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## SECTION I.

THE agents which more generally influence chemical and, thence, pharmaceutical combinations, are *Attraction and Repulsion.*

### I. ATTRACTION.

ATTRACTION is the term employed to denote that power which causes bodies to approach towards each other, and which preserves them in a state of union after they come into contact. We are ignorant of the cause of this power, but some of the laws respecting it are sufficiently evident; and from observing the different phenomena to which these give rise, we are inclined to believe that there are different species of attractions, although, perhaps, the difference is more in degree than in kind.

When this power is exerted on masses of matter, at sensible distances, in the direct ratio of the quantity of the matter, and

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the inverse ratio of the square of the distance, it is named *Gravitation;* but when its operation is confined to the minute atoms of bodies, and is exerted only when these are near to each other, or in apparent contact, it is denominated *Contiguous Attraction*. The former causes bodies on this globe to fall in a line perpendicular to its surface, preserves the planets in their orbits, and sustains in their places all the parts of the magnificent frame of the universe: the second is the cause of the regular figures of natural bodies, and of the various combinations of matter, which take place in and upon the surface of our globe. It is this species which we are here to examine.

CONTIGUOUS ATTRACTION, operating on particles of the same kind, forms an aggregate or mass; and the power, in this instance, is named the *attraction of aggregation* or *cohesion:* but, acting on dissimilar particles, and producing bodies possessed of new properties, different from those of their components, it constitutes *chemical attraction* or *affinity*.

*a.* OF COHESION.

The Attraction of *Cohesion* is that force which retains together the particles of bodies at insensible distances. According to the degree of force which it exerts, substances assume the solid, the fluid, or the aëriform state.

1. In *solid* bodies this force is sufficiently powerful to prevent their component particles from being moved with regard to one another, except in a very small degree; and to oppose a considerable resistance to any mechanical power applied to separate them. In the same kinds of bodies, all the circumstances being equal, it is always the same; but in dissimilar bodies it is exceedingly various: from which, and the peculiar arrangement of the particles, arise the different qualities of solids, denominated hardness, softness, malleability, ductility, and elasticity.

The attraction of cohesion in solids is exerted at insensible distances only, and may be weakened or altogether overcome by caloric, or that matter which produces the sensation of heat. If a piece of ice, for example, be brought near a fire, the cohesion of its particles is weakened as the caloric flows into it, till it is changed from the solid state to the fluid, or water; and by continuing and increasing the heat, the particles are still further separated from one another, until the fluid passes into the gaseous form, or becomes steam. This power is also weakened by chemical affinity; for, when a solid body is put into a fluid, the affinity between the particles of the fluid and those of the solid is often sufficient to overcome the aggregation of the solid; and its detached particles, being uniformly diffused through the fluid, now form a part of it, without altering

either its fluidity or its transparency. This constitutes the ordinary chemical or pharmaceutical process of *solution*, which is always favoured by the application of heat, owing to the assistance it affords in overcoming the cohesive attraction, as has been already noticed.

2. In *liquid* bodies this force also operates, but in a less degree than in solids, their particles being at greater relative distances, and moveable with regard to each other by a very small force; but, as their mobility does not change their relative distances, they remain within the sphere of this attraction, and are kept together. The exertion of this power varies in different liquids: it is greater in mercury than in water, and in this than in alcohol. It offers, however, scarcely any resistance to the combination of fluids with other bodies: and thence, the mutual affinity of two bodies is always favoured, when one of them is in the liquid state.

3. This attraction is not exerted over *aëriform* substances; for while these remain at the temperature necessary for the preservation of their aërial state, their particles mutually repel each other, and would recede to an indefinite distance, were they not prevented by the pressure of the surrounding bodies. Thus, a portion of air which can be contained in a vessel of 1 cubical inch of capacity, will fill a vessel of 100 cubical inches of capacity, if the pressure which confines it within the smaller vessel be removed.

One of the most important results of this variety of contiguous attraction, in a pharmaceutical point of view, is the formation of crystals, or the regular and determinate figures assumed by many bodies in passing from the fluid to the solid state, when nothing opposes the union of their particles according to the laws of aggregation.

The process of *crystallization* requires that the particles of the substance to be crystallized become moveable; and, consequently, in order to obtain any body in a crystalline state, it must first be rendered fluid, either by solution in a liquid, or by fusion.

The crystallization of salts is usually effected in the first method. When a salt is much more soluble in hot water than in cold, as is the case, for example, with sulphate of soda, nothing more is required for its crystallization than to saturate boiling water with the salt, and set the solution aside to cool. As the caloric is dissipated, the saline particles gradually approach one another, and uniting, form solids of that regular shape which characterizes the crystals of this peculiar salt. But, when the salt is one which is almost equally soluble in hot and in cold water, as muriate of soda, for instance, its

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crystallization can be effected only by evaporating a part of the fluid; and the more slowly the evaporation proceeds, the mutual attraction of the particles is more regularly effected, and the more regular is the shape of the crystals which are obtained. In both cases, however, the affinity of the saline particles at length ceases to act, while the fluid still retains as much saline matter as it can hold dissolved at the temperature of the atmosphere, or is a saturated solution; but, by a greater reduction of temperature in the one case, and a further evaporation in the other, it will again yield crystals.

By *fusion*, bodies which are not soluble in water, as glass, sulphur, &c. are enabled to assume the crystalline form. In this case the body is, as it were, dissolved in caloric: and the particles being separated from one another, these, when the cooling is gradual, assume, in aggregating again, the regular arrangements which take place in crystallization. This mode of crystallizing substances is never used for pharmaceutical purposes.

Crystallization is promoted or retarded by various circumstances, to be afterwards noticed. (See *Section* iii.) Its theory is still obscure; but some light has been thrown upon it by the experiments of Haüy. He found that crystals may be mechanically divided, and reduced to certain primitive forms, which are always the same in the same kind of substances, and depend upon the figure and the mode of combination of the integrant particles composing the crystals. The varieties of figure of these particles, notwithstanding the great diversity of crystalline forms, are reducible to three: namely, 1. the parallelopiped, the faces of which are six, parallel two and two; 2. the triangular prism; and 3. the tetrahedron, or four-sided pyramid: and these particles, therefore, according to the mode in which they unite, which may be either by their faces or their edges, form primitive crystals, which are the nuclei of the secondary crystals. The forms of primitive crystals may be reduced to the following six: 1. the parallelopiped, which includes the cube, the rhomboid, and all solids terminated by six faces, parallel two and two; 2. the regular tetrahedron; 3. the octahedron with triangular faces; 4. the six-sided prism; 5. the dodecahedron, terminated by rhombs; and 6. the dodecahedron, with isosceles triangular faces. The variations of the forms of secondary crystals are considerable in the same salt, and depend, in general, either on variations in the proportions of the ingredients which compose the integrant particles, or on the properties of the solvent in which the crystals are formed. Thus, alum crystallizes in octahedrons, but the addition of a little alumina produces cubes; and an excess of this earth prevents crystallization altogether:

thus also, muriate of soda, which crystallizes in cubes, when dissolved in water, assumes the regular octahedral form when it is crystallized in urine. Independent, however, of these causes, a variety of secondary forms make their appearance; which the theory of Haüy explains, by supposing that, as the matter which envelopes the primitive nucleus to form a secondary crystal is attracted in thin layers, each layer decreasing in size in consequence of one or more rows of integrant particles being abstracted from its primitive edges or angles. The decrements may be on the *edges* of the slices, which correspond with the edges of the primitive nucleus; or on the *angles*, that is, parallel to the diagonals of the faces of the primitive nucleus; or the decrements may be *intermediate*, parallel to lines situated obliquely between the diagonals and edges of the faces of the primitive nucleus. It would be impossible, however, to give a satisfactory view of this ingenious theory in the narrow compass of this epitome; and therefore I must refer the reader to Haüy's *Traité de Minéralogie*, tomes 1 and 2; to the *Annales de Chimie*, tom. 17; and the third volume of the fifth edition of Thomson's *System of Chemistry*.

Such is the Attraction of Aggregation, and its general effects. It is frequently concerned in modifying pharmaceutical results; but it is a power of much less importance than the next variety of *contiguous attraction*.

*b.* OF CHEMICAL ATTRACTION, OR AFFINITY.[1]

*Chemical attraction*, or *affinity*, is that power by which dissimilar substances placed under certain circumstances are enabled to unite, and form new aggregates, in which the properties of the component particles are lost or changed. Its action is confined to the minute atoms or particles of bodies, and is exerted only at insensible distances: not indifferently, however, but electively, between the particles of all bodies. The result of its operation is a *combination* of the constituent particles of the substances, so intimate that the components cannot be recognised, nor separated by any mechanical force. Thus, lime acts as a powerful caustic when applied to animal matter, and is partially soluble in water; phosphoric acid has an acid taste, and is very soluble in water; but phosphate of lime, the compound produced by the chemical combination of these substances, is inert when applied to animal matter, insipid, and insoluble in water; and cannot be again resolved into lime and phosphoric acid by any mechanical power.

*Chemical combination*, therefore, is the result of the affinity

[1] For many of the following observations on affinity, I am indebted to the remarks of my late respected friend, Dr. Murray: see his *System of Chemistry*, vol. i.

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of two or more substances for each other. It differs from *mixture*, in which the substances are only blended without acquiring any new properties, and in which the dissimilar parts are easily discovered, and may be separated by mechanical powers. Chemical compounds can, however, be decomposed, either by exposure to a high temperature, which weakens the force of attraction existing between their principles; or, by mixture, under favourable circumstances, with some other chemical agent, which has a more powerful affinity for one of the components than these have for each other: and by such means, which constitute *chemical analysis*, the principles of a compound may be ascertained.

As *Analysis* separates compounds into their constituent principles, so *Synthesis* may reproduce them by recombining these principles; and when this can be effected, it is the surest proof of the accuracy of any analysis. In many instances, however, this is impossible: and the evidence of the truth of an analysis is to be drawn from other sources.

It is an acknowledged law of chemical affinity, that a compound "does not possess properties merely intermediate between those of its component parts, but has acquired others more or less new." One of the most general changes is that of form. The combination of two gases, for example, *muriatic gas* and *ammoniacal gas* form a fluid: that of two fluids, again, may form a solid, as is demonstrated by dropping into a saturated solution of *muriate of lime*, some concentrated *sulphuric acid*; and the common process of *solution* presents to us the fact, that, by the combination of a solid with a fluid, the solid assumes the fluid form. In the last-mentioned instance the fluid is generally regarded as the active substance; but, nevertheless, the attraction of affinity is reciprocal; and thence, the general mode of expressing the fact, that the fluid dissolves the solid, or is the *solvent* or *menstruum*, is, in strict language, erroneous. These terms, however, are more correctly applied, when the properties of the solid, except form, are scarcely sensibly altered; as, for example, when common salt, muriate of soda, is dissolved in water.

Chemical combination produces an alteration of *density* — that of the compound not being the mean of the components, but often different. In the greater number of cases the density is increased; and there is a diminution of volume, owing, probably, to the compound atom being of a form admitting a more compact aggregation than the component atoms in their separate state; but the specific gravity of a compound cannot be determined by calculation from the specific gravity of its ingredients. There are cases of combination, however, in which

the density is diminished, and there is an increase of volume in the resulting compound: for instance, when a solid is dissolved by a liquid, the increase of volume acquired by the solid, in passing into the fluid state, may be greater than the condensation resulting from its union in that state with the liquid; and this happens from the solution of a considerable number of the salts in water.

"The exertion of chemical attraction is accompanied by a *change of temperature*." Thus, if four parts of sulphuric acid and one part of water, both at the temperature of 32°, be mixed together, the temperature of the mixture rises to 300°; and the density of the compound is much greater than the mean of the densities of the components. The heat also which is evolved by combustion, and in fermentation, is the direct consequence of chemical combination. In all cases the increase of temperature is accompanied with an increase of density, to which, and the change of form suffered by one or both of the components, its production may be ascribed. Thus water, which is solidified by being mixed with quicklime, parts with a large portion of caloric. The contrary effect, however, or an absorption of caloric, is also produced by chemical combination, when the density of the compound is less than the mean; as, for instance, when, by solutions of salts in water, or in some other fluids, very intense colds, greater than any natural cold, are artificially produced.[1]

The exertion of chemical affinity is influenced by various circumstances: these, according to Berthollet, are mass, cohesion, insolubility, specific gravity, elasticity, and inflorescence.

1. That *mass* has a considerable share in influencing chemical affinity was first suggested by Berthollet, who states it as a canon, that combinations do not depend altogether on the attraction of affinity, but on the proportions also of the substances brought into action. Thus, if A and B form a compound, and C be a substance which has a stronger affinity for A than B has, it should be able when mixed with a compound, to withdraw A altogether from B, if combination was regulated by affinity only: but this, he affirms, is not the case in fact; for C does not entirely combine with A, but is shared between it and B, according to the force of the affinity, and the bulk of each. This view of the subject affords a reason why, in pharmaceutical compositions, a small quantity of a substance may be added to a compound, without producing any sensible effect, although if added in large quantity, decomposition would directly ensue. It follows, also, from it, 1st, that "the chemical action of one substance on another, must di-

[1] See Appendix to Part I. No. I.

minish as it advances to saturation:" and, 2dly, that a decomposing substance "must oppose a stronger resistance to the decomposing agent, in proportion as the decomposition proceeds, from the increase in the relative quantity of one of its ingredients to the other, which is abstracted:" and, lastly, "that in estimating the relative forces of affinity in bodies, the quantities of them must be taken into account, and ought to be equal." Objections of considerable weight have been advanced to the opinions of Berthollet on this subject, by Pfaff, Sir H. Davy, and others: but it is unnecessary to enter into an examination of them at the present moment; and we may only observe, that the theory of Berthollet, however plausible, is not unobjectionable: so that it is, perhaps, better for the student to regard affinity as truly *elective*, and that the constituents of all compound bodies are constant.

2. *Cohesion* has an evident influence in opposing chemical action, and counteracting the exertion of chemical affinity. Thus all aggregates are more slowly acted on by liquids, in which they are soluble, than when their parts are mechanically divided: and this does not happen altogether from the mere circumstance of a larger surface being presented to the fluid; for native oxide of tin, which, in the aggregate, resists completely the action of any acid, becomes soluble when its aggregation is overcome by mechanical operations; and some other substances are similarly affected. Hence *trituration*, *levigation*, and *granulation*, are ranked among pharmaceutical operations, and are of importance "in facilitating chemical action, partly by diminishing aggregation, and partly by increasing the surface on which affinity is exerted." In some instances mechanical division is not sufficient, and recourse must be had to precipitation. Thus liquid potash will not dissolve silica in powder, as it can be obtained by trituration; but when the silica is precipitated from a state of chemical solution, it is readily dissolved in liquid potash.

Owing to the force of cohesion, also, solid bodies seldom act chemically on solids; while fluids readily combine with fluids, and likewise act with energy on solids for which they have an affinity. Fluidity, however, is not indispensable to chemical action; there being many cases in which two solids, in a state of minute mechanical division, act chemically on one another.[1] (See *Section* iii.) When, however, the specific gravities of even two fluids are very materially different, their chemical combination is opposed, to a certain extent, by the force of cohesion of the heavier fluid; and thence, *agitation* is frequently necessary for aiding the operation of affinity.

[1] Thence the axiom *Corpora non agunt nisi sint soluta*, which was formerly established in chemistry, is not generally true.

Cohesion has sometimes a considerable influence in determining the proportion of combinations formed in consequence of new affinities. Thus, if its intensity be sufficient to counterbalance the affinity of the fluid in which the integrant particles resulting from a new combination are formed, it will combine these, and produce crystallizations or precipitations, which, withdrawing the substance thus formed in part from the sphere of action, and opposing a resistance to any further exertion of chemical power, will, consequently, determine the proportions of the combination.

3. *Insolubility* must necessarily modify chemical action. If an insoluble compound substance be acted on by any substance tending to combine with one of its principles, this is protected, in some degree, by the insolubility of the compound withdrawing it from the action of the decomposing substance; and if a compound, which is produced in the progress of combination, be insoluble, it will be directly precipitated, and thus fixed in its proportions. In decomposition this is extremely useful; for the insoluble product being immediately separated, cannot oppose the further action of the decomposing substance, which would be the case were it to remain in solution.

4. *Specific gravity* influences considerably the exertion of affinity, particularly if the substance be of little solubility, by withdrawing it from the sphere of action, and hence retarding its combinations; and in many instances this can be but imperfectly counteracted by agitation.

5. Chemical attraction, as far as the aëriform substances are concerned, is opposed by *elasticity*. Thus, when two gases having mutual affinities are mixed together, they very seldom combine, which is ascribed to the distances between the particles of substances existing in the gaseous state: for, as chemical attraction is exerted at insensible distances only, the particles of the two gases, although mingled together, are yet without the sphere of attraction. That this is owing to elasticity, is evident from the circumstance that the vapours which are not elastic more readily combine. Hence, whatever gives density to highly elastic substances, as, for example, mechanical pressure, or cold to a certain degree, must favour their chemical combination.

6. *Efflorescence* may also influence chemical affinity; a fact which was first observed by Scheele, who ascertained, that if in a paste composed of several saline substances decomposition is going on, one of the resulting compounds often rises through the mass, and forms an efflorescence on its surface; and its being thus withdrawn from the sphere of action contributes towards forwarding the decomposition.

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7. The influence of *temperature* in modifying chemical action is very considerable. An increased temperature by promoting fusion, and in other respects weakening the attraction of cohesion in solids, favours combination; but opposes it in some cases, as much as it augments elasticity. In both instances its effects are much modified by the degree of its intensity; combinations effected at a lower, being often dissolved at a higher temperature, owing to one or more of the components having its affinity weakened by an increased elasticity. Thus mercury exposed to air for some time at a temperature equal to its boiling point, combines with the oxygen of the air, and is converted into red oxide of mercury; but, if the fire be raised so as to make the retort red-hot, this oxide is again decomposed, and running mercury and oxygen gas are obtained.

From the influence of the above circumstances on chemical combination, the utility of these pharmaceutical and chemical operations, which diminish aggregation, overcome the effect of specific gravity, diminish elasticity, and regulate temperature, such as pulverization, trituration, granulation, agitation, and compression, with the proper management of furnaces, is sufficiently obvious.

In that department of pharmacy, also, which regards extemporaneous compositions, it is of importance to attend to the slowness with which chemical action is in many instances produced; for substances, which have mutual affinities for each other, may give no indication of any change when newly mixed, but yet, after some time, may act, and produce even complete changes. Such compounds, therefore, when they are intended to act *medicinally*, should be exhibited as soon as possible after they are made.

Chemical attraction may be exerted between more than two bodies, so as to bring three or four into one combination; and such compounds are named *ternary*, *quaternary*, *&c.* according to the number of their components. Several examples of these are to be found among the saline preparations, (*Part* iii.); and almost all the vegetable substances are compounds of three or more principles.

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The forces with which chemical attraction is exerted are different in different bodies. In cases where this attraction is exerted in a superior degree, by a third body, to that of either of the components of a compound of two bodies, so as to decompose it, and form a new compound, while, at the same time, one of the components of the previous compound is set free, the affinity thus exerted has been termed *single elective attraction*. To represent the relative forces of affinity, tables were first constructed by Geoffroy; and afterwards much

improved and extended by other chemists, particularly Bergman. The remarks of Berthollet may have tended to lessen their value in the opinions of some; but their utility to a certain extent must undoubtedly be acknowledged.[1] When the elective attractions are more complicated, or when two elective affinities are exerted, and two new compounds formed, this is termed *double elective attraction*. In such cases, Mr. Kirwan denominated the attractions which tend to preserve a compound in its original state *quiescent*; while the others, which tend to separate the principles of a compound from each other, he termed *divellent attractions*. As an example of double elective attraction, let it be supposed that two compounds, one consisting of potash and sulphuric acid, or *sulphate of potash*, and the other consisting of muriatic acid and lime, or *muriate of lime*, be mixed together, a double decomposition will take place, and two new compounds, *sulphate of lime*, and *muriate of potash* will be formed. In this case, if the attraction between potash and sulphuric acid be 62, and that between lime and muriatic acid be 20, the sum of the quiescent attractions will be 82; but if the attraction between potash and muriatic acid be 32, and that between sulphuric acid and lime be 54, the sum of the divellent attractions will be 86: which, exceeding the former sum of the quiescent, will operate and produce the above-stated decompositions and resulting compounds.[2]

According to the opinions of Bergman, the relative force of the affinities which produce these effects is capable of being measured, and the changes are altogether to be ascribed to the predominance of the affinities of one set of substances over those of another.

But the changes produced by the predominance of certain affinities over others, are ascribed by Berthollet to those circumstances which influence attraction, and limit combination. If four substances, for example, be presented to each other, two of which have a greater tendency to cohesion than the other two have, so as to form by their union an insoluble compound, instead of one compound being formed by the union of the four, in which the affinities are balanced, this will be

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[1] See Appendix to Part I. No. II.

[2] To represent this effect of double elective affinity more clearly, diagrams are used, the idea of which first occurred to Dr. Cullen. Thus the above operations would be represented in the following manner: The inverted triangle in the centre denotes water or that the decomposition was effected in the humid way.

Muriate of potash.

Sulphate of potash. { Potash 32 / 62 ▽ / Sulphuric acid 54 } { Muriatic acid / 20 = 82 / Lime } Muriate of lime.

Sulphate of lime.

averted by the force of cohesion, and the two which form the insoluble compound will unite, and be separated by precipitation or crystallization, leaving the other two in combination in the fluid which has been the medium of action. "If even these four substances were previously in the reverse binary combinations, on presenting them to each other, the affinities within the sphere of action must be reciprocally exerted; and the same extraneous forces will cause an exchange of principles, or the phenomena which have been ascribed to elective affinities will be produced." To avoid the term elective attraction, Berthollet denominates cases of this kind *complex affinity*. The explanation of single elective attraction, or where three substances are presented to each other, is precisely the same; the union which takes place between two of them being determined by the tendency to cohesion, or the disposition of the combination of two of them to form a compound of little solubility.

Elasticity, likewise, has a considerable influence in determining decompositions where the application of heat is necessary; and, according to Berthollet, the decomposition of a compound body of which one of the ingredients has a great tendency to assume the elastic form, is to be ascribed to the disposition it has to escape from its combination, when aided by the intervention of even a weaker affinity.

In complex affinities the same cause determines the union of substances disposed to assume the elastic form, and separates them as a volatile compound. "If therefore," says he, "it be desired to know the result of the exposure of two salts to the action of heat, it is only necessary to consider which of the two bases and which of the two acids have the greater volatility, if there be a difference: for the more volatile base and acid will escape and enter into combination, and the fixed base and fixed acid will remain behind, and combine with one another."[1] Tables representing the forces of affinity have been constructed; but, as Dr. Henry has justly remarked, "one great obstacle to the construction of such tables, is the difficulty of ascertaining, with precision, the quantities of bodies required for neutralization."[2]

A knowledge of the doctrines of affinity is of the utmost importance in pharmacy; and, as the foregoing sketch presents little more than an outline, I must refer those who would wish to investigate the subject to Thomson's and Murray's Systems of Chemistry, Bergman's Dissertation on Elective Attraction, Berthollet's Researches into the Laws of Chemical

[1] *Researches*, p. 3. quoted by Murray, *System of Chemistry*, i. 120.
*Henry's Elements of Experimental Chemistry*, 7th ed. vol. i. p. 57.

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Affinity, Richter's Foundation of Stochiometry, and Sir Humphrey Davy's Elements of Chemical Philosophy.

## II. REPULSION.

REPULSION is that force which separates the particles of bodies from one another, and consequently counteracts or modifies the attractions by which they are combined and preserved together in masses. It is supposed to depend on the operation of one or more of the three following powers; *Caloric*, *Light*, *Electricity*.

### *a.* CALORIC.

The cause of the sensation of heat is denominated *Caloric*. Philosophers are not completely agreed whether it is a property only of bodies, such as a vibration of their particles,[1] or a peculiar substance; but the latter opinion is the one more generally adopted.

Under this opinion caloric is regarded as a very subtile, elastic fluid, which penetrates more or less all bodies, passing readily from one to another; and is every where diffused. Its particles are supposed mutually to repel each other; and bodies into which it enters in any sensible quantity are increased in bulk, and undergo other changes of form, while their density is diminished. It is radiated in the same manner as light, and in this state forms a part of the solar ray.[2] The rays are refrangible, and capable of reflection, and of polarization, like those of light. It has no ascertainable gravity; and neither the addition nor the abstraction of it alters sensibly the weight of bodies.[3] It exists in two different states; in a *free* state, in which it is merely loosely mingled, as it were, with other bodies; and, in a *latent* state, or one of intimate combination.

Regarding it as matter, the sources whence it may be obtained, the laws which regulate its motion and distribution, and its effects, require to be noticed.

#### *Sources of Caloric.*

The known sources of caloric are the *sun*, *combustion*, *percussion*, *friction* and *mixture*.

*a.* The *sun* is an apparent source of caloric; but the direct action of the sun's rays upon bodies seldom produces a temperature exceeding 160°. When these, however, are concentrated by means of a concave mirror, or a lens; or when means are taken to prevent the communicated heat from being carried off by the surrounding bodies, a much higher temperature can be produced. This source of caloric is not resorted to for pharmaceutical purposes.

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[1] The idea of caloric being motion or vibration orginated with Lord Bacon.
[2] *Philosophical Trans.* 1807. [3] Ib. 1799, p. 179.

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