a large quantity of oxygen can be farther combined with an acid without increasing, but rather diminishing its acid powers, the name is expressed by prefixing the epithet *oxy*, as oxymuriatic acid.

Acids have an extensive power of combination. From the numerous affinities they exert, and from the facility with which they afford oxygen, they are the most active of any of the compound chemical agents, and are hence employed in many pharmaceutic operations. Those of most importance under this view are the sulphuric, nitric, and muriatic.

The Sulphuric Acid, formed from the full oxygenation of sulphur, exists combined with a small quantity of water in the form of a liquid of great density, and from this state of concentration acts powerfully; exerting strong attractions to other bodies, and though, from the strength of affinity between its principles, it does not directly afford oxygen with facility to many substances, it enables them to attract oxygen from water, and thus subjects them to chemical change. The SULPHUROUS ACID, which is formed from the same base in a lower degree of oxygenation, existing naturally in the elastic form, which is an obstacle to its entering into combination, and not being very largely absorbed by water, so as to form a concentrated solution, is much weaker.

NITRIC ACID is the result of the full oxygenation of nitrogen; and the oxygen, not being retained in the combination by a strong attraction, the acid yields it readily, and hence acts with more facility and energy on inflammable and metallic substance than any other acid,—oxidating the former, and first oxidating, then combining with the latter; hence in pharmacy it is used as the most general solvent of the metals. What is named NITROUS ACID, is the nitric, with an impregnation of nitric oxide gas; it is of a yellow colour, and emits similar coloured dense fumes, while the other is colourless: the chemical agencies of both are nearly the same.

MURIATIC ACID exists when uncombined in the aërial form, but it is absorbed in large quantity by water, and forms a liquid acid of considerable strength. Its analysis had not been effected, and even yet, by the action of potassium on it, there have been established only some singular facts, with regard to water combined with it, and the effect of this water on its acidity; the quantity of water in combination with the acid even in its elastic state, is supposed to amount to at least one-third of its weight; and though the acid itself cannot be obtained free from this water, yet when combinations of it with other acids are procured in this state, the acid powers are completely suspended, and are restored on the addition of a little water. This acid, not directly affording oxygen to bodies, oxidates them only by enabling them to attract oxygen from the water it contains; it thus dissolves metals; and it farther combines with other substances, as the alkalis or earths. It is capable of uniting with an additional proportion of oxygen, forming what is named Oxymuriatic Acid, which, although its acid powers are weaker, imparts oxygen more readily to bodies. And, with a still larger proportion of oxygen, it forms a third acid, Hyper-oxymuriatic Acid, which gives to the saline compounds in which it exists, the power of acting with much energy on inflammable bodies, in consequence of the very large quantity of oxygen condensed in the combination, and not retained by any great force.

Other acids, less important as pharmaceutic agents, are the Carbonic, Phosphoric, Boracic, and Fluoric.

CARBONIC ACID, the product of the complete oxygenation of carbon, existing in the elastic form, and being absorbed by water only in sparing quantity, has no very active chemical power, but is of importance from existing in many natural combinations, particularly of saline and earthy substancesbelonging to the Materia Medica. The characters eminently distinguishing it are its only weakening, not entirely neutralizing the properties of the alkalis, when in combination with them, and its being disengaged rapidly with effervescence by other acids from these compounds, and from those it forms with the earths.

Phosphoric Acid has phosphorus for its base; and the affinity between this base and the oxygen, with which it is combined, being strong, it scarcely acts on bodies by oxygenating them, but simply by entering into combination with them; nor are these combinations comparatively of much importance. Phosphorous Acid, in which the proportion of oxygen is smaller, is still less important.

Boracic Acid exists in the concrete form, and its chemical action is comparatively weak. So powerful is the affinity between its base and oxygen, that it has only been decomposed by galvanism, or by potassium; and its decomposition, there is reason to conclude, is even not complete: a dark olive coloured substance is obtained, inflammable, and which, by combining with oxygen, reproduces boracic acid; this substance being probably the real base in a lower degree of oxygenation.

Fluoric Acid is elastic, and is not very largely absorbed by water; its chemical action is from these circumstances, therefore, not powerful. It unites, however, easily with the alkalis and earths, and, what peculiarly distinguishes it, is capable of dissolving siliceous earth. It suffers partial decomposition from the action of potassium, oxygen being abstracted from it, and a chocolate coloured substance deposited which burns in oxygen, and reproduces the acid.

There is a series of acids with compound bases, derived from the vegetable and animal system; but those of them entitled to notice will be best considered with the classes of substances with which they are more strictly connected.

The acids combine with the alkalis, the earths, and the metallic oxides; and when the combination is established in the due proportion, the chemical properties of the acid, and of the base with which it is united, are mutually neutralized. Hence these compounds are named Neutral Salts, and, as an order of chemical agents, they are distinguished by certain common properties. They can always be obtained in the solid state: they are generally, though not universally soluble in water; those of them which are soluble, are capable of assuming a crystalline form, the form being very different in different salts. Those which crystallize from their aqueous solution, always retain a quantity of water greater or less in combination, essential to the crystal, and therefore named their water of crystallization. When heated, the increase of temperature is often sufficient to enable this water to dissolve the real saline matter: this is named the watery fusion of salts; as it evaporates, the salt becomes concrete, and, by a farther increase of heat, is either fused or decomposed. The term Neutral Salt is sometimes restricted to those of which the alkalis are the bases: those formed from the earths are named Earthy

Salts; and those from the metallic oxides, Metallic Salts. The nomenclature of the whole series is in the modern chemical language simple, and, at the same time, systematic and precise. They are formed into genera and species, according to the acids, and the bases of which they are composed; the name of the genus is derived from that of the acid, the name of the species from that of the base with which the acid is united. Thus all the salts formed from sulphuric acid are considered as constituting one genus, and are named Sulphates; and the name of each species is expressed, by adding the name of the base, as Sulphate of Soda, Sulphate of Lime, Sulphate of Iron, &c. The acid which sulphur forms in a different degree of oxygenation, the Sulphurous, forms a different order of salts; these are named Sulphites; and in like manner we have Nitrates and Nitrites, Phosphates and Phosphites, &c. Those formed from oxymuriatic acid are named Oxy-muriates. Salts are sometimes formed with an excess of acid, or with an excess of base: the acid being considered as the principle forming the genus, these are distinguished by prefixing to the usual name the epithet *super*, when the acid is predominant, and the epithet *sub* when it is deficient, or when the base is in excess, as Super-sulphate of Potash, Sub-carbonate of Soda, &c. When an acid is combined in one compound with two bases, as sometimes happens, the names of both bases enter into the name of the Salt, as Tartrate of Potash and Soda. Thus, by this simple system, a facility of nomenclature is afforded; the whole is uniform and systematic, and the memory is aided, by the name pointing out the nature of the salt; and the adoption of this nomenclature in Pharmacy is an important improvement.

So far the chemical analysis of unorganized substances connected with the Materia Medica has been the subject of consideration. It remains to take notice of the analysis of those belonging to the vegetable and animal kingdoms,—a subject of much importance, particularly as it relates to the vegetable part of the Materia Medica, and which, from this importance, as well as from the nature of the substances themselves, requires to be considered with more minute details.

These two classes of bodies are distinguished by very obvious chemical characters. In unorganized substances, the principles are few, and are combined generally in very simple states of union; their analysis can be executed with accuracy; even the proportions of their principles can be determined with precision, and they can be again combined so as to form the decomposed substance, thus confirming the analysis by synthesis. But, with regard to the products of organization, while the composition, so far as it relates to the ultimate elements, is more uniform, it is with regard to the modes in which they are united much more complicated. They consist of a few common principles; but these, presented to each other in the vessels of the organic being, have been placed under circumstances indefinitely varied, and which art can very imperfectly imitate. Combinations of the same elements are formed, therefore, greatly diversified, and properties are derived from differences of proportions, or modes of union extremely minute. Hence their accurate analysis is executed with difficulty,—a difficulty increased by the circumstance, that these elements having strong mutual affinities, cannot in general be obtained insulated, but when the compound has been decomposed enter into new combinations liable to be modified by slight variations of circumstances; the proportions therefore can seldom be determined with accuracy, the modes of union in general remain unknown, and the confirmation by synthesis is entirely precluded.

Another character distinguishes these two classes. The composition of unorganized bodies being more simple, is not so liable to be subverted; their constituent principles being few, their affinities operate with more force, and the combination is more permanent. That of organized bodies being more complicated, has characters precisely the reverse. Composed always of several elements, the affinities are more nicely adjusted, and are therefore more easily modified; and their principles having tendencies to enter into numerous forms of combination, slight variations of circumstances subvert the equilibrium. Hence the susceptibility of decomposition by which they are distinguished: they are liable even to spontaneous changes from the reaction of their elements, and when this is favoured by humidity, elevation of temperature, or the action of the air, new combinations are established, whence the original compounds are decomposed.

From the peculiar constitution of the products of organization, there are two kinds of analysis to which they are subject. The object of the one is to discover their ultimate composition; that of the other is less refined, being confined to the investigation of the proximate principles of which they are composed.

It is seldom that a vegetable substance is homogeneous. The seed, for example, the bark, or the leaves of a plant, is not of one uniform composition, but consists of various proximate principles in a state of mixture, or of slight combination, and capable of being easily separated from each other. Now, these are often connected with their medicinal virtues; the virtue residing perhaps not in the entire substance of the leaf, bark, or seed, but in a principle capable of being separated, and which may frequently be employed in its insulated state. Hence the importance of the analysis of the vegetable substances belonging to the Materia Medica, so far as relates to their proximate principles; the knowledge it conveys enabling us to employ them with more discrimination, and to submit them to the proper pharmaceutic treatment. An enumeration of their proximate principles, and more particularly of those on which their medicinal powers depend, accordingly always enters into their description as articles of the Materia Medica.

This analysis is executed in various modes, adapted to particular cases, according to the principles which form the vegetable substance.

An important principle is sometimes separated merely by heat. The temperature cannot indeed be elevated very high, as then the proximate principles of the vegetable would be themselves decomposed, and their elements brought into new combinations. But at a heat comparatively moderate, as that of boiling water, this does not happen; and at this temperature several of the principles of plants, such as their essential oil, camphors, and some others not very well defined, are volatilized without decomposition, and of course can be obtained pure.

The action of different solvents is of more extensive use in conducting the vegetable analysis. Water dissolves several of their component principles, such as gum and extractive matter, tannin, saline substances, and some others. These are dissolved in greater or less quantity, and in more or less purity, according to the temperature of the water employed. In general, by raising the water to its boiling point, it is able to dissolve them more completely; but some of them are apt to be volatilized, and others altered in their composition, especially if the atmospheric air is not excluded. Of the substances which the water holds dissolved, part are separated as it cools; the gum can be precipitated by alkohol; the saline substances may be crystallized, or can be discovered by evaporating the solution to dryness, and exposing the mass to such a heat as will destroy the inflammable parts; and tannin is detected by its chemical tests.

Alkohol is another agent of much importance in executing the vegetable analysis. It dissolves the resin, balsam, camphor, and essential oil: these solutions are decomposed by water, each substance being separated, and discernible by its peculiar qualities. Equal parts of alkohol and water, or proof spirit as it is named, is also often employed as a solvent in the analysis of vegetables. Ether dissolves nearly the same principles as alkohol. And the acids, alkalis, and soluble earths, are sometimes of utility as re-agents, in pointing out the existence of peculiar principles.

Lastly, in the analysis of vegetables, we are often able to procure several of their proximate principles, by mechanical means, particularly by expression. Sometimes, too, they exude spontaneously from the growing vegetable, or are obtained by it from incisions made in the branches or trunk.

After we have discovered the proximate principles of vegetables, the next step is to ascertain their composition. This is an investigation attended, however, with much difficulty, as being liable to all the deceptions arising from a complicated analysis, and incapable of being confirmed by the surer test which synthesis affords.

The composition of these substances with respect to their ultimate principles is nearly uniform. All of them contain carbon and hydrogen, generally if not invariably united with oxygen: some farther contain nitrogen and phosphorus; and in others several of the metals, particularly iron and manganese, exist. Lime, too, and the two fixed alkalis, either pure or more commonly in combination with some of the acids, are not unfrequently constituents of vegetable matter. These latter substances, however, are seldom in any considerable proportion; nor in general do they appear to modify much the properties of the substances in which they exist. Nitrogen, and perhaps lime when present, appear to have the most important influence, and with the exception of the few compounds of which they form a principal part, it may be said, that the vegetable proximate principles consist of carbon, hydrogen and oxygen; the differences in their properties being produced by differences in the proportions of these principles, and of the modes in which they are combined.

That a difference in the proportions of these elements may give rise to the differences in the properties of the compounds which they form, cannot be doubted; since in many other cases of chemical combinations, where there is no difficulty in the analysis, differences equally important and well marked are produced by this cause. In vegetable substances we accordingly can often trace this as the cause without being able to point out any other. Thus, fixed and volatile oils have properties in many respects dissimilar: by analysis both are found to consist of carbon and hydrogen, united only in different proportions, the volatile oils having more hydrogen in proportion to the carbon than the fixed have: this is a cause sufficient to account for the difference in their properties; and it accords sufficiently with that difference, for hydrogen being a substance extremely rare and volatile, those compounds in which it predominates, as ether, alkohol and others, are in general light and volatile. The greater volatility, therefore, of the essential, compared with the fixed oils, may be ascribed to its predominance.

In other cases, it is probable that the mode in which the constituent principles of these substances are united, is the cause of the difference in their qualities. This is indeed a cause which can be but imperfectly investigated, either by analysis or synthesis; but it is conceivable *a priori*, and sufficiently confirmed by chemical facts, that a difference in the mode of union may give rise to very important diversities of properties. If a compound, for example, consist of three elements, these may be united in two modes. Their attractions may be reciprocally balanced, and they may form what is named, in strict propriety, a ternary combination; or, from a variation in the circumstances under which the union has been effected, two of them may be combined, and the compound thus formed may exert an attraction to the third principle, unite with it, and form a new substance. The compounds resulting from these different modes of combination, though composed of the same principles, united perhaps even in the same proportions, would still have properties different from each other. Still greater diversities will be produced where the elements are more numerous, and the possible modes of union of course more diversified. And when we consider these causes from difference of proportions, and modes of combination, we shall scarcely be surprised at the number of different substances, immense as it is, which nature forms from a few elementary principles.

The proximate principles of vegetables are sometimes analysed by exposure to heat: their elements enter into new combinations, and from the nature of the products, we discover what the principles were. Thus, if the substance exposed to heat yields a large quantity of acid, we conclude that it contains a considerable quantity of oxygen as a constituent part. If it afford much empyreumatic oil, we infer that it contains a large proportion of hydrogen, this principle being necessary to the constitution of that product. When ammonia or prussic acid is afforded by this kind of analysis, we conclude, for the same reason, that nitrogen has been a constituent principle. And by the same mode are discovered the earths and metals which had been present in it; these remaining after the volatile parts have been expelled. Lastly, by the quantity of charcoal which remains as a residuum, we can form some conclusion as to the quantity of carbon which the vegetable substance contained.

Their analysis is also effected by exposing them to heat with the access of atmospheric air, and collecting the products of the combustion that takes place. From the nature of these products, we can ascertain the proportions in which they were united. Oil, for example, when subjected to this analysis, yields nothing but carbonic acid and water. We conclude therefore that it is composed of carbon and hydrogen, since these principles, united with oxygen, form these products, and since, if any other simple substance had existed in the oil, it would have appeared either pure or in combination with oxygen. We can even determine in this manner the proportion in which the carbon and hydrogen existed in the combination. From knowing what quantity of carbon exists in a given quantity of carbonic acid, and what quantity of hydrogen exists in a given quantity of water, we thus also discover whether any oxygen had existed in the composition of the oil.

They are sometimes analysed by subjecting them to spontaneous decomposition. It is thus that sugar is brought into the state of fermentation; and from the products of the fermentation the principles of the saccharine matter are determined.

Lastly, their analysis is sometimes executed by the agency of the nitric acid, which communicates to them oxygen, and by the product ascertains the nature of their acidifiable base.

Such are the methods by which these principles of vegetable matter are analysed. It is to be remarked, that the analysis is so difficult, as to afford, even when executed with the greatest care, only approximations, and as applied to the articles of the Materia Medica is seldom of utility, since we can scarcely ever discover any relation between the ultimate composition and the medicinal powers of the substance analysed. These, in common with all its properties, no doubt depend on that composition; but our modes of analysis are still too limited and imperfect to admit of our tracing the connection between them. The application of chemistry, therefore, to the vegetable substances belonging to the Materia Medica, is, as has already been remarked, in a great measure confined to the discrimination of their proximate principles.

The proximate principles of vegetables are numerous, and of very different kinds. They are not all to be met with in every vegetable, or in every period of vegetation: some exist only in certain plants, and that only in their state of vigour and maturity: at other times they are to be found only before they have arrived at that period; some are deposited in particular organs, others are diffused through the whole substance of the vegetable, and mixed in a manner more or less intimate with all its parts: and some are nearly peculiar to certain vegetables, while others are common to almost every plant. Those only require to be pointed out in this sketch, which are particularly connected with medicinal properties.

These principles are the products of vegetation from a common juice or sap, which circulates freely through every part of the vegetable system, being supplied by absorption from the soil, and perhaps from the atmosphere. It varies in its qualities, particularly according to the season, and the progress of the plant to maturity; frequently too it has an intermixture of the proper juices: it always contains the usual elements of vegetable matter, with generally saline substances, having principally lime for their base. By the chemical changes it suffers from the action of the vessels of the plant, aided by the action of the air and of light, its elements pass into various states of combinations, whence the peculiar products of vegetation are formed.

The first transition of the sap appears to be into MUCILAGE, or GUM, one of the proximate principles contained in greatest abundance in vegetables. It is found in all young plants, in greater or less quantity; and is often so abundant in the plant, as to be discharged by spontaneous exudation. It abounds also in their roots, stalks, and leaves, and especially in their seeds. It is an inodorous, insipid, and glutinous substance, soluble in water, in every proportion, and forming with it a thick viscid solution, which by evaporation affords a tenacious mass, that when dried is brittle and again soluble. It is insoluble in alkohol, ether, or oil, and is precipitated from its solution in water by the addition of alkohol. It does not absorb oxygen from the atmosphere; though its solution becomes sensibly acid by keeping, owing to partial spontaneous decomposition, and the combination of part of the principles of the gum, so as to form acetic acid. Exposed to heat it is neither fusible nor volatile. At a temperature superior to 212, but inferior to that of ignition, it is decomposed; its principles entering into new combinations: the products are an acid liquor consisting principally of acetic acid, carbonic acid and carburetted hydrogen gases, with a little ammonia, and a residuum of charcoal containing lime, one ounce of gum, affording 6 grains of lime. This lime is also detected by adding sulphuric acid to a solution of gum. From these products of the analysis, it is evident that the ultimate principles of gum are, oxygen, hydrogen, and carbon, with smaller proportions of nitrogen and lime. Gum is not capable of passing into the vinous fermentation, which appears to be owing to the portion of lime existing in it, as lime has the effect of preventing even sugar from suffering this change.

Gum is not inflammable; for although, when heated, in contact with atmospheric air, it combines with oxygen, it emits no flame. The principal products of this combination are carbonic acid and water. By the action of nitric acid it is converted into oxalic, malic, and saccholactic acids. Oxymuriatic acid converts it into citric acid.

Gum is usually obtained either by spontaneous exudation, or by incisions made in the trunks and branches of trees. It is more or less pure as it is obtained from different plants. Its existence in vegetables is detected by boiling gently the vegetable substance with water: the water dissolves the gum, and if much of that principle be present, the solution is glutinous. It may be allowed to remain till the impurities have subsided; then be evaporated to the consistence of thin syrup; and the addition of 3 parts of alkohol will separate the whole of the gum in flakes.

Pure gum is not an active substance, considered with respect to its effects on the living system. In medicine it is only used for its lubricating quality; and so little activity does it exert, that it has often been taken for a considerable time as an article of food. From its chemical properties it is of rather more importance. As a component part of vegetable matter, it renders the other parts more soluble in watery liquors, and may thus favour their action on the stomach. In Pharmacy it is used as a medium to combine balsams, resins and oils with water. If a small quantity of any of these substances be triturated with a little gum or mucilage, on the addition of water they remain suspended in it, forming a white milky like mixture, retaining all the properties of the balsam or oil. Though pure gum is thus inactive, yet the virtues of many vegetables depend on a gummy matter.

FECULA is a principle approaching in several of its characters to gum. Like it, it is soluble in hot water, and forms a viscid glutinous solution; but it is at once distinguished by being perfectly insoluble in cold water. It exists principally in the tuberose roots and gramineous seeds. It is extracted by beating the dried root or seed with a large quantity of water; the liquid soon becomes milky, from the diffusion of a white powder through it. On being poured from the remaining vegetable matter, and allowed to remain at rest, this powder is deposited, and when washed and dried is the fecula of the plant. It is generally mild and insipid, of a white colour, with a peculiar kind of brilliancy, soft to the touch; but portions of the other principles of the plant sometimes adhere to it, from which it receives colour, smell, and taste. Starch is the fecula of wheat, and is the most abundant part of that grain.

Fecula is insoluble in alkohol. The action of the acids on it is somewhat analogous to that they exert on gum, dissolving it when they are weak or diluted, but decomposing it when they are more concentrated. The alkalis also dissolve it. Exposed to heat, it is charred, and suffers decomposition, affording products which indicate carbon, hydrogen and oxygen to be its constituent principles. A property eminently characteristic of it, and probably depending on its composition, is that of being convertible into saccharine matter, and thence ultimately passing into the vinous fermentation,—a property not belonging to gum or any other principle. This conversion takes place in germination, and is accompanied with an absorption of oxygen, and formation of carbonic acid.

Fecula is a substance highly nutritive, and is usually contained in those plants which serve as food. It is sometimes employed in its pure state in medicine, on account of its nutritive quality, and from its being easy of digestion: sago and salop are substances of this kind.

Gluten. This principle is usually associated with fecula, and is obtained in the process in which the fecula is separated. It then appears as a viscous, elastic, and fibrous like substance, which, from its close resemblance to the animal product named Gluten, has been denominated Vegetable Gluten. It is obtained from the flower of wheat in greatest abundance: the flour is made into a paste with water, which being compressed by the hand, while a stream of water falls upon it, the fecula is carried off in the state of powder: the mucilaginous and saccharine parts of the grain are dissolved by the water; and there remains a tenacious ductile mass, forming the gluten: it has scarcely any taste, is of a greyish colour, and when dried is semi-transparent, resembling glue in its appearance: it is insoluble in water, and is dissolved in very small quantity by alkohol: by the action of nitrous acid, it is converted into oxalic acid, giving out, at the same time, nitrogen gas: decomposed by heat, it affords a large quantity of ammonia, and it is subject like animal matter to putrefaction. It contains a larger proportion of nitrogen than any other vegetable product does, and it is supposed to render those vegetables in which it is present highly nutritive.

Another principle occasionally found in vegetables, but belonging more exclusively to animal substances, is that which has been named Albumen, from its resemblance to the animal principle of that name. It is soluble in cold water, its solution being coagulated by heat: it is coagulated also by alkohol, but is dissolved by the alkalis: like gluten it is liable to putrefaction, and furnishes a large quantity of ammonia by distillation. This principle is found in hemlock, scurvy grass, cresses, and several other plants, and is obtained from the fresh expressed juice of the leaves when they are heated nearly to the boiling point; the albuminous matter coagulating, and separating in the form of flakes. A similar separation takes place on the addition of spirit of wine. It is contained also in the seeds of other plants, particularly in the different nutritive grains; in the farina of wheat, for instance, it is found dissolved in the water which is employed in separating the fecula from the gluten. This principle, it may be added, has been regarded, and perhaps justly, as a variety of gluten; it differs little from it in chemical properties; and the peculiar physical qualities supposed to be distinctive of gluten are obviously derived from the process by which it is obtained.

SACCHARINE MATTER. This exists in many vegetable substances, especially in their fruits and roots, but often intimately united with their mucilaginous and extractive matter. When freed from these, its taste is sweet, without any peculiar flavour; it is soluble in water and in alkohol; is capable of crystallizing; its watery solution enters first into the vinous, and then into the acetous fermentation. By the action of nitric acid, it is converted into oxalic acid; by decomposition by heat, it affords a large quantity of empyreumatic acetic acid, a small quantity of empyreumatic oil, carbonic acid and carburetted hydrogen gases, the residuum being charcoal. It consists, therefore, of carbon, hydrogen and oxygen; and from the large quantity of acid which its analysis yields, it appears to contain more oxygen than any other vegetable substance that is not acid.

Sugar appears to be formed from the fecula of the vegetable in which it exists. It contains nearly the same principles as it does, and the operation of malting throws considerable light on its formation; in this process, the fecula of grain is converted into saccharine matter, oxygen is absorbed, and carbonic acid formed; and this abstraction of carbon, if it constitutes the whole change, of course proves that the sugar, which is the product of the operation, has an increased proportion of hydrogen and oxygen. Saccharine matter has little activity, though there are some varieties of it, in which some weak medicinal powers reside.

Oil is a common proximate principle of vegetable matter; it is of two kinds, expressed or fat oil, and distilled, volatile, or essential oil. These have the common qualities of unctuosity and inflammability; but they also possess peculiar properties, by which they are distinguished as distinct species.

The expressed, fat, or fixed oils, are thick and unctuous, insipid and inodorous; they congeal on exposure to cold, are lighter than water, and insoluble in that liquid; they are likewise insoluble, except in very minute quantity, in alkohol, and they combine with the alkalis, forming soap. They are not volatilized at the temperature of 212°: some require to be raised to 600 to make them boil, and the condensed oil is changed in its properties. At a temperature somewhat higher, they are decomposed in close vessels, and burn when the atmospheric air is not excluded. They also slowly absorb oxygen at a low temperature; a small quantity of an acid is formed, which renders them rancid; by longer exposure to the air, they are inspissated, and even become at length concrete. Those oils in particular which have been expressed with the aid of heat, and which are named drying oils, suffer this last change, and are ultimately converted into a resinous matter.

Expressed oils consist chiefly of carbon and hydrogen, as is established by the products of their decomposition by heat, which are chiefly carburetted hydrogen and carbonic acid. The products of their combustion are water and carbonic acid.

These oils are generally contained in the seeds and fruit of vegetables, and only at the period of their maturity. They are extracted by expression, or by decoction with water; they are frequently impregnated with part of the extractive, mucilaginous or resinous particles, which the seed or fruit contains; from which they derive colour, and in many cases peculiar taste and odour, and even perhaps certain medicinal powers. In general, however, they have little activity as medicines. They are mild and emollient, and are used principally for these virtues. They are rendered miscible with water by the medium of gum or sugar, or by the addition of a small quantity of any of the alkalis.

Volatile or essential oils have characteristic properties different from those of the expressed oils. They are volatile at a low temperature, and are entirely and quickly converted into vapour at the heat of boiling water, without being decomposed; they are soluble in a small proportion in water, and hence the impregnation which water receives from many vegetables by distillation. In alkohol, they are completely soluble; but they do not combine with the alkalis with facility; they are in general odoriferous, pungent, and even acrid; they are more highly inflammable than the fixed oils, and by exposure to the atmosphere they slowly absorb oxygen, are thickened and coloured more deeply, lose much of their smell and pungency, and are at length converted into substances of a resinous nature. This change is partly owing to the escape of part of the oil, but principally to the oxygen absorbed combining with part of their hydrogen.

These oils, from their analysis by heat, or by combination, appear to consist principally of carbon and hydrogen. They differ from the fixed oils in containing a larger proportion of hydrogen; hence they are more volatile, and more inflammable, and during their combustion they afford a larger quantity of aqueous vapour.

Volatile oils are less abundant in the products of vegetation than some other principles; they do not exist indeed in any considerable quantity but in the aromatic plants: in some plants, the oil is confined to the flowers, fruit, leaves, or bark; sometimes it is contained in several of these parts, and in a few instances it is found diffused through every part of the plant. The quantity varies, not only according to the age, but also according to the vigour of the plant; hence it is much influenced by climate, soil, and season. It is remarkable, that some of the most odoriferous flowers, as the rose or jessamine, yield scarcely any essential oil, though they lose their flavour by a gentle heat.

Some of these oils, being contained in distinct vesicles, may be obtained by simple pressure. In this manner, essential oils can be obtained from orange or lemon rhnd. More usually, they are procured by distillation; the vegetable is boiled in water; the essential oil is volatilized with the aqueous vapour; both are condensed in close vessels; the water has the taste and flavour of the plant, from having dissolved a small part of the oil: the greater part of it, however, is collected pure, either swimming on the surface of the water, when the oil is lighter, as is generally the case, or, in a few cases, when it is heavier, having fallen to the bottom.

The essential oils of vegetables may be considered as medicines of some activity. They have always the odour, and generally the taste of the vegetable from which they are obtained, accompanied with more or less pungency. Some of them, however, are less pungent and less acrid than the vegetable matter from which they are procured, these qualities residing in the resin, or some of the other proximate principles.

A proximate principle, found in some vegetables similar in many of its properties to essential oil, is CAMPHOR. It is a solid substance of a white colour, semitransparent, having a strong peculiar smell, and a penetrating taste; tenacious, and slightly unctuous to the touch. It is very sparingly soluble in water, but is completely soluble in alkohol, ether, and oils; from these solutions, it is precipitated by the addition of water. It evaporates entirely, though slowly, at the common temperature of the atmosphere; at a higher temperature, in close vessels, it is sublimed without alteration; it is also highly inflammable, the product of the combustion being carbonic acid, and a quantity of what is named camphoric acid. It is acted on by the more powerful acids, sulphuric acid charring it and forming a portion of tannin; nitric acid dissolving it, and decomposing a portion of it, converting it into an acid; muriatic, fluoric, acetic and carbonic acid dissolving it, without materially changing its composition, as the greater part can be precipitated by water. Nitric acid, repeatedly distilled from it, converts it into a concrete acid, named camphoric acid, which appears to be different from any known acid.

By particular management, camphor may be decomposed by heat. If it is intimately mixed, with six parts of clay, and made into small balls, by the addition of water its volatilization is prevented, and, by the heat which may be applied to it, its decomposition is effected. A volatile oil, fragrant and pungent, of a golden yellow colour, amounting to one-third of the weight of the camphor, distils over; a quantity of charcoal, about $\frac{1}{4}$th of the weight of the camphor, remains; the remaining products of the decomposition are, carburetted hydrogen, carbonic acid gas, and camphoric acid. From the result of this analysis, camphor appears to differ from the essential oils, principally in containing a much larger proportion of carbon, since, by its decomposition by heat, it is resolved principally into charcoal, or compounds of carbon, and into an oil, which has all the properties of an essential oil, being odorous and pungent, volatile and inflammable, soluble in alkohol, and precipitated from it by the addition of water.

Camphor is found in distinct vesicles, in the wood and bark of certain vegetables. It is also contained in many essential oils, as those of lavender, sage and others, from which it is deposited on long keeping. The curious fact has been established, that it may be artificially formed, this formation of it taking place in the action of muriatic acid on oil of turpentine.

The same relation which camphor bears to the volatile, wax seems to have to the fixed oils. This substance, though formed perhaps by the bee, is also a product of vegetation; it is yielded by the leaves and fruit, and it is sometimes intimately mixed with the resin, gum, or extractive matter of plants. It is insoluble in water, and is soluble in very small quantity with the aid of heat in alkohol. It combines with the fixed alkalis, though with some difficulty. It unites easily with the expressed oils. It melts at a moderate heat. By distillation in close vessels it affords an acid, and a considerable quantity of thick oil, a small quantity of charcoal being the residuum.

Resin. This principle is in some measure connected with essential oil, and in plants is often united with it, as well as with other principles. Some vegetables, however, exude juices which concrete into a matter entirely resinous, and it is from these that the characters of the substances belonging to this genus are taken. The distinguishing properties of a resin are its existing in a solid state, being insoluble in water, but soluble in alkohol, ether, and oils; the solution in ether or alkohol is decomposed by water: resins are in general odorous and sapid, though neither of these qualities is essential to a pure resin; they are inflammable, and burn with much smoke; at a temperature nearly that of boiling water they melt; but they cannot be volatilized without being decomposed. In close vessels the products of their decomposition by heat are water, empyreumatic acetic acid, an empyreumatic oil, and a residuum of charcoal, indicating carbon, hydrogen, and oxygen, to be their ultimate principles. At the common temperature of the atmosphere, they do not combine with oxygen; neither are they acted on by water; the solutions of them in alkohol are therefore employed under the form of varnishes, to preserve other bodies from alteration by exposure to the air. They are dissolved by the fixed alkalis, likewise by some of the acids, especially the acetic: the stronger acids decompose them.

The existence of resin in a vegetable is discovered by infusing it in alkohol; this dissolves the resin if any is present, and it can then be precipitated from the solution by the addition of water. The method of estimating the quantity of resin in any vegetable, is by ascertaining the increase of weight which alkohol acquires from it by digestion, or the alkohol may be evaporated by a moderate heat, and the resin obtained pure.

Resins are in general more active than gums, with respect to their medicinal powers. The purest resins are indeed nearly inert, but there are many vegetable substances which act powerfully on the system, that appear to consist principally of resinous matter, and it is in this resinous part that their powers reside. The proper solvent or menstruum of resin is alkohol; by this it can be extracted from some of the other constituent parts of vegetables, though there are others which are soluble in the same fluid, and therefore it is difficult to obtain the resin pure. Though resin is insoluble by itself in water, yet part of it can be taken up, and kept suspended by the medium of gum. These two principles are often naturally mixed in vegetables, forming what are named Gum-resins, and some of the most active articles of the Materia Medica are natural compositions of this kind. Their properties are derived from the two principles of which they consist: thus, they are only partially soluble either in water or in alkohol; they are soluble in alkaline liquors; they are not fusible by heat, they only soften, and if the heat is raised higher are decomposed, affording a little ammonia with the usual products, probably derived from the gum they contain. The proportions of gum and resin, thus mixed, are in different substances of this family very various; but they are generally such, that a mixture of equal parts of water and alkohol dissolves the gum-resin. This is their proper solvent; it also dissolves some other vegetable principles, particularly extract, and hence it is the menstruum most generally used in Pharmacy to extract the active matter of vegetables.

Balsams are resinous juices, with an intermixture generally of essential oil, and containing always a portion of the acid named Benzoic Acid. They are usually thick and tenacious, becoming by age concrete. They are odorous and pungent, principally from the essential oil they contain.

A principle of considerable importance in its pharmaceutic relations, is what has been named by the French Chemists, by whom its characters were first established, EXTRACT, or Extractive Matter, and which is supposed to constitute the active matter of many vegetables. Its leading character is that it is soluble equally in pure water and in alkohol; and hence a solution of it in the one fluid is not precipitated by the addition of another. By this property it is distinguished both from gum and resin, the one being insoluble in water, the other in alkohol. The compound of the two, or gum-resin, is indeed partly soluble in either of these fluids, but it never is completely so, since if it contain as much gum as renders it soluble in water, it is only partially dissolved by alkohol; and if it consist principally of resin, so as to be completely dissolved by alkohol, it is imperfectly dissolved by water. If a gum-resin be digested with alkohol, the tincture it affords is decomposed by water, and, *vice versa*, its watery solution is decomposed by alkohol.

There is another character by which extractive matter is distinguished, that of suffering decomposition when exposed in a humid state to the atmospheric air; this takes place even at natural temperatures, and with still more rapidity when the temperature is raised, as when the extractive matter is boiled in water: it then becomes insoluble and comparatively inert. This change, Fourcroy ascribed to the fixation of oxygen. According to T. Saussure, oxygen is indeed absorbed, but carbonic acid is at the same time formed; he supposes, too, that part of the oxygen and hydrogen of the extractive matter combine and form water, and that the inert insoluble precipitate has therefore an increased proportion of carbon. It is from this cause apparently that the medicinal powers of many vegetables are injured by decoction in water with the admission of air, and not, as was at one time believed, from the dissipation of any volatile active principles; many plants indeed which sustain injury from this operation, containing no such principles.

By oxymuriatic acid, extract is converted into a concrete substance of a yellow colour, insoluble in water, probably from a similar change. It exerts affinities to argil and to metallic oxides. By heat it is decomposed, affording empyreumatic oil and acid, with a portion of ammonia; and in this, as well as in its spontaneous decomposition, when the re-action of its elements is favoured by humidity, it leaves as a residuum carbonates of potash and lime.

This principle is supposed to be the base of what are named the Extracts of Plants;—preparations formed by boiling vegetables in water, and evaporating the clear liquor to a thick consistence. As procured in this way, it must generally have an intermixture, greater or less, of those principles, which are soluble in water; and from being so liable to decomposition, it must be injured during the evaporation. It is the basis, too, though in a similar state of intermixture and partial decomposition, of what are named the inspissated juices of plants. It exists also in the seeds, leaves, bark, and wood.

Though the characters of this principle appear to be distinctive, there is still some ambiguity with regard to it, particularly from the circumstance, that these characters are not uniform; a principle existing in some vegetables which has some of these distinctive properties, without the others; as, for example, in Peruvian bark, the active matter of which is rendered inert and insoluble by decoction in water, and so far has one of the peculiar properties of extract; while it has not the other, that of equal solubility in alkohol and water, but is more soluble in the former than in the latter. Nor is there any certainty that this extractive matter has been obtained pure and insulated; and it is therefore possible that it may consist of some of the other principles in a state of mixture, their properties being modified by their reciprocal action.

Tannin. The important medicinal property of astringency, appeared from some chemical facts to be dependent in vegetable substances on a peculiar principle, as it is discoverable in them by a chemical test, that of striking a deep purple colour with the salts of iron. This effect is exhibited by all the powerful vegetable astringents, and in a degree nearly proportional to their astringency. A peculiar acid having been discovered to exist in these astringents, afterwards named Gallic Acid, it was supposed to be the principle on which this property depends. But subsequent experiments have proved, that it resides in a principle of a different nature, which being the agent chiefly concerned in the operation of tanning, has received the name of Tan or Tannin.

This principle exists in all the powerful vegetable astringents; it is extracted by maceration with water, and is detected in the infusion by a peculiar test, that of the animal principle denominated Gelatin. If a solution of gelatin is added to the infusion, it becomes turbid, and a precipitate is thrown down composed of the tannin and gelatin in combination. We have no very perfect process for obtaining tannin in an insulated state; but the most simple is precipitating it from the infusion of a vegetable astringent by lime water, and afterwards submitting the compound of lime and tannin, which is formed, to the action of dilute muriatic acid, which abstracts the lime, and leaves the tannin.

Tannin evaporated from its solution is loose and friable, having a resinous fracture, of a brown colour, a peculiar odour, and a taste rough and bitter. It is soluble in water, either cold or warm, and in alkohol not very highly rectified. It appears to suffer decomposition from exposure to the air in a humid state. By the acids, it is precipitated from its watery solution, and by some of them is decomposed. It unites with the alkalis, forming soluble compounds; with the earths it forms compounds of sparing solubility; it exerts affinities to the metallic oxides, and it is principally from its action that infusions of vegetable astringents produce dark coloured precipitates with metallic salts. Exposed to heat, it affords an acid liquid, an oil, and a considerable quantity of carbonic acid, leaving a spongy charcoal.

Its action on animal gelatin is its most important property in relation to the object of the present outline, as on this probably depends its astringent power; it combines with it, forming an insoluble precipitate, whence it corrugates and renders more dense the animal fibre of which gelatin constitutes a principal part. It exists in all the powerful vegetable astringents, mixed with extractive matter, mucilage, gallic acid, and other principles. It has also been established, that it is capable of being artificially formed, principally by the action of sulphuric and nitric acids on vegetable products which abound in carbonaceous matter.

VEGETABLE ACIDS. The acid found in the juices and other parts of plants, is not always the same. Not less than seven acids, different from each other, are of vegetable origin,—the Gallic, Oxalic, Malic, Citric, Tartaric Benzoic and Acetic. To these may be added the Prussic, though this is more peculiarly formed from animal matter.

GALLIC ACID. The existence of this acid in some of the more powerful astringents, particularly in the gall nut, can be discovered by their watery infusion reddening the infusion of litmus. If the concentrated infusion be left exposed to the air for some months, this acid is deposited in the state of a crystalline deposite, mixed with mucous flakes, from which it may be purified. It may also be obtained by sublimation from the gall nut, or even by distillation with water, though it is doubtful whether, as procured by these or other processes, it is altogether free from tannin; that by sublimation appears to be most so. By crystallization it is obtained in slender prisms of a white colour; its taste is sour, and it reddens the vegetable colours; it is soluble in 24 parts of cold, and in less than 2 parts of boiling water; it is also soluble in alkohol. It suffers decomposition from heat, and the process indicates a large quantity of carbon in its composition. It combines with the alkalis and earths, and also with the metallic oxides, forming with the latter in general coloured precipitates; it is doubtful, however, whether these colours are not in a great measure derived from the tannin adhering to it.

Gallic acid was at one time supposed to be the principle of astringency, from being contained in the vegetable astringents, and giving a dark colour with the salts of iron, the chemical test by which astringency appears to be indicated. It is doubtful, however, as has just been remarked, whether this latter property does not arise from the presence of tannin: the colour it does produce is less deep too, than that which the infusion itself strikes; and the acid in its insulated state has no astringency. Tannin is much rather to be considered as the astringent principle, and it exists accordingly in some of the more powerful vegetable astringents, as in catechu or kino, with scarcely any trace of gallic acid.

Malic Acid is contained in the juice of unripe apples and other fruits; it is uncrystallizable, forming when evaporated merely a thick liquor, which, if the heat be continued, becomes charred. By this and by the properties of the salts which it forms, it is principally distinguished from the other vegetable acids. By nitric acid it is converted into oxalic acid.

Citric Acid often accompanies the malic acid in the juices of unripe fruits, and it exists in a purer form in the juice of the lemon and lime from which it is extracted; the mucilaginous matter of the juice being separated by alkohol. It crystallizes in rhomboidal prisms; which, when it is pure, are colourless; its taste is extremely sour; it is abundantly soluble in water; its solution undergoes spontaneous decomposition, but the crystallized salt can be preserved without injury. The more powerful acids decompose it, converting it principally into acetic acid.

Oxalic Acid exists in the juice of the sorrel (oxalis acetosella) and some other plants, combined with a portion of potash, not sufficient to neutralize it. It can also be artificially formed by subjecting fecula, gum, or sugar to the action of nitric acid. It crystallizes in slender prisms of a white colour; its taste is extremely sour; it is soluble in twice its weight of cold water, and an equal weight of boiling water; it is also soluble in alkohol. It is decomposed by the more powerful acids: in its decomposition by heat, it affords little empyreumatic oil; hence it appears to contain a small proportion of hydrogen; and as some of the other vegetable acids are converted into it by the action of nitric acid, there is probably a large proportion of oxygen in its composition. The test by which it is peculiarly distinguished, is the insoluble precipitate it forms with lime, which it attracts from all the other acids.

TARTARIC ACID. This acid, as it exists in vegetables, is usually combined with potash, in such a proportion, however, as to leave an excess of acid in the combination. This forms the super-tartrate of potash which is contained in a number of vegetable fruits. It is deposited from the juice of the grape in its conversion into wine, or in the slow fermentation which the wine suffers when kept. The acid procured from this salt is in tabular crystals, transparent; they are very soluble in water, the solution when concentrated being of an oily consistence. It is decomposed by heat, affording a large quantity of liquid acid little changed, with much carbonic acid gas. By nitric acid repeatedly distilled from it, it is converted into oxalic acid. This acid is an important one in pharmacy, from the numerous combinations of it applied to medicinal use.

BENZOIC ACID is obtained from the vegetable balsams, generally by the process of sublimation. It condenses in slender crystals, white and brilliant. It is volatile, as this mode of preparation shews; its vapour is also inflammable; it is very sparingly soluble in cold water, but abundantly in hot water; the solution on cooling depositing nearly the whole of the acid in prismatic crystals: it is also soluble in alkohol, from which it is precipitated by cold water; it is pungent, but not very acid to the taste; in its usual state its smell is fragrant, especially when it is heated; but this odour has been supposed to arise from a minute portion of the oil of the balsam adhering to it; as by repeated combinations with an alkaline base, and precipitation by an acid, it is obtained at length inodorous. It is not easily decomposed by the action of the more powerful acids. Decomposed by heat, it affords a larger quantity of empyreumatic oil than any other vegetable acid, whence hydrogen is supposed to predominate in its composition.

ACETIC ACID. This acid has been considered as more exclusively the product of fermentation; it exists likewise, however, ready formed in the sap of the vine, and, combined with alkalis and earths, very generally indeed in the sap of plants. In its pure and concentrated state, in which state it can be procured only by artificial processes, it is a very powerful acid, highly pungent and fragrant, volatile and inflammable, and is distinguished by the peculiar action it exerts on some of the other proximate principles of plants,—essential oil, resin, gum-resin, camphor, gluten, and caoutchouc, which it dissolves without decomposing. Hence, even in its diluted state, under the form of distilled vinegar, it is sometimes used as a solvent in pharmaceutic processes; though it is seldom that it can be employed to advantage, as it is liable to modify the powers of the substances it dissolves.

PRUSSIC ACID. The substance to which this name is given, is formed from some varieties of animal matter by artificial processes. It had often been remarked, that its odour is similar to that of the peach blossom, and that the same odour is perceptible in the distilled water of the cherry laurel, and of the bitter almond. This led to experiments on these; whence the fact, rather singular, has been discovered, that all of them contain this acid. The fact, not less important, has been established, that the narcotic property possessed by these distilled waters depends on the prussic acid. In its insulated state, this substance is volatile, so that it escapes even from its watery solution under exposure to the air. It has no sensible sourness, and does not redden even the more delicate vegetable colours. The character of acidity is therefore given to it, rather from its powers in the combinations it forms, especially those with the metallic oxides, than from its properties in its insulated state.

Several of the vegetable acids, particularly the citric, malic, and tartaric, exist together in the same vegetable, and in proportions varying according to the stage of vegetation, whence it is probable that they are mutually convertible. They seldom exist pure, but generally in combination with saccharine, mucilaginous and extractive matter. Combined with alkaline and earthy bases, they form what have been named the essential salts of plants.

The last of the proper proximate principles of vegetables is LIGNIN, or wood; the substance which, composing the vessels of the plant, is the basis through which the other principles are diffused, or to which they are attached, and which is the basis therefore of all the parts of vegetables, with the exception of their secreted juices. It is, when freed from the principles diffused through it, insipid, inert, and insoluble, liable in a humid state to slow spontaneous decomposition, inflammable, and decomposed by heat, leaving a large residuum of charcoal, which indicates carbon to be its predominant ingredient, whence probably arises its solidity and comparative chemical inactivity. Being insoluble in water, or in alkohol, it forms the greater part of the residuum, when the active matter of vegetable substances has been abstracted by maceration in these solvents.

Besides the principles which can thus be obtained in a distinct form from vegetables by analysis, there are others of a more subtle nature, which have been supposed to exist in vegetable matter, though scarcely capable of being exhibited in an insulated state; such are the Aroma or Spiritus Rector of plants, the Acrid Principle, the Bitter Principle, and the Narcotic Principle.

The AROMA is the principle in which the odour of plants has been supposed to reside. This quality is generally found in the essential oil; but there are some vegetables, having a strong odour, which yield little or no essential oil, such as the jessamine, the violet, or the rose; or, if this oil be procured from them in small quantity, it has not that strength of odour which, considering their fragrance, and the smallness of its quantity, might be expected from them. They exhale this odour, however, when exposed to the air; it is at length dissipated, or it is communicated to water by distillation at a very gentle heat. Hence it has been concluded, that a principle more subtle than the essential oil exists in which the odour resides, and that it is even this principle which communicates odour to the oil.

These facts, however, are altogether inconclusive. The property of odour may belong to any of the proximate principles of vegetables, and does belong to principles of very different kinds; it exists in other bodies in which we cannot suppose the existence of any common principle; nor is there any reason to assume the existence of such a principle in plants: and all the facts, which have been considered as favourable to the opinion, are accounted for on the supposition that essential oil is the more common principle of odour, and is capable of being volatilized in small quantity at a low temperature, and of thus being diffused through the atmosphere, or communicated to water.

The existence of an Acrid Principle has been inferred from an acrimony residing in some plants, which they lose on drying, while their other active powers remain; and from this acrimony being in some cases transferred to water or alkohol by distillation. It is not very certain, however, if this quality is not in such cases connected with some of the known proximate principles; nor has this acrid principle, if it do exist, been obtained so as to submit it to chemical examination.

A principle has been supposed to exist in some of the vegetable bitters in which their bitterness resides. It is obvious, however, that the quality of bitterness may belong to any of the known proximate principles; and the qualities which have been assigned to this principle as it exists in some vegetables, particularly in gentian or quassia, such as equal solubility in water and in alkohol, and being precipitated by certain re-agents, rather prove it in these cases at least to be a variety of extractive matter.

A Narcotic Principle has been supposed to exist, from the narcotic power of some vegetables being impaired by age, without any apparent loss of matter, and from its being rendered inert by decoction, though no volatile matter is collected possessed of the quality. But such facts are rather favourable to the conclusion, that the loss of power is owing to chemical changes in one or other of the known principles, probably the extract, in which the narcotic quality may be supposed to reside. In submitting opium to analysis, it has been affirmed, that a crystalline matter is obtained, which proves narcotic, and has been supposed to be the principle on which that quality possessed by the opium depends. But it does not, admitting its existence, appear to be possessed of the narcotic property in that high degree we should expect, were it the principle on which that property is dependent, nor is there any proof that it exists in any other narcotic.

The existence of all these principles, therefore, is extremely problematical; and the qualities assigned to them may, with much more probability, be referred to modifications of composition in the known principles, which are probably too subtle to be ever determined by chemical analysis.

ALKOHOL, and the ETHERS formed from it by the action of acids, cannot be regarded as vegetable products; yet they have a relation to these, as their chemical constitution is similar, and they cannot be formed but by changes produced in vegetable matter. As important, medicinal, and pharmaceutic agents, they are entitled to notice.

ALKOHOL is formed by the process of fermentation from saccharine matter, or from fecula, the latter being previously subjected, partially at least, to the operation of malting, by which it is in fact converted into the former. The fermented liquor being distilled, affords the alkohol formed during the process, diluted with water, and with some impregnation of odour from the fermented substance. From this pure alkohol is procured by repeated distillation, the abstraction of the water from it being aided by the action of potash, or rather sub-carbonate of potash.

Alkohol is a colourless transparent fluid, having a specific gravity, according to its state of concentration, from 0.835 to 0.800; it is fragrant and pungent, and in its action on the living system possesses a high degree of stimulant and narcotic power; it is volatile, and inflammable, affording, during its combustion, no products but water and carbonic acid, the quantity of water exceeding even the weight of the alkohol. It contains, therefore, much hydrogen in its composition, with which carbon is combined, and perhaps also a portion of oxygen. It combines with water in every proportion, and, in consequence of the affinity between these fluids, they mutually precipitate substances which either has dissolved, that are insoluble in the other. It is decomposed by the acids, affording, as the principal product, the different ethers. As a pharmaceutic agent, it is of much importance from the solvent power it exerts on a number of the vegetable proximate principles,—essential oil, camphor, extract, and others, and by its property too of counteracting the spontaneous changes to which vegetable matter is liable.

Ether. The name Ether is given to a peculiar product obtained by the action of the more powerful acids on alkohol, the product differing in its properties according to the acid employed in its formation, but in general being extremely light, volatile, and inflammable. Sulphuric ether, formed by the action of sulphuric acid on alkohol, has a specific gravity not greater, when it is pure, than 0.716; it is so volatile as to evaporate rapidly at the common temperature of the atmosphere; in burning it affords water and carbonic acid: its odour is fragrant and penetrating; its taste pungent; it is soluble in water only in limited proportion, about one part in ten. It exerts on the vegetable principles the same solvent action nearly as alkohol, except on extract which it has been said to precipitate,—an effect, however, I have not been able to obtain from it. Nitric ether is equally light and even more volatile; it is inflammable; it is soluble in water in limited quantity, but combines with alkohol in every proportion: its odour is strong and penetrating. Muriatic ether is more volatile than either, existing in the state of gas, under the atmospheric pressure, at 60°; at 50 it becomes liquid, and its specific gravity is not less than 0.874; it is transparent, colourless, odorous, and pungent. Acetic ether is moderately light, volatile, and inflammable, soluble in water in limited quantity, and has an odour etherial, but approaching also to that of vinegar. All these ethers appear to differ from alkohol, principally in having a larger proportion of hydrogen in their composition, to which probably their greater levity and volatility are to be ascribed; and they generally contain a portion of the acid by the action of which they have been formed, which, in some of them at least, appears essential to their chemical constitution.

HAVING pointed out the distinguishing properties, and the general pharmaceutic relations of the Proximate Principles of Vegetables, it may be proposed as a question important in relation to the object of the present outline, Do these principles usually exist in the vegetable in a state of chemical combination, whence some modification of their powers might result, or are they more generally mechanically mixed?

The latter appears to be generally the case. These principles can often be observed existing apart from each other, and even placed in separate vesicles; they can in many cases be separated by mechanical means; and even where they are more intimately mixed, that change of properties does not take place, which we must have expected were they chemically united, the virtues of each principle being discernible in the entire mixture, weakened, but not changed. It seems to follow, therefore, that the virtues of vegetable substances do not depend on chemical combinations of their proximate principles, but rather on the peculiar ultimate composition of one or other of these principles. Hence also it is evident, that in separating the proximate principles of any vegetable, we cannot expect to alter or improve its virtues, farther than in concentrating them by a separation from what is inert, or in separating principles which are possessed of different or even opposite powers. The attainment even of these ends, however, is, in innumerable cases, of importance in their exhibition as medicines.

From this enumeration of the Proximate Principles of Vegetables, we may perceive the reasons for those pharmaceutic processes to which plants are usually subjected.

Vegetable matter being liable to decomposition when in a humid state, from the re-action of its elements and their entering into new combinations, exsiccation is an operation to which they are generally subjected, to preserve them without injury. It is performed either by the action of a current of air, or by exposure to heat, care being taken that the heat shall not be such as to dissipate any of their volatile principles, or cause any chemical change.

By Infusion in water, the fluid is impregnated with the gum, sugar, extract, tannin, saline substances, part of the essential oil, and part also of the resinous principle. The aroma of the plant is generally first taken up : by longer infusion the water is loaded with the colouring, astringent, and gummy parts : these are also most abundantly dissolved when the temperature is high. Hence an infusion differs according as the water has stood longer or shorter on the materials, and according as it has been promoted or not by heat. An infusion made in the cold is in general more grateful, while one made with heat, or by keeping the fluid long upon the materials, is more strongly impregnated with active matter.

By Decoction or boiling, the solvent power of the water is still farther increased ; and hence the liquor always appears darker coloured, and is, in fact, more loaded with the principles of the vegetable which it can hold dissolved. The volatile parts, however, particularly the essential oil, are entirely dissipated ; and therefore it is an improper process for those vegetables whose virtues depend, wholly or partially, on these parts. Even the fixed principles of vegetables, at least some of them, are injured by long decoction. The extractive matter, for instance, gradually absorbs oxygen from the atmosphere, and is converted into a substance nearly insipid and inert. Opium, Peruvian bark, and many other vegetables, are injured in this manner by decoction, especially if the atmospheric air is freely admitted ; and these two circumstances, the dissipation of the volatile matter, and the oxygenation of the extractive, considerably limit the application of this process. It is still used, however, with advantage, to extract the mucilaginous parts of vegetables, their bitterness, and several others of their peculiar qualities.

Alkohol may be applied to vegetables to extract those principles which are not soluble in water. It dissolves entirely their essential oil, camphor, and resin; and as these are often the parts on which the virtues of vegetables depend, these solutions, or Tinctures as they are termed, are often active preparations.

Equal parts of alkohol and water, in general, extract still more completely the active matter of plants, as we thus obtain a solution of all those substances which are separately soluble in either of these fluids.

When by the action of one or both of these fluids, we obtain a solution of the active principles of a vegetable, the solution may be evaporated to the consistence of a thick tenacious mass. This forms what is termed an Extract: it is named an Aqueous Extract when obtained from the aqueous infusion or decoction of a plant, and Spiritous when alkohol has been the solvent. The design of this preparation is to obtain the active matter of the vegetable in a small bulk, and in such a state that it may be preserved a long time without suffering any alteration. It is evident, that it is a process which can be properly applied to such plants only as have their virtues dependent on some of their fixed principles, and even these are often injured by the heat applied, and the free access of the atmospheric air.

Distillation is another process applied to vegetable substances, by which we obtain some of their active principles, particularly their essential oil. If the vegetable matter be heated with a large portion of water, the oil is volatilized with the aqueous vapour: it separates from the water on being allowed to remain at rest; a part of it, however, is also dissolved, and communicates to the water a considerable degree of flavour, and often also of pungency. This forms what are named Distilled Waters. If alkohol be used instead of water, the essential oil is completely dissolved in it, and we thus obtain what are termed Distilled Spirits.

By such processes we extract the active matter of vegetables from the inert matter with which it is more or less mixed, and are enabled to administer many remedies under a variety of forms, suited to particular circumstances. A single example will shew the utility of investigations of this kind, respecting the component principles of vegetable products, and their relations to the more important chemical agents. Peruvian bark is one of the most important remedies in the Materia Medica. Practitioners have not always found it practicable to exhibit it in substance with advantage, as where the stomach is uncommonly irritable, or where, from the nature of the disease, it is necessary to give it in large doses, frequently repeated, it is apt to occasion sickness and other uneasy sensations, and even to be rejected by vomiting. Such inconveniences are attempted to be obviated, by giving it in the different forms of infusion, decoction, tincture or extract, as any of these may be best suited to the case. Our knowledge of its constituent parts can only lead us to the proper application of these processes. From an accurate analysis of this bark, it has been proved that seven parts out of eight consist of woody fibre, or of a matter inert and insoluble, which cannot act on the system, and which affects the stomach only by its weight and insolubility. The remaining eighth part is that in which the activity of the medicine resides: it is therefore evident that if this be extracted, without injuring its activity, the medicine could be exhibited with much more advantage. This is in part accomplished by the preparations of it that have been mentioned; but even these do not convey it in all its force. If one ounce of the bark be infused or boiled in a certain quantity of water, the infusion or decoction is not nearly equal in efficacy to the whole quantity of bark operated on. It is therefore evident, that during either of these operations, the active matter of the bark has not been entirely extracted, or has suffered some change. And here Chemistry lends her assistance, and still farther elucidates the peculiar nature of this substance, and the changes produced in it by these processes. It has been proved by experiment, that the matter on which the power of the bark depends, has a strong attraction for oxygen at a temperature moderately increased; that during the infusion, and particularly during the decoction of that drug, this active matter absorbs oxygen from the atmosphere, and is converted into a substance insipid and inert. This leads to the improvement of the preparations of this medicine; and experiments instituted for the purpose have accordingly proved, that, while by long boiling the virtues of the bark are nearly totally destroyed, they are fully extracted by a few minutes' decoction in covered vessels. The same investigations have pointed out the nature of the action of some other substances on bark, formerly not well understood. Thus, it has been found by experience, that the alkalies, and more particularly magnesia, enable water to extract the virtues of bark, more completely by infusion,—a circumstance elucidated by the fact since discovered, that the extractive matter of the bark, to which its activity is owing, combines with facility with these substances, and forms soluble compounds.

Similar examples might be given from several other important vegetable remedies, which would sufficiently prove the utility to be derived from the analysis of the substances belonging to the vegetable kingdom, and that indeed researches of this kind are absolutely necessary for their proper preparation as medicines.

The account of the analysis of animal substances, and of their proximate principles, would, to the same extent at least, be foreign to the objects of this sketch, as so few of these substances are employed in medicine; and of those which are used, the composition, and consequently the pharmaceutic treatment, are in a great measure peculiar to each.

Their general chemical characters are similar to those of vegetable principles.—Composed of a few ultimate elements, the differences in their properties arise in a great measure from the different proportions, or the different modes in which these are combined. And these elements having powerful reciprocal attractions, and being disposed to enter into combinations almost indefinitely diversified with regard to these circumstances, these substances are extremely susceptible of decomposition, from the re-action of their elements, favoured by humidity, by the action of the air, or by elevation of temperature. They are even more liable to this than vegetable substances; for their elements existing in simultaneous combination are more numerous, their affinities are therefore more nicely adjusted, and of course the equilibrium is more easily subverted.

Along with carbon, hydrogen, and oxygen, which are the chief constituent principles of vegetable matter, nitrogen, and frequently sulphur and phosphorus, enter into the composition of animal substances. Hence, when decomposed by heat, they afford products composed of these, of which ammonia is always the principal; and the re-action of these principles, and the evolution of the products arising from this, seem principally to form the series of changes which constitute putrefaction, the species of spontaneous decomposition to which animal matter is more peculiarly subject.

Like vegetable substances, the animal products consist of various proximate principles, and some analogy may be traced between several of the vegetable and animal proximate principles. Animal fat has a strict connection in properties and composition with fixed oil; animal mucus resembles vegetable mucilage; fecula has a similar relation to gelatin; vegetable and animal gluten are nearly if not entirely the same: a substance similar to saccharine matter exists in milk, and in some of the other animal secretions: in the bile is found a principle strictly analogous to resin; and benzoic, oxalic, and acetic acids are common to both. Hence, generally speaking, the few animal substances belonging to the Materia Medica are acted on by the usual solvents in nearly the same manner as vegetable substances, and are submitted to similar pharmaceutic processes. The results of these are similar officinal preparations. Thus, by the action of alkohol, the active matter of musk, castor, and cantharides is extracted, and tinctures of these are employed. In other cases water is the proper solvent, particularly of those which consist of gelatin; but such solutions being very liable to decomposition, must always be of extemporaneous preparation.

CHAP. II.

OF THE PHARMACEUTICAL OPERATIONS TO WHICH THE ARTICLES OF THE MATERIA MEDICA ARE SUBJECTED.

NATURAL substances, it has been remarked, are not always obtained in that state in which they are best adapted to exhibition as remedies. They are subjected, therefore, to various processes, with the view of preserving them, or of preparing them for use; and to complete this statement of the Principles of Pharmaceutic Chemistry, the nature of these is to be pointed out.

These processes, or at least the greater number, and the most important of them, are chemical, and are dependent therefore on the agencies of those general forces whence chemical changes arise; they are indeed little more than applications of these, under peculiar regulations adapted to different substances. The general facts, therefore, connected with the operation of these forces, are first to be stated, in so far as they have any relation to the present subject.

The force principally productive of chemical action, is that species of attraction exerted between the particles of bodies, which brings them into intimate union. If two substances of different kinds be placed in contact, and with that degree of fluidity which admits of the particles of the one moving to those of the other, it often happens that they unite together, and form a substance in which neither can be any longer recognised, and which is homogeneous, and in general possessed of new properties. This constitutes what, in the language of Chemistry, is named combination, and is conceived to arise from an attraction exerted between the particles of the one body to those of the other. It is this which is denominated Chemical Attraction or Affinity, and which is distinguished from the other species of attraction by the phenomena to which it gives rise, or by the laws it obeys, —from the attraction of gravitation, by not being exerted at sensible distances, or on masses of matter, but only at insensible distances, and on the minute particles of bodies,—from the attraction of aggregation, by being exerted between particles of different kinds, and forming a substance with new properties, while that force operates on particles of a similar nature, and of course unites them into an aggregate in which the same essential properties exist. It is possible that these forces, though thus distinguished, may be the result of the same power modified by the circumstances under which it acts.

The substance formed by chemical combination is named a compound. The substances united are the constituent or component parts or principles of the compound. When these are separated, the process is named decomposition. The most minute parts into which a body can be resolved without decomposition, are named its integrant parts ; and it is between these that the force of aggregation is conceived to be exerted. Chemical attraction is exerted between the constituent parts.

The most important phenomenon attending chemical combination is a change of properties. In general, the form, density, colour, taste, and other sensible qualities, as well as the fusibility, volatility, tendency to combination, and other chemical properties in the compound, are more or less different from what they are in either of its constituent parts, and frequently indeed they are wholly dissimilar. There are cases, too, however, where the change is less considerable, as is exemplified in several of the operations of Pharmacy,—the solution of the vegetable proximate principles in water or in alkohol, or the solution of salts in water, in which the body acquires merely the liquid form, with perhaps a slight change of density, but in which no important property is changed, nor any new one acquired.

Chemical attraction is not an invariable force exerted by every body to every other, and always with the same degree of strength. Between many substances, it does not sensibly operate, though this perhaps may be owing to the predominance of external circumstances, by which its operation is influenced, rather than to the absence of all mutual attraction. It is exerted too by each body towards others, with different degrees of strength.

It is not limited in its action to two bodies, but is frequently exerted at the same time between three, four, or a greater number, so as to unite them in one combination. Such compounds are named Ternary, &c. according to the number of their constituent principles; they are abundant among the productions of nature, and can be formed also by the arrangements of art.

This force is exerted too, so as to combine bodies in more than one proportion; and, from the union of two substances in different proportions, compounds are formed frequently as dissimilar in their properties as if they were composed of principles totally different. In some cases, the combination is unlimited with regard to proportions; in others, it is fixed to two or three relative quantities, and there are examples where it can be established in only one proportion. The opinion has been maintained, and is probably just, that the tendency of chemical attraction is to unite bodies indefinitely with regard to proportion, and that determinate proportions are established only by the operation of external forces.

The compounds formed by the exertion of chemical attraction have apparently the same relation to this power as simple bodies have: they have a similar tendency to combination, unite in different proportions, and with different degrees of force; and all these combinations are accompanied by the same phenomena, and appear to observe the same laws. It has been supposed, however, that when compound substances combine together, the combination is the result, not of the mutual attraction between the integrant particles of these compounds, but of the affinities of their ultimate elements modified by the condition in which they exist.

In all cases, attraction is much modified, and its results determined by circumstances foreign to the attractive force itself. The operation of these circumstances has been established with more precision by the labours of Berthollet, and been proved to be more important than was formerly believed. They require, therefore, more distinct enumeration, especially as some of them give rise to important results in the processes of Pharmacy.

1st, Quantity of matter influences affinity, an increase in the relative quantity of one body with regard to another enabling it to act with more force; or, as the law has been stated, "every substance having a tendency to "enter into combination, acts in the ratio of its affini"ty and its quantity." Hence an effect can be produced from the mutual action of two bodies, when one is in a certain relative proportion to the other, which will not be obtained when the proportion is changed,—a circumstance of much importance in Pharmacy, requiring, in particular, attention towards insuring the uniform strength of active preparations; and of much influence too on the results of chemical decomposition, rendering it frequently partial, where it was supposed to be complete.

2d, COHESION, or the state of a body with regard to the aggregation of its integrant particles, must obviously modify the chemical action of another body upon it, by opposing a resistance which must be overcome before the union of their particles can be effected; hence the cause, that two solid bodies seldom act chemically on each other, and that fluidity promotes chemical action. But besides this obvious effect, cohesion, even when it has been overcome, still modifies the exertion of chemical attraction, by resuming its force whenever the force of that attraction is diminished, and thus sometimes giving rise to new combinations; and sometimes too, when suddenly established in consequence of the affinities becoming effective, it determines the proportions in which bodies combine, by insulating the compound at a certain stage of the combination. It is thus the most powerful cause in placing limits to the exertion of chemical attraction. INSOLUBILITY is merely the result of the force of cohesion, in relation to the liquid which is the medium of chemical action, and its action is of course similar; and great DENSITY, or specific gravity, so far as it influences attraction, operates in nearly the same manner, counteracting it, by withdrawing the substances between which it is to be exerted from the sphere of mutual action.

3*d*, ELASTICITY, or that property of bodies arising from repulsion between their particles, and present to any extent only in those existing in the aëriform state, opposes the exertion of chemical attraction, by enlarging the distances at which these particles are placed. Hence aërial fluids combine in general with difficulty; and hence too, a compound which contains an ingredient which, when insulated, assumes the aërial state, is more easy of decomposition, and the decomposition is more complete, than a compound, the ingredients of which are fixed;

for the tendency to elasticity in the volatile ingredient counteracts the mutual affinity; and when, by the application of heat, or the operation of a superior attraction, any portion of it is displaced, by assuming the elastic form it is withdrawn from the sphere of action, and ceases to oppose any obstacle by its affinity or quantity to the progress of the decomposition. Elasticity too, by counteracting attraction, places limits to the proportions in which bodies combine.

4th, The last circumstance influencing attraction is TEMPERATURE, or the state of a body with regard to heat or cold, which sometimes favours, and in other cases subverts combination. The cause of temperature is a peculiar subtle power or principle, (in modern chemical language denominated Caloric), capable of being communicated to bodies, and of being in part at least withdrawn from them. Its immediate tendency is to establish a repulsion between their particles; hence it gives rise to expansion or enlargement of volume, greater in each body according to the quantity of caloric introduced. This progressive augmentation of distance, at which the particles are placed by its action, is accompanied with a proportional diminution in the force of cohesion; if carried, therefore, to a certain extent, that force is so far modified, that the particles become capable of moving easily with regard to each other,—a state which constitutes fluidity; and, if the communication of caloric be continued, the expansion still continuing, the particles are at length placed at such distances, that the attraction is entirely overcome, and they repel each other,—a state which constitutes the aërial or gaseous form. The operation of caloric in influencing chemical attraction, appears to depend on the changes it occasions in the cohesion and elasticity of bodies,—favouring combination by diminishing cohesion, counteracting or subverting it by communicating or increasing elasticity; these effects too being often produced together, and modifying each other.

From the differences of the forces of affinity among bodies, or still more perhaps from the operation of those circumstances by which affinity is modified, its power is often suspended or overcome, and substances which have been combined are separated. This forms what in Chemistry is named Decomposition, and it presents results equally important with those from combination.

The decomposition may be simple, that is, a compound may be resolved into its constituent parts, each of which is insulated. This is in general effected by the agency of heat. Within a certain range of temperature, the affinity which has combined two bodies continues to operate; but when the temperature is raised, and when the bodies differ in their volatility, or the tendency they have to assume the elastic form, the elasticity of the more volatile one is so far favoured by the elevated temperature, that the mutual affinity is overcome, and it is disengaged. It is generally obtained pure; but the fixed substance, from the influence of quantity on chemical attraction, frequently retains a portion of the other combined with it.

Decomposition is more complicated when it is produced by the introduction of a third substance, which exerts an attraction to one of the ingredients of a compound. When this is effective, the body added combines with this ingredient, forming a new compound, and it is only the other ingredient of the original compound that is obtained insulated. A case still more complicated is, where two compound substances are brought to act on each other, and the principles of the one exert affinities to those of the other; so that an interchange takes place, the two compounds are decomposed, and two new ones are formed. Both these kinds of decomposition are likewise materially modified by the state with regard to temperature. The former case used to be named by chemists single elective attraction; the latter double elective attraction; and both were considered as the results of the relative forces of attraction among the bodies concerned. But there is reason to believe, that they arise from the operation of cohesion, elasticity, and the other forces that influence attraction; and that but for the operation of these forces, three or more bodies presented to each other would enter into simultaneous union, instead of passing into binary combinations.

Galvanism, as well as caloric, influences chemical affinity, and, by the attractive as well as by the repulsive force it exerts, is even more powerful in producing decomposition. It scarcely admits, however, of being applied to any pharmaceutic process.

The OPERATIONS of Pharmacy are generally dependent on these chemical powers; they consist of arrangements of circumstances, with the view either of promoting their exertion, or of obtaining the products of chemical action.

Some preliminary operations are frequently had recourse to of a mechanical nature, to diminish the cohesion of bodies, or enlarge their surface. Such are Pulverization, Trituration, Levigation, Granulation, &c. PULVERIZATION is the term employed where solid bodies are reduced to powder by beating: TRITURATION that where the same effect is produced by continued rubbing. LEVIGATION denotes the operation where the powder is rubbed to a still greater fineness, the rubbing being facilitated by the interposition of a fluid, in which the solid is not soluble. As by any of these operations, the powder must consist of particles of unequal size, the finer are separated from the coarser by sifting or washing. Sifting is passing the powder over a sieve, the interstices of which are so minute as to allow only the finer particles to pass. WASHING or ELUTRIATION, is an operation performed only on substances which are not soluble in water. The powder is diffused through a quantity of that fluid, and the mixture is allowed to remain at rest. The coarser particles quickly subside, and the finer remain suspended. It is then decanted off, the powder is allowed to subside, and is afterwards dried. These methods of reducing bodies to powder, can be applied to very few of the metals, their force of cohesion being too strong. They are mechanically divided by rasping, or by being beat into leaves, or they are granulated,—an operation performed by melting the metal, and when it is cooled down as far as it can be, without becoming solid, pouring it into water: it passes to the solid state, assuming the granular form.

In Pharmacy, these operations are sometimes of importance, besides merely promoting chemical combination, as there are some medicines which act with more certainty, and even with more efficacy, when finely levigated, than when given in a coarse powder.

As means of promoting chemical combination, it is evident, that they can act only indirectly; the bodies being far from being reduced to their minute particles, between which only chemical attraction is exerted. They are therefore employed, merely as preliminary to those operations in which such a division is obtained by chemical means.

Of these, the first is SOLUTION. By this is understood that operation in which a solid body combines with a fluid in such a manner that the compound retains the fluid form, and is transparent. Transparency is the test of perfect solution. When the specific gravity of a solid body differs not greatly from that of a fluid, it may be diffused through it, but the mixture is more or less opaque; and on being kept for some time at rest, the heavier body subsides; while in solution the particles of the solid are permanently suspended by the state of combination in which they exist, and are so minute as not to impair the transparency of the liquid.

The liquid has, in this case, been regarded as the body exerting the active power, and has been named the Solvent or Menstruum; the solid is considered as the body dissolved. The attraction, however, whence the solution proceeds, is reciprocal, and the form generally proceeds from the larger quantity of the liquid employed, and from the absence of cohesion being more favourable to the combination proceeding to a greater extent.

In general, the solution of a solid in a liquid can be effected only in a certain quantity. This limitation of solution is named Saturation; and when the point is reached, the liquid is said to be saturated with the solid. As the fluid approaches to saturation, the solution proceeds more slowly. When a fluid is saturated with one body, this does not prevent its dissolving a portion of another; and in this way three, four or five bodies may be retained in solution at the same time by one fluid. In these cases, the fluid does not dissolve so large a proportion of any of these substances, as if it had been perfectly pure, though sometimes the whole proportion of solid matter dissolved is increased from the mutual affinities the bodies exert. Neither is the solvent power always thus limited, there being many cases where a solid may be dissolved in a fluid to any extent. Gum or sugar, for example, will dissolve in water, and form a perfect solution in every proportion.

An increase of temperature, in general, favours solution, the solution proceeding more rapidly at a high than at a low temperature; and in those cases in which a certain quantity only of the solid can be combined with the fluid, a larger quantity is taken up when the temperature is increased. The quantity dissolved is not in every case promoted alike by an increase of temperature; water, for example, having its solvent power, with regard to nitre, greatly increased by augmentation of temperature, while sea salt is dissolved in nearly as great a quantity by water at a low as at a high temperature. This difference in these salts, and in many others, depends on the difference in the degree of their fusibility by heat; those which are most easily fused having their solubility in water most largely increased by increase of temperature. All these facts, indeed, with regard to solution, are explained, by considering this operation as depending on chemical affinity overcoming cohesion in the body dissolved.

Agitation favours solution, by bringing successively the different parts of the liquid into contact with the solid, and thus preventing the diminished effect which arises from the approach to saturation in the portion immediately covering the solid. The mechanical division of a solid too, is favourable to its solution, principally by enlarging the surface which is acted on.

Solution is an operation frequently had recourse to in pharmaceutical chemistry, the active principles of many bodies being dissolved by their proper solvents. Salts are dissolved in water, as are also gum, extract, and other vegetable products. Products of a different kind, as resin, camphor, and essential oils, are dissolved in alkohol and wine; and metals are rendered soluble and active by the different acids. Solutions in water, alkohol, or wine, possess the sensible qualities and medical virtues of the substance dissolved. Acid and alkaline liquors change the properties of the bodies which they dissolve. In Pharmacy, the operation receives different appellations, according to the nature of the solvent, of the substance dissolved, and of the manner in which it is performed. When a fluid is poured on any vegetable matter, so as to dissolve only some of its principles, the operation is named EXTRACTION, and the part dissolved is said to be extracted. If it is performed without heat, it is termed MACERATION; if with a moderate heat, DIGESTION; if the fluid is poured boiling hot on the substance, and they are kept in a covered vessel till cold, this is denominated INFUSION. DECOCTION is the term given to the operation when the substances are boiled together. It is evident, that these are all instances of solution, varied only by particular circumstances; and I have already stated, under the analysis of the vegetable part of the Materia Medica, the advantages belonging to each. LIXIVIATION is the term applied to solution performed on saline substances where the soluble matter is separated, by the action of the solvent, from other substances that are insoluble; and the solution obtained in this case is named a LEY.

The other principal method by which that fluidity necessary to chemical action is communicated, is FUSION. It requires, merely with regard to each substance, the necessary degree of heat; and where this is high, it is performed usually in crucibles of earthen ware, or sometimes of black lead, or on a large scale in iron pots.

Chemical combination is frequently promoted by an elevation of temperature, though the heat may not be so high as to produce fusion, but only to diminish cohesion to a certain extent. CALCINATION, as it used to be named, or metallic oxidation, is an example of this; a metal being heated to a high temperature, so as to enable it to combine with the oxygen of the air. DEFLAGRATION is a similar operation, an inflammable or metallic substance being exposed to a red heat in mixture with nitre: the acid of the nitre yields its oxygen; which being thus afforded in large quantity and nearly pure, the oxidation takes place with rapidity, and generally to its *maximum*.

When chemical action has been exerted, other operations are sometimes required to obtain the product, or sometimes this product is formed and collected in the operation itself.

By EVAPORATION, or dissipating a liquid by the application of heat, a solid substance which has been dissolved in it is recovered, and this operation is one frequently performed in Pharmacy. When performed on a small scale, vessels of glass, or of earthen ware, are generally employed, and the heat is applied either by the medium of sand, or, if it is required to be more moderate, the vessel is placed over water which is kept boiling, forming what is named the Water Bath, or *Balneum Mariæ*. When performed on a larger scale, shallow iron pots or leaden troughs are used, to which the fire is directly applied; and experiments have shewn that the operation is conducted more economically when the liquor is kept boiling strongly, than when it is evaporated more slowly by a more gentle heat. There is, on the other hand, however, some loss, from part of the dissolved substance being carried off when the heat is high, by its affinity to the liquid evaporating; and in many cases in Pharmacy, particularly in the evaporation of vegetable infusions or tinctures, the flavour, and even the more active qualities of the dissolved substance, are liable to be injured, especially towards the end of the operation, by a strong heat.

When the object is to obtain the volatile matter by evaporation, the process is of course conducted in close vessels adapted to condense the vapour and collect the liquid. This forms the operation of DISTILLATION, which, with regard to different substances, requires to be conducted in various modes.

When a volatile principle is to be obtained from vegetable substances by this process, the difficulty is to apply the heat sufficiently without raising it too high. The mode generally employed is to heat the vegetable matter with water, and the distillation is then usually performed in the common still. At the heat of boiling water, the essential oil of plants, which is the chief volatile principle they contain, is volatilized; it rises with the watery vapour; is condensed; if little water has been employed, the greater part of the oil is obtained apart; if much has been used, it retains it dissolved, acquiring taste and flavour, and thus forming the distilled water of plants. If alkohol, pure or diluted, has been the medium of distillation, it always retains the oil in solution, and forms what are named Distilled Spirits. The still in which the operation is performed with these views is of copper or iron; it consists of a body and head, the former designed to contain the materials, and to which the fire is applied, the latter to receive the vapour; there issues from it a tube, which is connected with a spiral tube, placed in a vessel, named the refrigeratory, filled with cold water. The vapour, in its progress through the tube, is condensed, and the liquid drops from the extremity of it.

When metallic matter would be acted on, by the materials or the product of distillation, vessels of glass or earthen ware are employed; the retort, which is generally used, being connected with a single receiver, or with a range of receivers, according as the vapour is more or less easily condensed; or, if the product is a permanently elastic fluid, which cannot be condensed but by passing it through water, a series of bottles connected by tubes, on the principle of Woolfe's apparatus, is used. When the product obtained by distillation is not perfectly pure, it can be frequently purified by a second distillation; the process is then named *Rectification*: when it is freed from any superfluous water combined with it, the operation is named *Dephlegmation* or *Concentration*.

When the product of volatilization is condensed, not in the liquid, but in the solid form, the process is named SUBLIMATION, and the product a Sublimate. As the condensation takes place with much more facility, a more simple apparatus is employed, consisting usually of a conical bottle or flask with a round bottom, thin and equal, named a Cucurbit, in which the materials are contained, heat being applied by the medium of a sand bath. The vapour condenses in the upper part of the flask, forming a cake, which adheres to it, the orifice being lightly closed to prevent any part from being lost; or a globular head, with a groove at its under edge, and a tube to convey off any liquid that may be condensed, (a Capital as it is named), being applied.

When a solid substance is thrown down from a liquid by chemical action, it forms the operation of PRECIPITATION, and the matter thrown down is named a Precipitate. Frequently the substance precipitated is one which had been dissolved in the liquid, and which is separated by a substance added, combining with the liquid, and weakening its attraction to the one which it held in solution. Or sometimes it arises from a compound being formed by the union of one body with another, which is insoluble in the liquid that is the medium of action. The precipitate is allowed to subside, is usually washed with water, and is dried. From the law of chemical attraction, that quantity influences the force of affinity, it often happens that the precipitate either retains in combination a portion of the substance by which it had been dissolved, or attracts a portion of the substance by which it is thrown down, and this sometimes proves a source of impurity, or of peculiar powers in medicinal preparations.

When a substance, in passing to the solid state, assumes a regular geometric form, the process is named CRYSTALLIZATION, and these figured masses are denominated Crystals. Their forms are various, though nearly constant with regard to each substance; they are usually transparent, hard, and have a regular internal structure. The crystallization may happen in two ways, from a state of solution. If a saturated solution has been prepared with the aid of heat, the increased quantity of the solid, which the heat has enabled the liquid to dissolve, separates as the temperature falls; and the attraction of cohesion being thus slowly exerted between the particles, unites them so as to form crystals. Or, if a portion of the solvent be withdrawn by evaporation, and especially by slow evaporation, the particles of the solid unite slowly, and with a similar result.

In both these kinds of crystallization from a watery solution, the crystallized substance always retains a quantity of water, and frequently even a considerable proportion, in its composition. It is essential to the constitution of the crystal, its transparency, structure and form, and is hence named the Water of Crystallization. Some crystals lose it from mere exposure to the air, when they are said to effloresce; others attract water, and become humid, or deliquesce.

Crystallization is promoted by the mechanical action of the air; likewise by affording a nucleus, whence it may commence, and especially a crystal of the substance dissolved; and with regard to a few substances, their affinity to the solvent requires to be diminished by the addition of another substance to enable them to crystallize.

In Pharmacy, crystallization is of importance, by enabling us to obtain substances, especially those belonging to the class of salts, in a pure form; different salts, even when present in the same solution, being thus separated by their different tendencies to crystallization, according as they are more or less soluble in the solvent, or have their solubility more or less promoted by heat, and each salt, when it does crystallize, being in general pure.

These are the principal operations of Pharmacy. Connected with this subject, there remain to be noticed the weights and measures which are usually employed. The division according to what is named Troy weight, is that ordered in the Pharmacopœias. Its parts, with the symbols by which they are denoted, and their relative proportions, are represented in the following table:

A pound	(libra),	℔	contains	12 ounces.
An ounce	(uncia),	℥		8 drachms.
A drachm	(drachma),	ʒ		3 scruples.
A scruple	(scrupulus),	℈		20 grains (grana) gr.

Measures have been subdivided in a similar manner, being made to correspond to the specific gravity of water. As the specific gravities of liquids vary, however, considerably, a source of error is introduced in applying the standard measure to different liquids, unless the due allowance be made for the difference in specific gravity. This it is to be presumed will often be neglected, and hence the Edinburgh College have rejected the use of measures, and given the proportions of every liquid by weight. The use of measures, however, in apportioning liquids, being more easy and convenient, will probably always be retained ; and the London College have therefore, in the late edition of their Pharmacopœia, sanctioned their use. They adopt measures subdivided from the wine gallon, as represented with their symbols in the following table :

A gallon	(congius),		contains	8 pints.
A pint	(octarius,)	O		16 fluidounces.
A fluidounce	(fluiduncia),	f℥		8 fluidrachms.
A fluidrachm	(fluidrachma),	fʒ		60 minims; (minima,) ♏.

This last measure is one newly introduced. In apportioning liquids into very small quantities, the quantity has been usually estimated by drops (gutta, gtt.) allowed to fall from the edge of the mouth of a bottle ; but the size of the drop is liable to vary much, not only according to the mobility and specific gravity of the liquid, a circumstance of little importance, since with regard to each substance it remains the same, but also according to the thickness of the edge and degree of inclination. The London College have therefore substituted this division of minims, which are measured in a slender graduated glass tube. The measures of a table and of a tea spoonful are sometimes used in extemporaneous prescription, and, though not very accurate, may be admitted where a small difference in the dose is not important. The one is understood to be equal to half an ounce by measure, the other to about one drachm.