LVI. Reflections on some mineralogical systems. Translated entire from the French, with notes by the translator

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entered in combination, and which in my opinion would be in a very condensed state in it*.

To conclude:—During the whole operation, hydrogen is extricated, alkali not metallized, and radical prussic gas. I have collected this last product in particular in great quantities.

These results tend, therefore, to prove either that hydrogen is one of the constituent parts of the alkalis, and the disengagement of which is favoured by charcoal, or rather that the charcoal itself is a compound of which hydrogen is one of the principles. We must choose between one or other of these hypotheses.

LVI. *Reflections on some Mineralogical Systems.* By R. CHENEVIX, Esq. F.R.S. and M.R.I.A., &c. Translated entire from the French, with Notes by the Translator†.

FUNDAMENTAL PRINCIPLES AND GENERAL EXAMINATION OF THE WERNERIAN SCHEME.

NATURE has given to all bodies properties which are either immediately or mediately sensible. This is the basis of all systems of mineralogy. One mean of rendering our learning useful is by establishing unities, to which every thing may be referred, and which we afterwards adopt either wholly or in part. We seek a principle the most general and least variable possible, to employ it as a basis for the determination of these unities: in natural history, it is agreed to call the latter by the name of *species*. In the vegetable and animal kingdoms, the faculty of reproducing individuals fecund and similar to their parents constitutes a species.

This principle of specification has been received as lawful; but it is not applicable to the mineral kingdom. Does there exist any other? If we consult the ancient works on mineralogy, we are tempted to believe that it is totally wanting. In more modern times, M. Werner is engaged in seeking and noting in minerals every thing that immediately

* The opinion expressed in this paragraph has been since retracted by the French chemists.—EDIT.

† As the learned author has not thought proper to publish these ingenious and scientific reflections in his native language, a circumstance much to be regretted, the translator has, for the sake of perspicuity, taken the liberty of classing them under different heads, according to the subject discussed: he has also ventured occasionally to introduce in [ ] the real or approximate synonyms of the various minerals mentioned by the author, in order to enable the English reader to form more precise notions of the different substances, and feel the force and justice of the author's reasoning. B.

strikes the senses; and he has succeeded in uniting the principles which enable him to class and distinguish minerals into a body of doctrine. The colour, brilliancy, fracture, and other properties, have been examined in a point of view the best calculated to attain this object: the advantages which a knowledge of the latent qualities may offer have not been neglected;—these labours have procured the author the approbation of the learned world. In this manner a great step has been made; and if it does not conduct us entirely to our object, it at least demonstrates the difficulty of attaining it. M. Werner has said (Memoir of Daubuisson, *Journal de Physique*, Frimaire, 16th year), “that all the minerals which have the same constituent parts, both with respect to quality and quantity, form only one species; and that all those which differ essentially belong to different species. If, in the same species,” he adds, “divers minerals having the same characters (one only excepted) differ from others in two or three characters (a greater number would induce a difference of species) from those which we have designated, they form a particular subspecies. Finally, When an individual in a species, or subspecies, presents but one different character, it forms a variety.”

To the word *essentially* I have two objections. In the first place, it does not excite the same idea in all minds, and we can have no precise notion respecting it, while it has no fixed signification. In the second place, the chemical means which could enable us to pronounce with some certainty on what belongs essentially or accidentally to the composition of a mineral, are entirely omitted. But let us suppose, for a moment, that we have acquired the necessary knowledge. *The chemical composition is therefore the true basis of specification in this system**. We also learn from the above quotation, that when two minerals of the same species differ in one

* To this the Wernerians object, that it is degrading to mineralogy to be dependent on chemistry; that it is possible for a man to be a very good mineralogist without being previously a chemist; and that they are two distinct and independent sciences. In support of these positions, they sometimes appeal to the increasing number of botanical nomenclaturists who are not vegetable physiologists; but the allusion only tends to place mechanism before science; the former are to the latter what sculptors and lapidaries are to scientific mineralogists. The Wernerians, therefore, when they reject chemical science, and build solely on their external characters, place themselves on precisely the same basis as the lapidaries and sculptors; they become artists, but not men of science properly so called. They may indeed be most acute observers, very accurate reporters of their observations, and even pioneers in the fields of mineralogical science; but they ought not to aspire to be world-makers, or attempt to raise any superstructure without the aid of chemistry; while mineralogy and particularly geology are not less sciences of deduction than of observation.—TRANS.

character,

character, they are varieties ; if in two or three, they form subspecies. If the number of dissimilar specific characters exceed three, the minerals thus characterized must belong to different species. Here, then, is a second idea of the species which has just presented itself ; and to reconcile it with the first, we have only to believe that the variation of more than three specific characters is an inseparable consequence of an essential difference in the chemical composition of minerals.

We cannot be perfectly sensible why the number three should be that which characterizes a change in the chemical composition, and we are tempted to believe that it has been taken at random. It is nevertheless founded on a motive. The species is subdivided into subspecies and variety ; the variety, therefore, is the last subdivision of the species ; and to determine the last subdivision but one, the variation of two or of three has been chosen. It is, therefore, necessary to carry beyond three the difference of species ; that is to say, (according to the passage already quoted,) the essential difference in the chemical composition. I have said that there was a very good motive for choosing the number three ; but I have not said that it was susceptible of being acknowledged by nature.

In establishing the difference of species solely on the difference of any determinate number of specific characters, we render it independent of every consideration either of the value of the characters, or of the extent in which the shades of these characters differ. In this hypothesis it matters not, that two minerals have two or even three characters so different that they form, if we may so speak, the extremes of the series of characteristic analogies : if we cannot discover a fourth which is also different, these two minerals must belong to the same species : or let any number whatever of minerals that I can divide into two series form a difference in three specific characters ; let all those of the first portion be opaque, ductile, and so soft as to be cut with the nail ; let those of the second be transparent, not ductile, and so hard as to resist the file ; let all the other characters be entirely similar in every respect, still the individuals which compose these two portions are of the same species, since the number of different characters does not exceed three. Moreover, let us suppose all these minerals of a brownish red colour, except one only, which may be a reddish brown. Here we must now renounce these principles in which the single shade between brownish red and reddish brown, (for M. Werner places them in two different species among

among the colours) effects the translation of a mineral from one species to that of another, as it is that which, super-added to the first, forms the fourth characteristic difference, while the other minerals always remain in the same species as before.—It is the last pound under which the camel succumbs.

Here is a second example of the very serious inconveniences arising from making the species depend on any fixed number of characters. Form is a character, crystallization is comprehended in forms. M. Werner admits the prism only where there exist certain proportions between its height and its breadth; if we diminish the former, the prism becomes a table. The prism and table are considered as making two different species of primitive forms. Take a crystal of calcareous spar in a hexahedral prism, and another crystal of the same in a hexahedral table; here is a different primary specific character in these two specimens of calcareous spar. Suppose the table very near becoming a prism, and the prism approaching very near to the table; and suppose the one translucent and the other opaque; add two specific characters not less insignificant than these two, and behold a new species at very little expense. But, had the causes which determine crystallization added some molecules of carbonate of lime to the calcareous spar, in the direction of the axis of the prism which was considered a table, it would have been saved from this forced separation from its equals.

In establishing a subspecies, if the liberty of choosing two or three for the number of characters by which the observer decides, leave any influence to the particular value of each character, it is necessary that this value should rest on a solid basis; otherwise we risk the danger of making arbitrary dispositions, and the same mineral may be found belonging to as many different species as there will be persons who shall examine it. M. Werner, indeed, has distinguished some characters by the order of importance in the determination of the species, as well as in the diagnosis of minerals. He gives sometimes to the specific gravity, sometimes to the colour, more value than to the greater part of the other characters. I have seized every opportunity to acquire clear ideas on this subject, either in consulting M. Werner himself, or addressing those who had profited most by his instructions; and all that I have been able to learn amounts only to this, That the value of a character varies from one species to another: thus, then, to decide on it, it is necessary to know the species, that is to say, in

algebraic language, for to find the value of x , we must commence with knowing it.

WERNERIAN DIVISION OF THE EXTERNAL CHARACTERS.

M. Werner has divided the external characters into generic characters, specific characters, and characters of varieties which influence the systematical distribution of minerals under analogous denominations. The colour, lustre, and specific gravity undergo subdivisions. White, gray, black, blue, green, yellow and brown, are *species* among the colours. The shades of these characters form subdivisions, and they are pronounced in adding an epithet to the word which designates the specific character. Thus, celadon- or sea-green is a variety of green; gosling- (*serin*) green is another; sky-blue is a variety of blue, as sulphur-yellow is one of yellow. These distinctions cannot be mistaken as soon as we understand to pronounce the attributes of the specific colour according to the rules. But the difference between celadon-green and gosling-green is really greater than between sky-blue and celadon-green, and the same between gosling-green and sulphur-yellow: that is to say, the varieties of the same species differ more from each other than two species differ. This mode of distribution may suffice for the nomenclature, but by no means for the thing; it satisfies the ear, because the ear does not judge of colours.

The division of external characters into specific and generic characters, and characters of variety, places us in a new difficulty; for we here see a third principle of classification relative to minerals. We had the number of different characters, and the value of each character; now we have the intensity of these same characters. It is also impossible to see clearly how we ought to form species and varieties in minerals: if it is by the number solely, we exclude the importance of characters, and the shades are all of the same value; if we concede any thing to the importance, we must modify the rules respecting the number; and if the character of variety be sufficient to establish the mineralogical variety, as but one is wanting, What shall we do when it is a specific character which differs? How many characters of variety are equivalent to a specific character? How many to a generic? In all these, too, we must carefully avoid taking the least possible difference of characters to establish the mineralogical subdivision, which is not itself the smallest.

Unity of principle in a system of classification is that which tends most to give it precision. If we feel ourselves obliged to admit several principles, it loses this advantage,
unless

unless that the consistence of these principles be not so necessarily united as to prevent their separation. For example; if a certain colour was an inevitable consequence of the presence of a certain constituent part, we might adopt the colour as a principle of classification, at the same time with the presence or absence of this constituent part. But, in doing this, we would admit at bottom but one single principle as the basis of the system, since the existence of the one would necessarily imply that of the other. As M. Werner has admitted external characters to form the basis of his system, at the same time that he explicitly declares, that "all minerals which have essentially the same constituent parts both with respect to quality and quantity form the same species," we must suppose that he has discovered certain connexions which exist between these characters and the essential chemical composition of the same mineral. The results of chemical analysis, nevertheless, do not correspond with this supposition; and the science which unfolds the composition of minerals pronounces it in a manner that does not agree with our received ideas of the external characters. At the first glance over the classification of M. Werner, we may perceive the difficulty in which this contradiction involves us; for the desire of reconciling two things dissimilar in themselves, has introduced an uncertainty which prevails over all its parts. If we wish that this celebrated author should remain faithful to his principles, I see no other mode than to suppose that he takes the testimony of external characters as the index of the chemical composition, rather than the results of chemistry itself.

Other authors, who have published works according to the principles of M. Werner, tell us, that although this philosopher considers all minerals which correspond in external character and chemical composition, as belonging to the same species, he does not pretend that his arrangement should agree with the experiments of the chemist. This is to speak at hazard, and to avow frankly that he regards theoretical assertions as superior to experience, and the system which he has adopted as preferable to the principles of science. It would therefore only be when the chemical results agree with the external resemblances of minerals, that they could occupy a place in this system. We see sensible characters combined with chemical composition to determine a species; but if they do not agree with the results of chemistry, this science can be of no utility.

Such ideas will not be very generally received among those who have studied this science, nor even by those who are most disposed to discover its imperfections.

INCONSISTENCY AND UNCERTAINTY OF THE WERNERIAN
PLAN OF SPECIFICATION.

We now perceive the difficulty of reconciling the immense number of principles which this system has founded, and the contradictions which the minerals themselves must render unavoidable in whoever adopts them as a basis. Let us examine, in a few examples, if their celebrated author has been able to draw any uniform laws from them. Five things are to be known, viz.

1st. If all the minerals which have essentially the same chemical composition are ranged in the same species.

2dly. If all those which have an essential difference in their chemical composition are placed in different species.

3dly. If all the minerals which differ in more than three specific characters, whatever may be the number of those which they have in common, belong to different species.

4thly. If all those which do not differ in more than three different characters, are ranged in the same species. And,

5thly. If the minerals are always divided into genera, species, and varieties, according to their difference; that is to say, if those placed in separate genera always differ more from each other, than those which belong to species, or to different varieties, &c.

The relative condition in the 1st Art. is violated in the most striking manner by Werner's zirconian genus, which is divided into three species, and to which chemical analysis gives the same results. In corundum and adamantine spar we have two species * with the same chemical composition: it is the same in appatite, asparagus-stone and phospholite. Gypsum and *frauenëis* (selenite) are in a similar state; and carbonated lime presents us with no less than the alarming number of 14 species, which contain eight subspecies and six varieties.

In the 2d Art. we have beryl which contains glucine earth, and schorlous beryl which contains none, but which has instead of it fluoric acid. These minerals, without any

* Here the Wernerians make a distinction without a difference: corundum is used as synonymous with the adamantine spar of Kirwan, and imperfect corundum of Greville and Bournon; while diamond spar is made a distinct species, although forming only the subspecies *corindon harmophane* of Haüy, or adamantine corundum of Brogniart.—TRANS.

affinity in their chemical compositions, belong to the same species. (June 1805 *.)

I shall not stop to give examples proving that the 3d rule has been abused: it has been violated at almost every step. In the greater part of the minerals which are but varieties of the same species, if we examine them closely, we shall find more than three specific characters which are dissimilar. The division of characters into generic, specific, and characters of variety, and the little precision which exists in all that has been said on the number and importance of characters, render this examination irksome.

As to the 4th Art. I asked the celebrated author of the system of External characters, if there existed a sufficient disparity between the properties of sulphated barytes and sulphated strontian to constitute them two species; and he answered No. Here chemistry makes two genera where the external characters would not have two species.

For the 5th Art. there is not less difference between the garnet and pyrope, quartz and *eisenkiesel* [iron flint, Jameson], beryl and emerald, than between the common or compact feldspar and *hohlspath* (*macle* of the French), potter's clay and *schieferthon* [slate clay of Jameson, and *argile feuilletée* of Brogniart], mountain cork [*asbeste tressé* of Haüy, or *A. suberiforme* of Brogniart], and amianth, calcareous spar, pisolite [peastone of Jameson, and *chaux carbonatée concretionnée* of Haüy] and compact, common and fibrous limestone.

I have chosen only a few examples; but they are sufficient to prove that there is not one of the rules proposed to serve as a basis to the system which has not been infringed; sometimes one prevails, sometimes another; and we can only refer the consequent instability to the insufficiency of the principles.

PHILOSOPHERS AND PHILOSOPHY OF FREYBERG.

During a residence of 18 months at Freyberg, where I had every day occasion to admire the precision and accuracy with which the learned professor recognized minerals at the first view, and where I was more than ever convinced by the example of others of the difference which exists between the institution of species and the knowledge of individuals,

* Professor Jameson has even gone further, and divided, after Werner, beryl into two subspecies, calling the one "*first* subspecies, precious beryl" (beryl of Kirwan), and the other "*second* subspecies, shorlous beryl," the pycnite of Haüy, and shorlite of Kirwan; thus indicating a relation in numerical order which has no existence in nature.—TRANS.

I neglected no means of forming to myself a distinct idea of the former. Sometimes they spoke to me of the chemical composition; but when I cited the zircon and hyacinth, I was answered, that the external characters made the difference. If heavy spar and celestine were the subject, they again referred to chemistry. Often they spoke to me of approximate characters (*caractères des rapprochemens*), or characters of agreement and disagreement, of which no mention has been made in the enumeration; and they quoted to me, as a reason for placing potter's clay (*glaise*) and schistose argil in the same species, that both are disunited in water. To justify the separation of chalk from mineral agaric [rock milk, Jameson; and spongy carbonated lime, Haüy], of foaming earth [or schaum earth of Jameson, silvery chalk of Kirwan, talcous pearly carbonated lime of Haüy] from *schiefferspath* [slate spar of Jameson, argentine of Kirwan], they relied on the external characters; and to prove that *bitterspath* [muricalcite, Kirwan; *chaux carbonatée magnésifère*, Haüy; *chaux carbonatée lente picrite*, Brogniart] justly makes a species different from calcareous spar, they turned about to chemistry without daring openly to claim its support. Sometimes the colours were but shades or accidents; sometimes they offered characters of the highest importance. At other moments they confessed to me that *they made species by instinct*: and when I complained of not being satisfied with some conclusions indicated by this guide, they answered, "*One is not always in his instinct.*" Finally, after being detected in every manner, they referred the specification to the *tact* of the observer*. But, in this respect, who should venture to make species if not M. Werner alone?

If I have spoken of these details which I often collected

* True philosophers are deeply indebted to Mr. C. for this clear and manly exposition of a system not of science but of delusion worthy only of the lowest religious jugglers and fanatics. The "mineralogical instinct" is certainly a new faculty discovered in the human mind by the philosophers of Freyberg, whose ardent zeal in propagating their opinions furnishes a better proof of their passions than of their logic or reasoning powers. It may, perhaps, be laid down as a general truism, applicable in every branch of natural philosophy, that all schemes or systems of natural knowledge may be esteemed scientific or dogmatic just in proportion as their followers embrace them by reason or by passion. Science is properly a creature of reason, and modestly retires whenever the passions or affections appear: opinions, being originally suggested by the feelings, are naturally supported and propagated by the passions, while science can only be maintained and disseminated by close abstract reasoning. Hence it is not difficult to conceive why some of the more imprudent Wernerians have expressed themselves with so much violence against the volume containing the above statement of facts and reflections.—TRANS.

in conversation, and if I have quoted the words of other persons as well as M. Werner, it is to prove that in the *system of external characters there are no principles of specification which could serve as the basis of any science*; for, if there had been any, it is more than probable that some one would have been able to show me them; and, until that I receive a clear and distinct answer on this head, I shall be pardoned for believing and saying that there are none.

BASIS OF A SCIENTIFIC SYSTEM OF MINERALOGICAL SPECIFICATION.

If in the multitude of properties which distinguish bodies we are fortunate enough to find those which lead to a more certain and exact determination, let us hope that when properly unfolded they may be converted into principles, and that a science shall spring up from the whole. The precision of the terms which it shall employ will be the measure of its accuracy, and the definitions become its language.

The knowledge which we have hitherto acquired, furnishes us with two means of appreciating in bodies those qualities which escape the cognizance of our senses. These means are physical and chemical; they unite, to the advantage of being able to appreciate with more precision the properties which on the first view are but imperfectly discovered, that still greater, of developing the new properties which are only manifested by indirect means. Having seen the little success attending the system of immediately sensible properties, and the little hope which remains of improving it, since M. Werner has not been able to make it better, let us have recourse to the succour of these two sciences to establish mineralogical species.

Physics and chemistry furnish us two modes of attaining the final results of the division of bodies. Without entering into useless metaphysical discussions on infinity, we may suppose any substance whatever reduced to the finest and most imperceptible particles which the mind can imagine. This is the last point of physical division, and one of these grains presents us with the physical element of a body. Yet this element may be still very compound in another point of view, and undergo another species of division by means which are properly the province of chemistry. When the latter is also carried to its ultimate point, we obtain the chemical element. By physical element we understand that which occupies the smallest portion of space which we can conceive; chemical element supposes the least possible number of component principles.

The former eludes our senses by its extreme tenuity long before it has attained its limit; the latter would not be less correctly represented by a mountain of pure silica than by the smallest atom. The function of the one in nature is to aggregate itself in quantities more or less considerable to form masses, from those particles which we can perceive only by the aid of the microscope, to those enormous piles which we can scarcely embrace in imagination; the office of the other is to form bodies which we call compound: thus the simplicity of one of these elements does not affect the other. They have nothing in common, but as being the results to which we are led by the only two means of division hitherto known. We may affirm that in every case we can obtain these results, or that we cannot be obliged to take the limits of our knowledge for those of nature. This is sufficient; and we are not in opposition to philosophy, when, in making some efforts to advance towards the end, we substitute the one for the other; and when we find a representation, which in every thing essential resembles the object of research, we may dispense with a rigour which would in some respects be superfluous.

Hence, from the combination of these elements under different circumstances, results that infinite variety of nature which we call fantastical when we do not comprehend it; and it is by depriving the products of nature of the accidents which alter them, that we bring them back to that simplicity in which alone they are constant. What, then, remains for genius to do, but to investigate nature in a manner in which it cannot escape our researches, and to obtain unequivocal proofs, or else consider it in a state in which it ceases to be changeable?

**MECHANICO-CHEMICAL OR CRYSTALLOGRAPHICAL SYSTEM
OF HAÜY, AND HIS DEFINITION OF MINERALOGICAL
SPECIES.**

Now, what has the author of a mineralogical system founded on internal properties effected in our times? Instead of stopping at the surface, he has penetrated into the interior of the mineral, and a new world has presented itself to his contemplation. He has seen it in its simplicity, considered the elements which compose it, examined their habits and mutual relations, discovered the chain which in an invariable manner unites the final results of the only two means of division of which we know the possibility, and has defined the species. "The mineralogical species," says M. Haüy, "is a collection of minerals whose integral
molecules

molecules are similar, and composed of the same elements united in the same proportion." It is the assemblage of all the minerals which agree, with respect to the final results of division, in their physical and chemical molecules, in the true expression of nature reduced to its greatest simplicity*.

This definition of the mineralogical species is rigorous, and leaves nothing to be desired; but it requires a knowledge of the integral molecules. In the first place, it requires us to ascertain what its form is in all cases similar to itself: in the second place, we must be able to determine the nature and relations of its chemical elements. The first problem consists in finding the planes which terminate the small solid called the integral molecule, or, what amounts to the same thing, a solid which may resemble it; for it is not the absolute but the relative dimensions of this molecule which are required. But, the planes which terminate this solid can be but those which are parallel to the different directions in which a mineral is divisible without breaking, or what has been denominated the direction of the cleavage.

It is otherwise with the problem respecting the chemical element. We know that there exist vacuums between the molecules of bodies, and that even these vacuities are very considerable: hence it is that foreign matters have so often interposed themselves, and altered the sensible characters of a group of molecules or of a mass. Suppose that all the directions of the cleavage parallel to the planes which terminate the physical molecule are ascertained. Whatever may be the dimensions of the piece in which these directions are found, we have the representative of the molecule; but as these dimensions necessarily exceed those of the molecule itself, it follows that the piece contains more than one molecule, and hence foreign matters may deposit themselves in the interstices. Hitherto chemistry possesses only the means of distinguishing the simple parts which compose the physical elements from those which are interposed. Hence a source of uncertainty in the results of chemical analysis; and, in order that it may enjoy all the

* Most assuredly this conception, even were it devoid of basis, would do honour to the human intellect. Man is placed in the middle of the universe, as if to contemplate the infinite space which surrounds him. On whatever side he looks,—whether he contemplates those worlds whose volumes and remote distances are to him without measure, or whether he considers the atoms which form them and the laws by which these atoms are united, —every thing is to him infinite, and begets in his mind that sentiment of sublimity originating in a grandeur for which we have no expression.

confidence which the state of our knowledge should insure it, we should apply it only to the physical molecules which have been previously separated one by one to carry off the foreign matter interposed. But, as the true physical molecule is situated beyond our means, and the thought only can reach it, a knowledge of the chemical element would seem to be too remote for us ever to aspire to it. Nevertheless nature and labour offer us some means. First, it does not always happen that the physical molecules are embarrassed by foreign matter: next, suppose several minerals whose physical division gives, for instance, an irregular tetrahedron, but in all of uniform dimensions, and that chemistry finds in one the elements a, b, c, d, e ; in another, a, b, c, d ; in short, that d, e , and others if we please, may be variable, but that a, b, c , may be sensibly invariable in all the different pieces: now the species is unchangeable; therefore we have a right to conclude that a, b, c , are the chemical elements of the species, and that the others are accidental. It is thus that chemistry itself furnishes a method of correction which has been found sufficiently rigorous, and the two molecules are still in our power.

Taking the point in its most general sense; every time that we can discover in any mineral whatever the relative connexions of the simple component substances which have been observed to be invariable, as well as the relative dimensions of the solid which is produced by division in all the divers directions of the cleavage, we have every thing necessary to define a species. All minerals, however, do not present these data; and this principle of specification, however precise it may be, does not embrace the whole of the mineral kingdom.

Let us suppose a thousand individuals or mineral molecules of a single species suspended in the same solvent. By a diminution of the dissolving power, these individuals would tend to unite themselves in groups; it might then happen either that the molecules should assume such an arrangement as the aggregate would easily yield to mechanical division, whence we might extract the integral molecule of the species or its representative; or that the molecules might unite confusedly in an irregular mass, so that the type of the species could not be recognized. Again; if we suppose the molecules of several species in the same solvent, we shall have two analogous cases; the molecules of each species might unite to form aggregates of sensible dimensions, and afterwards concur in the formation of the mass, in which each species would be perfectly discernible;

ble; or, they might be so blended together in their origin, that in the mass which would be produced, it would be impossible to discover one simple species whose molecules had contributed to form it.

TRUE PRINCIPLES OF FORMING MINERALOGICAL SPECIES.

In the mineral kingdom, therefore, we must admit the following four conditions, arising from circumstances which have presided at the formation of minerals:

1st. Simple minerals whose molecule we are able to discover:

2d. Simple minerals whose molecule eludes our researches:

3d. Compound minerals in which the simple component minerals are discernible:

4th. Compound minerals in which we cannot distinguish the simple components.

Of these four conditions there is but the first which gives the species with strictness, and which truly appertains to science; but the others belong to nature, and must not be excluded from the method of classification. If, then, we find in any mineral, characters sufficiently marked to establish a well-founded opinion that it is of the same species with some one of the first section, we refer it by analogy to this, and consider it as belonging to the same species.

What is carbonated lime?—It is a mineral composed of 0.55 lime, and 0.45 carbonic acid, and which has for its molecule an obtuse rhomboid, whose great angle is $101^{\circ} 32' 13''$. Here is carbonated lime defined; and it is evident that in our principles a mineral which has these properties necessarily belongs to this species. What is compact carbonated lime?—It is a mineral whose chemical composition makes us presume with the utmost likelihood that it is of the same species as crystallized carbonated lime, and that it differs only in the circumstances under which it has been formed, not having permitted the symmetrical arrangement of its molecules, so that one might extract from the mass the solid, which it represents. Here the type is but presumed; and it is only after strong proof from analogy that we resolve to class in the species of carbonated lime, a substance which cannot be proved strictly to belong to it.

In granite, gneiss, and porphyry we distinguish the pieces of simple minerals of which they are composed. They appear to have enjoyed in their formation all the circumstances which could favour the union of the molecules of the same species

species together, to form masses of a perceptible magnitude. If the result appears to be invariable, at least in what relates to the general mode of aggregation, should it be every where the same, we shall be obliged to admit that nature here also works by immutable laws, and that we must find means to comprehend them in the system of science. These masses will therefore be mixed species, and appertain to geognosis; they will be strictly geognostic species, seeing that the simple minerals of which they are composed are so, that in their union they have observed invariable laws, and that it is no more difficult to pronounce on three species united, provided that the specific character be there distinctly visible, than on three species when they are separated.

The minerals in the fourth condition constitute the greatest difficulty in mineralogy. This science here finds its cryptogamia.

The analogy which led us to assign a place to the confused mixtures of molecules of one species, abandons us as soon as we wish to apply it to pieces which are composed of imperceptible molecules of divers species. In the supposition that we cannot discern those molecules of each species, it is impossible to refer the piece with propriety to any one. But if we observe in these masses the same constancy of character as in the mixtures of perceptible species, although we can demonstrate nothing in their constitution, we must assign them a place, and the appreciation of nature here be abandoned in some measure to the conscience of the observer. The first difficulty is to know what is the number of different species, the molecules of which have contributed to the formation of the mass. Suppose an aggregate in which we cannot discover any form of molecule, which at the same time effervesces with acids, and emits fire with steel, of which one part dissolves in muriatic acid, leaving carbonic acid gas to escape, while the other is entirely insoluble; that the dissolved part be lime, the other silica; To what species shall it be referred? Is it even possible to refer it to any? There is carbonated lime and silica, and our operations inform us that there has been a mixture of the two species. But this advantage, however weak it may be, no longer exists, if all the molecules which are found in the same mass act in the same manner with the same chemical and physical instruments; and we have no more resources to learn if it is composed of molecules of one species, of two, or of several. I shall cite the agate, jasper, hornstone, and the long list of species which
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are found in the argillaceous or clay genus of Werner, of which we are ignorant, and perhaps for ever shall be ignorant, to how many simple species they owe their origin. What do we know of the family of argillaceous schist, of serpentine, of *pierre ollaire* [potstone, Jameson; *talc ollaire*, Haüy, and *serpentine ollaire*, Brogniart], of pipe-clay, and of fuller's earth; except that we do not conceive why they have been made strictly species? Whenever a mineral gives no true representative of the species, and that we do not there find other physical or chemical properties to refer it with sufficient certainty to any whatever, in which it may be strictly admissible, it is better to make it a species of convention, in order to complete the outline which nature has traced.

DISTINCTION BETWEEN MINERALOGICAL SPECIES.

In this point of view, the species of the mineral kingdom should be divided into four sections, corresponding with the four conditions of which I have already spoken. The first should contain the species strictly so called (*espèces de rigueur*); the second, those by analogy; the third, those which I call geognostic; and the fourth, those of convention. All belong to nature; the first only appertains to science, if we wish to preserve to this word that idea of rigour which it necessarily carries with it.

The principle of M. Haüy embraces all those which are known in the first section, therefore this system embraces all the mineralogy which is capable of becoming a science.

The method of M. Werner extends to all the mineral kingdom. "Who embraces too much, badly binds," it is said: thus we know not what is a species, because all are species. We have a measure without unity.

I pretend not that the system of mineralogy should be subjected to the division indicated by these four sections; but if we wish to consider the bodies which compose this kingdom with respect to the rank which they ought strictly to occupy, we can no longer divide them otherwise; and even in classing them according to more essential principles, it would not be useless to mention this, in order that each individual may be estimated at its just value.

The advantages that mineralogy has derived from the philosophic spirit which directed the researches into the true type of the species, and the happy application of an exact method of determinating it, have been immense. All at once it is become a science; it is supported by fixed principles

principles susceptible of demonstration, and has resolved problems, enlightened futurity, and anticipated the results of analysis.

SYSTEM OF HAÜY AND WERNER CONTRASTED.

By a happy anticipation of chemistry, which has been confirmed by experiment, we owe to the system of latent properties the union of beryl with emerald, granatite with staurolite, as well as the separation of chabasie from analcime [both are denominated cubic zeolite by Werner and his disciple Jameson], stylbite [foliated zeolite, Jameson] from mesotype [radiated zeolite, Jameson], and the acaticone from thallite. It has left existing the harmony by which nature has united zircon, hyacinth, and zirconite; garnet and pyrope, quartz and *eisenkiesel* (iron flint). It has not made a mineralogical species of heliotrope, composed, according to Werner, who admits it as a species, of chalcedony and green earth, of prase, which consists of quartz and *strahlstein* [actinolite, Jameson; actinote, Haüy; amphibole actinote, Brogniart]. It has not placed sapphire and corundum in two different genera; but agreeing with chemistry, and renouncing prejudices, it has not classed a fossil entirely composed of alumine in the siliceous genus merely because it is hard. It has no repugnance to the admission of the diamond among combustibles. In the argillaceous genus, where the subdivisions are so little characterized, it has not made 32 species no more than 14 in carbonated lime, nor two in sulphated lime, or four in sulphated barytes; and above all, we have not 103 species in the earthy fossils. It has not transposed a mineral this year to the side of a species from which it was separated in the preceding, and which some months after will be chased from the side of its new neighbour to pursue its fortune elsewhere. It has not made different species, the one after the other, traverse the whole list of minerals, without being able to find where to fix themselves, like those importunate guests, who go every where and whom all persons evade. Its principles are fixed; and although it occupies more time to pronounce, it virtually decides sooner, as it disposes more surely and leaves nothing arbitrary. It neither makes distinctions without differences, approximations [*rap-prochemens*] without analogies, nor species without characters.

Notwithstanding, it will not pretend that minerals should persevere in retaining a rank which principles refuse them; nor will it deem the circumstance a misfortune, that the science

science varies in gaining new means of improving itself. Since the publication of his work, M. Haüy has already made considerable changes in his system, but all of them were foreseen and previously indicated, with the single exception of sphene, which he then knew only by some indistinct crystals. When one has laid down certain principles, the path of science is then found circumscribed, but its march is direct: if it change, it is only for a rational melioration, and it proceeds in advancing. If delivered to the current of opinions, or of hypotheses, it is discussed in every sense, and fortunate if it does not retrograde. For it there is no more surety, each one buffeting it at his pleasure. To reform is a great art, and to retouch without defacing requires great ability. Principles produce improvements, arbitrariness induces revolutions.

M. Haüy had formerly determined the molecule of *spargelstein* [asparagus-stone, the *chaux phosphatée chrysolithe* of Haüy and Brogniart] as well as that of apatite; but at an interval of several years, as the idea of comparing his results did not occur till M. Vauquelin had discovered that *spargelstein* is a phosphate of lime. Here chemistry was found to agree with crystallography.

A mineral was discovered, which some thought to be of the calcareous genus, which dissolved in acids without either effervescing or emitting fluoric acid, but which nevertheless gave traces of a combination with an acid; and M. Werner pronounced it a phosphate of lime. He was not deceived; but the difference which there is between reasoning and divining, is, to set out on a principle, or to start at hazard. Yet, even in setting out on a principle, we are not always sure of reasoning. Phosphorus in burning is phosphorescent and odorous; quartz when rubbed has the same properties; therefore silica is composed of phosphoric acid and lime. It is thus that a very celebrated German professor spoke, and he pretended to reason: his pretensions were so much the greater, that the combination of phosphoric acid and lime is neither phosphorescent nor odorous.

[To be continued.]

LVII. On the Decomposition of Water by Charcoal. By M. TORDEUX, Student of Chemistry in the Polytechnic School*.

IN the note at the end of the observations of M. Figuier, on the sulphurets contained in the soda of commerce, in a

* *Annales de Chimie*, tome lxxvi. p. 318.