GEORGES LOUIS LECLERC BUFFON

BUFFON'S NATURAL HISTORY. VOLUME X (OF 10)

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Buffon's Natural History. Volume X (of 10) Containing a Theory of the Earth, a General History of Man, of the Brute Creation, and of Vegetables, Minerals, &c. &c:

Содержание

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OF THE DEGENERATION OF ANIMALS

THE deer-kind whose horns are a sort of wood, and of a solid texture, although ruminating, and internally formed like those whose horns are hollow and porous, seem to form a separate family, in which the elk is the trunk, and the rein-deer, stag, axis, fallow-deer, and roe-buck, are the lesser and collateral branches; for there are only six species of animals whose heads are armed with branched horns that fall off and are renewed every year. Independently of this generic character, they resemble each other still more in formation and natural habitude; we should, therefore, sooner expect mules from the stag or fallow-deer, joined with the rein-deer or the axis, than from a union of the stag with the cow.

We might be still better authorised to regard all the different kinds of sheep and goats as composing but one family, since they produce together mules, which immediately, and in the first generation, ascend to the species of sheep. We might even add to this numerous family of sheep and goats those of the gazelles and bubalus, which are not less in number. The muflon, the wild goat, the chamois, the antelope, the bubalus, the condoma, &c. seem to be the principal trunks of this genus, which contains more than thirty different species, and the others are only accessory branches which have retained the principal characters of the stocks from which they issued; but which, at the same time, have prodigiously varied by the influence of the climate, the difference of the food, and by the state of slavery to which man has reduced most animals.

The dog, the wolf, the fox, the jackal, and the isatis, form another genus, the different species of which resemble each other so strongly, especially in their internal conformation, and in the organs of generation, that it is difficult to conceive why they do not intermix. From the experiments which I made to form a union of the dog with the wolf and fox, the repugnance to copulate seemed to proceed from the wolf and fox rather than from the dog, that is, from the wild animal and not from the tame; for those bitches which I put to the trial would readily have permitted the wolf and fox, whereas the females of the two latter would never suffer the approaches of the dog. The domestic state seems to render animals less faithful to their species: It gives them also a greater degree of heat and fecundity, for the bitch generally produces twice a year, while the females of the wolf and fox litter only once; and it is to be presumed, that those dogs which have been left in desert countries, and which have so greatly multiplied in the island of Juan Fernandes, and in the mountains of St. Domingo, &c. produce only once a year, like the wolf and the fox. This circumstance, if it were proved to be the fact, would fully establish the unity of genus in these three animals, which resemble each other in conformation so strongly as to oblige us to attribute their repugnance to some external circumstances.

The dog seems to be the intermediate species between the fox and the wolf. The ancients have stated, that the dog, in some countries, and under particular circumstances, engenders with the wolf and fox. I was desirous of verifying this assertion, and although I did not succeed in the trials I made, yet we must not conclude that it is impossible, for my experiments were with captive animals; and it is known that in some species captivity alone is sufficient to extinguish desire, and to give them a repugnance to copulation, even with their own kind; consequently they would still more refuse to unite with individuals of another species: but I am persuaded, that when in a state of freedom, and deprived of his own female, the dog would unite with the wolf and fox, particularly if he had become wild, lost his domestic cast, and approached the manner and natural habits of these animals. The fox and wolf, however, never unite, though they live in the same climate and country, but support their species pure and unmixed; we must, therefore, suppose a more ancient degeneration than history has recorded, if they ever belonged to one species; it was for this reason I asserted that the dog was an intermediate species between the fox and wolf; and his species is also common, since it can unite with both; and if any thing could shew that they all three originally sprang from the same stock, it is this common affinity between the dog, the fox, and the wolf, and which seems to bring their species nearer than all the conformities in their figures and organization. To reduce the fox and wolf, therefore, into one species, we must return to a state of nature very ancient indeed; but in their present condition, we must look upon the wolf and fox as the chief trunks in the genus of the five animals. The dog, the jackal, and the isatis, are only lateral branches placed between the two first; the jackal participates of the dog and wolf, and the isatis of the jackal and fox. From a great number of testimonies it appears that the jackal and the dog engender easily together; and it is observable, from the description and history of the isatis, that it almost entirely resembles the fox in its form and temperament, that they are equally found in cold countries, but that, at the same time, it inclines to the jackal in its disposition, continual barking, clamorous voice, and the habit of always going in packs.

The shepherd's dog, which I have considered as the original stock of every other dog, is, at the same time, that which approaches nearest in figure to the fox. He is of the same size, and, like the fox, he has erect ears, a pointed muzzle, and a strait trailing tail. He also approaches the fox in voice, sagacity, and instinct. The dog, therefore, may originally have been the issue of the fox, if not in a direct, at least in a collateral line. The dog, which Aristotle calls *canis-laconicus*, and which he affirms to have proceeded from an union of the fox and dog, might, possibly, be the same as the shepherd's dog, or, at least, it has more relation to him than to any other dog. We might, therefore, be inclined to imagine, that the epithet *laconicus*, left uninterpreted by Aristotle, was only given to this dog because he was found in Laconia, a province of Greece; and of which Lacedæmon was the capital; but if we attentively consider the origin of this *laconic* dog we shall perceive that the breed was not confined to the country of Laconia, alone but must have been found in every country where there were foxes; and this induces me to presume, that the epithet *laconicus* might possibly have been used by Aristotle in a moral sense, to express the brevity and acuteness of his voice, because he did not bark like other dogs, but had a shorter and shriller note, like that of the fox. Now our shepherd's dog is that to which we can justly apply this term of *laconic*, for of all dogs his voice is the sharpest and most rarely employed. Besides, the characters which Aristotle gives to his *laconic* dog agree with those of the shepherd's dog, and perfectly persuade me they are the same.

The genus of cruel and rapacious animals is one of the most numerous and most diversified; evils here, as in other cases, seem to be produced under every shape, and to assume various natures; the lion and the tiger, being detached species, rank in the first line; all the others, as the panther, the ounce, the leopard, the lynx, the caracal, the jaguar, the cougar, the ocelot, the serval, the margai, and the cat, compose only one cruel family, whose different branches are more or less extended and diversified according to the difference of climate. All these animals resemble each other in natural dispositions, although they are very different with respect to size and figure. They all have sparkling eyes, short muzzles, and sharp, crooked, and retractile claws. They are all destructive, ferocious, and untameable. The cat, which is the last and the least species, although reduced to slavery, continues its ferocity, and is no less perfidious. The wild cat has preserved the character of the family, and is as cruel and mischievous as any of his larger kindred. They are all equally carnivorous, and enemies to other animals. Man, with all his art and power, has not been able to annihilate them: fire, steel, poison, pits, and every method has been used against them without attaining that point. As the individuals are very prolific, and the species numerous, the efforts of man have been limited to keeping them at a distance, and confining them in the deserts, whence they never sally without spreading terror, and making great depredations. A single tiger issuing from the forest is sufficient to alarm a multitude of people, and oblige them to take up arms. What then would be the consequence if these sanguinary animals came in numbers, like wolves or jackals, to commit their depredations? Nature has given this instinct to timid animals, but fortunately denied it to the bold tribes; they go singly, and depend upon their courage and strength for their safety and support. Aristotle observed, and justly remarked, that of all animals furnished with talons not any of them are sociable, or go together in troops.[1] This observation, which was then confined to four or five species only, being all that were known in his time, is extended and verified over ten or twelve other species since discovered. Other carnivorous animals, such as the wolf, the fox, the dog, the jackal, and the isatis, whose claws are straight, go mostly in troops, and are all timid, and even cowardly.

By thus comparing every quadruped, and ranking each with its proper genus, we shall find, that the two hundred species of which we have given the history, may be reduced to a small number of families, or principal stems, from which it is not impossible all the others have derived their origin.

To place this reduction in a regular method, we shall observe that all the animals of the two continents, as well as all those peculiar to the Old World, may be reduced to fifteen genera, and

[1] Nullum animal cui ungues adunci, gregatile esse perpendimus. Arist. Hist. Anim. Lib. i. Cap. 1.

nine solitary species. These genera are, first, the whole hoofed genus, properly so called, which includes the horse, the zebra, and the ass, with all the prolific and barren mules. 2. The large cloven-hoofed with hollow horns, as the ox and the buffalo, with their varieties. 3. The small cloven-hoofed animals with hollow horns, such as the sheep, the goat, the gazelle, the antelope, and every other species which participates of their nature. 4. The cloven-hoofed with solid horns, which are shed and renewed every year; this family contains the elk, the rein-deer, the stag, the fallow-deer, the axis, and the roe-buck. 5. The ambiguous cloven-hoofed, which is composed of the wild boar, and all the varieties of the hog, such as that of Siam, with a hanging belly, that of Guinea, with long ears, pointed and turned backwards, and that of the Canary islands with thick and long tusks, &c. 6. The very extensive race of digitated carnivorous animals with crooked and retractile claws, in which we must comprehend the panther, leopard, guepard, ounce, serval, and cat, with all their varieties. 7. The digitated carnivorous animals with straight and fixed claws, which include the wolf, fox, jackal, isatis, and the dog, with all their varieties. 8. The digitated carnivorous animals with fixed claws, and a pouch under their tails. This consists of the hyæna, civet, zibet, badger, &c. 9. The digitated carnivorous animals with long bodies, five toes to each foot, and the great toe, or thumb, divided from the rest; this genus is composed of the ferret, martin, pole-cat, weasel, sable, ichneumon, &c. 10. The numerous family of digitated quadrupeds which have two large incisive teeth in each jaw, and no bristles on their bodies; this contains the hare, rabbit, and every kind of squirrels, dor-mice, marmots, and rats. 11. The digitated quadrupeds, whose bodies are covered with spiny quills, as the porcupine and hedge-hog. 12. The digitated animals covered with scales, as the long and short-tailed manis, or scaly lizards. 13. The amphibious digitated genus, which includes the beaver, otter, musk-rats, walrus, and seals. 14. The four-handed genus, which comprehends the apes, baboons, monkeys, makis, loris, &c. 15. The winged quadrupeds, which includes bats, &c. with all their varieties. The nine detached species are the elephant, rhinoceros, hippopotamus, giraffe, camel, lion, tiger, bear, and mole, which are all subject to a greater or smaller number of varieties.

Of those fifteen genera, and nine detached species, seven genera, and two species are common to both continents. The two species are, the bear and the mole; and the seven genera are, 1. The great cloven-hoofed with hollow horns, for the ox is found in America, under the form of the bison. 2. The cloven-hoofed, with solid horns, for the elk exists in Canada, under the name of original; the rein-deer, under that of caribou; and stags, fallow-deer, and roe-bucks, are found in all the provinces of North America. 3. The digitated carnivorous animals with fixed claws; for the wolf and fox are found in the New World as well as in the Old. 4. The digitated animals with long bodies, as the weasel, martin, and pole-cat, are met with in America as well as in Europe. 5. We find also in America, part of the digitated genus with two large incisive teeth in each jaw, as the squirrels, marmots, rats, &c. 6. The digitated amphibious genus, as the walrus, seal, beaver, and otter, exist in the North of the New Continent. 7. The winged genus exist also in America, as the bat and vampire.

There remains, therefore, only eight genera, and five detached species, which are peculiar to the Old Continent. These eight genera are, 1. The whole-hoofed, properly so called, for neither the horse, ass, zebra, nor mule, were met with in the New Continent. 2. The small cloven-hoofed beasts with hollow horns; for sheep, goats, gazelles, or antelopes existed in America. 3. The family of hogs; for the species of wild boar is not to be found in America; and although the pecari, and its varieties, are related to this family, yet they differ in a sufficient number of remarkable characters to justify their separation. 4. It is the same with carnivorous animals with retractile claws; we do not meet with either the panther, leopard, guepard, ounce, or serval, in America; and although the jaguar, couguar, ocelot, and margai, seem to belong to this family, there is not, one of these species of the New World found in the Old, nor one of the Old to be met with in the New. 5. The same remark may be applied to the digitated quadrupeds whose bodies are covered with prickles; for although the coendou and the urson approach very nigh to this genus, nevertheless, these species are very different from those of the porcupine and hedge-hog. 6. The digitated carnivorous genus with fixed claws, and a pouch under the tail; for the hyæna, civets, and the badger, do not exist in America. 7. The four-handed genus; for neither apes, baboons, monkeys, nor makis, have ever been seen in America. The sapajous, sagons, opossums, &c. although quadrumanous, yet they essentially differ from those of the Old Continent. 8. The digitated genus whose bodies are covered with scales; for none of the scaly lizards are found in America, and the ant-eaters, to whom they may be compared, are covered with hair, and differ too much from the scaly lizards to be considered of the same family.

Of the nine detached species, seven, namely, the elephant, rhinoceros, hippopotamus, giraffe, camel, lion, and tiger, are found only in the Old World; and two, viz. the bear and mole, are common to both continents.

If we, in the same manner, enumerate the animals which are peculiar to the New World, we shall find, that there are about fifteen different species which may be reduced to ten genera and four detached species. These four species are the tapir, the cabiai, the lama, and the pecari; but there is only the tapir we can absolutely term detached; for the pecari has varieties; and the pacos may be united to the lama, and the Guinea hog to the cabiai. The ten genera are, 1. Eight species of sapajous. 2. Six species of sagoins. 3. The opossums, phalangers, tarsiers, &c. 4. The jaguars, couguars, ocelots, margais, &c. 5. Three or four species of coatis. 6. Four or five species of mouffettes. 7. The agouti genus, which comprehends the acouchi, the paca, the aperea, and the tapeti. 8. That of the armadillos, which consists of seven or eight species. 9. Two or three species of ant-eaters; and, 10thly, The sloth, of which we are acquainted with but two species.

Now these ten genera, and four detached species, to which the fifty species of animals peculiar to the New World may be reduced, though they differ from those of the Old Continent, nevertheless have some relations which seem to indicate some common affinity in their formation, and lead us to causes of degeneration, more ancient than any of the rest. We have already made the general remark, that all animals of the New World were much smaller than those of the Old. This great diminution in size, whatever maybe the cause, is a primary kind of degeneration, which could not be made without having a great influence on the figure of the animal, and we must not lose sight of this effect in comparing them together.

The largest is the tapir, which though not bigger than the ass, can only be compared with the elephant, rhinoceros, and hippopotamus; he claims the first place for size in the New Continent, as the elephant does in the Old. Like the rhinoceros, his upper lip is muscular and projecting; and, like the hippopotamus, he often enters the water. In some respects he represents them all three, and his figure, which partakes more of the ass than of any other animal, seems to be as degraded as his stature is diminished. The horse, the ass, the zebra, the elephant, the rhinoceros, and the hippopotamus, had no existence in America; neither was there an animal in this New Continent which could be compared with them, either with respect to size or figure. The tapir appears to have some affinity to the whale, but he is so mixed, and approaches so little to any one of them, that it is not possible to attribute his origin to the degradation of any particular species. And, notwithstanding these trifling relations which he is found to have with the rhinoceros, the hippopotamus, and the ass, we must look on him not only as a peculiar species, but even as a single genus.

The tapir, therefore, does not belong to any species of the Old Continent, and scarcely does he bear any characters which approximate him to those animals with which we have just been comparing him. The nature of the cabiai is likewise averse from our comparison: externally he has no resemblance with any other animal, and only approaches the Indian hog of the same continent, by his internal parts, and both species are absolutely different from all those of the Old Continent.

The lama and the pacos appear to have more significant marks of their ancient parents: the first with the camel, and the second in the sheep. The lama, like the camel, has a long neck and legs, slender head, and the upper lip divided. He resembles the latter also by his gentle manners, servility of disposition, endurance of thirst, and aptness for labour. This was the first and most useful domestic animal of the Americans: they made use of him to carry burdens, in the same manner as the Arabs do the camel. Here therefore are sufficient resemblances in the nature of these animals, to which we can yet add the permanent marks of labour;

for though the back of the lama is not deformed by hunches like that of the camel, he, nevertheless, has callosities on his breast, occasioned by the like habit he is used to of resting on that part of his body. Yet, notwithstanding all these affinities, the lama is a very distinct and different species from the camel. He is much smaller, not exceeding a fourth or a third part of the camel's magnitude. The shape of his body, and the quality and colour of his hair, are also very different. His temperament is still more so; for he is a phlegmatic animal, and delights only to live on the mountains, whereas the camel is of a dry temperament, and willingly inhabits the most scorching sands. On the whole, there are more specific differences between the camel and the lama, than between the camel and the giraffe. These three animals have many characters in common, by which they might be referred to one genus, but, at the same time, they differ so much in other respects, that we cannot suppose them to be the issue of one another; they are, therefore, only neighbours and not relations. The height of the giraffe is nearly double that of the camel, and the camel double that of the lama. The two first belong to the Old Continent, and form separate species. The lama, therefore, which is only found in the New, must be a distinct species from both.

It is not the same with respect to the pecari, for though a different species from the hog, he, nevertheless, belongs to the same genus. He resembles the hog in shape, and every external appearance, and only differs from it in some trifling characters, such as the aperture on his back, shape of the stomach, intestines, &c. We might, therefore, be led to suppose that this animal sprung from the same stock as the hog, and that he formerly passed from the Old World to the New, where, by the influence of the soil, he had degenerated to so great a degree as now to constitute a distinct species.

With regard to the pacos, though it appears to have some affinities with the sheep, in its wool and habit of body, yet it differs so greatly in every other respect, that this species cannot be looked on either as neighbours or allies. The pacos is rather a small lama, and has not a single mark which indicates its having passed from one continent to the other. Thus of the four detached species peculiar to the New World, three, namely, the tapir, the cabiai, and the lama, with the pacos, appear to belong originally to this continent, whereas the pecari, which forms the fourth, seems to be only a degenerated species of the hog, and to have formerly derived its origin from the Old Continent.

By examining and comparing, in the same manner, the ten genera, to which we have reduced the other animals peculiar to South America, we shall discover, not only singular relations in their nature, but marks of their ancient origin and degeneration. The sapajous and sagoins bear so great a resemblance to the monkeys, that they are commonly included under that name. We have proved, however, that their species, and even their genera, are different. Besides, it would be very difficult to conceive how the monkeys of the Old Continent could assume in America a different-shaped visage, a long, muscular, and prehensile tail, a large partition between the nostrils, and other characters, both specific and generic, by which we have distinguished and separated them from the sapajous. But as the monkeys, apes, and baboons, are only found in the Old Continent, we must look upon the sapajous and sagoins as their representatives in the New, for these animals have nearly the same form, as well externally as internally, and also have many things in common in their natural habits and dispositions. It is the same with respect to the makis, none of which are found in America, yet they seem to be represented there by the opossums, or four-handed animals, with pointed muzzles, which are found in great numbers in the New Continent, but exist not in the Old. We must, however, observe, that there is much more difference between the nature and the form of the makis, and of these four-handed American animals, than between the monkeys and the sapajous; and that there is so great a distance between the opossums and the maki that we cannot form an idea that the one ever proceeded from the other, without supposing that degeneration can produce effects equal to those of a new nature; for the greatest number of these American four-handed animals have a pouch under the belly, ten incisive teeth in each jaw, and a prehensile tail; whereas the maki has a flaccid tail, no pouch under the belly, and only four incisive teeth in the upper jaw, and six in the lower; therefore, though all these animals have hands and fingers of the same form, and also resemble each other in the elongation of the muzzle, yet their species, and even their genera, are so different, that we cannot imagine them to be one and the same issue, or that such great and general disparities have ever been produced by degeneration.

On the other hand, the tigers of America, which we have indicated by the names of jaguars, couguars, ocelots, and margais, though different in species from the panther, leopard, ounce, guepard, and serval, of the Old Continent, are, nevertheless, of the same genera. All these animals greatly resemble each other, both externally and internally; they have also the same natural dispositions, the same ferocity, the same vehement thirst for blood, and what approximates them still nearer in genus, those which belong to the same continent differ more from each other than from those of the other Continent. For instance, the African panther differs less from the Brasilian jaguar than the latter does from the couguar, though they are natives of the same country. The Asiatic serval, and the margai of Guiana, likewise differ less from one another than from the species peculiar to their own continents. We, therefore, may justly suppose, that these animals had one common origin, and that, having formerly passed from one continent to the other, their present differences have proceeded only from the long influence of their new situation. The mouffettes, or stinkards, of America, and the pole-cat of Europe, seem to be of the same genus. In general, when a genus is common to both continents the species which compose it are more numerous in the Old than in the New; but in this instance it is quite the reverse, for there are four or five kinds of pole-cats in America, while we have only one, the nature of which is inferior to that of all the rest; so that the New World, in its turn, seems to have representatives in the Old; and if we judged only from the fact, we might think these animals had taken the opposite road, and passed from America to Europe. It is the same with respect to some other species. The roe-bucks and the fallow-deer, as well as the stinkards, are more numerous, larger, and stronger in the New Continent than in the Old; we might, therefore, imagine them to be originally natives of America; but as we cannot doubt that every animal was created in the Old Continent, we must, consequently, admit of their migration from the Old to the New World, and at the same time suppose, that instead of having degenerated, like other animals, they have improved their original nature by the influence of the soil and climate.

The ant-eaters, which are singular animals, and of which there are three or four species in the New World, seem also to have their representatives in the Old. The scaly lizards resemble them in the peculiar character of having no teeth, and of being obliged to put out their tongues and feed upon ants; but if we would suppose them to have one common origin, it is strange, that instead of scales, with which they are covered in Asia, they are clothed with hair in America.

With respect to the agoutis, pacos, and other animals of the seventh genus peculiar to the New Continent, we can only compare them with the hare and rabbit, from which, however, they all differ in species. What renders their being of a common origin doubtful is, the hare being dispersed almost over every climate of the Old Continent, without having undergone any other alteration than in the colour of its hair. We cannot, with any foundation, therefore, imagine that the climate of America has so far changed the nature of our hares to so great a degree as to make them tapetis or apereas, which have no tail; or agoutis with pointed muzzles, and short round ears; or pacos, with a large head, short ears, and a coarse hair marked with white stripes.

On the whole, the coatis, the armadillos, and the sloths, are so different, not only in species, but also in genus, from every animal of the Old World, that we cannot compare them with any one; it is also impossible to refer them to any common origin, or attribute to the effects of degeneration the prodigious differences found in their nature from that of every other animal.

Thus, of ten genera, and four detached species, to which we have endeavoured to reduce all the animals peculiar to the New World, there are only two, the genus of the jaguars, ocelots, &c. and the species of the pecari, with their varieties, which can with any foundation be connected with the animals of the Old Continent. The jaguars and ocelots may be regarded as a species of the leopard or panther, and the pecari as a species of hog. After these are five genera and one detached species, namely the species of the lama, and the genera of sapajous, sagoins, stinkards, agoutis, and ant-eaters, which may be compared, though in a very distant and equivocal manner, with the camel, monkey, pole-cat, hare, and scaly lizards. There then remain four genera and two detached species, namely, the opossums, the coatis, the armadillos, the sloths, the tapir, and the cabiai, which can neither be referred nor compared to any genera or species of the Old Continent. This sufficiently proves that the origin of these animals, peculiar to the New world, cannot be attributed merely to degeneration. However, great and powerful the effects of degeneration may be supposed, we cannot, with any appearance of reason, persuade ourselves that these animals were originally the same as those of the Old Continent. It is more reasonable to imagine that the two continents were formerly joined, and that those species which inhabited the New World, because they found the climate and soil most suitable to their nature, were separated from the rest by the irruption of the sea when it divided Asia from America. This is a natural cause, and similar ones might be conceived which would produce the same effect; for example, if the sea should make an irruption from the eastern to the western side of Asia, and thus separate the southern parts of Africa and Asia from the rest of the Continent, all the animals peculiar to the southern countries, such as the elephant, the rhinoceros, the giraffe, the zebra, the orang-outang, &c. would be, relatively to the others, the same as those of South America at present are; they would be entirely separated from the animals of the temperate countries, and could not be referred to an origin common to any of the species or genera which inhabit these countries, on the sole foundation that some imperfect resemblances, or distant relations, might be observed between them.

We must, therefore, to find out the origin of these animals, turn back to the time when the two continents were not separated, and refer to the first changes which happened on the surface of the globe. We must, at the same time, place before our view the two hundred species of quadrupeds as constituting thirty-eight families; and although this is not the state of nature, such as it is come down to us, and as we have represented it, but, on the contrary, a much more ancient state, which we can only attain by inductions and relations nearly as fugitive as time, which seems to have effaced their traces, we have endeavoured, by facts and monuments still existing, to return to those first ages of nature, and to exhibit those epochas which appear to be most clearly indicated.

AND PROPERTIES OF MINERALS, VEGETABLES, &c. LIGHT, HEAT, AND FIRE

ALL the powers of Nature with which we are acquainted, may be reduced to two primitive forces; the one which causes weight, and that which produces heat. The force of impulsion is subordinate to them; it depends on the first for its particular, and on the latter for its general effects. As impulsion cannot exercise itself but by the means of a spring, and the spring only acts by virtue of the force which approximates the remote parts, it is clear, that to perform its power it has need of the concurrence of attraction: for if matter ceased to attract, if bodies lost their coherence, every spring would be destroyed, every motion intercepted, and every impulsion void; since motion cannot transmit itself from one body to another but by elasticity, it is demonstrable, that one body absolutely hard and inflexible, would be absolutely immoveable, and entirely incapable of receiving the action of another. Attraction being a general and permanent effect, impulsion, which in most bodies is neither constant nor fixed, depends on it as a particular effect; for, if all impulsion were destroyed, attraction would still equally subsist and act; it is, therefore, this essential difference which makes impulsion subordinate to attraction in all inanimate and purely passive matter.

But this impulsion depends still more immediately, and generally, on the power which produces heat; for it is principally by the means of heat, that impulsion penetrates organized bodies; it is by heat that they are formed, grow, and develope themselves. We may refer to attraction alone all the effects of inanimate matter; and in this same power of attraction, joined to that of heat, every phenomena of live matter. By live matter I understand not only every thing that lives, or vegetates, but also every living organic molecule, dispersed in the waste or remains of organized bodies. In it I comprehend also light, heat, fire, and all matter which appears to be active in itself. Now this live matter always tends from the centre to the circumference, whereas brute or inanimate matter tends from the circumference to the centre. It is an expansive power which animates the live matter, and it is an attractive force to which the inanimate matter is obedient. Although the directions of these two powers be diametrically opposite, yet they balance themselves without ever being destroyed, and from the combination of these two powers equally active, all the phenomena of the universe result.

But it may be said, by reducing all the powers of Nature to attraction and expansion, without giving the cause of either, and by rendering impulsion, (which is the only force whose cause is known and demonstrated to our senses) subordinate to both, do you not abandon a clear idea, and substitute two obscure hypotheses in its place? To this I answer, that as we know nothing except by comparison, we shall never have an idea of what general effect will produce, because such an effect belonging to every thing, we should be unable to compare it to any, and consequently there is no hope of ever knowing the cause or reason why all matter attracts, although we are sensible such is the fact. If, on the contrary, the effect were particular, like that of the attraction of the loadstone and steel, we might expect to discover the cause, because it might be compared to other particular effects. To ask why matter is extended, heavy, and impenetrable, are ill-conceived propositions, and merit not an answer; it is the same with respect to every particular property, when it is essential to the subject, and we might as well be interrogated why red is red? The philosopher becomes a child when he puts such questions; and however much they may be forgiven to the last, the former ought to exclude them from his thoughts.

It is sufficient that the forces of attraction and expansion are two general, real, and fixed effects, for us to receive them for causes of particular ones; and impulsion is one of these effects, which we must not look upon as a general cause, known and demonstrated by our senses, since we have proved that this force of impulsion cannot exist nor act, but by the means of attraction, which does not fall upon our senses. Nothing is more evident, nay, certain, than the communication of motion by impulsion; it is sufficient for one body to strike another to produce this effect. But even in this sense, is not the cause of attraction most evident, and that motion, in all cases, belongs more to attraction than impulsion?

The first reduction being made, it might perhaps be possible to adduce a second, and to bring back the power even of expansion to that of attraction, insomuch that all the forces of matter would depend solely on a primitive one; at least this idea seems to be worthy of that sublime simplicity with which nature works. Now cannot we conceive that this attraction changes into repulsion every time that bodies approach near enough to rub together, or strike one against the other? Impenetrability, which we must not regard as a force, but as a resistance essential to matter, not permitting two bodies to occupy the same place, what must happen when two molecules, which attract the more powerfully as they approach nearer, suddenly strike against each other? Does not then this invincible resistance of impenetrability, become an active force, which, in the contact, drives the bodies with as much velocity, as they had acquired at the moment they touched? And from hence the expansive force will not be a particular force opposed to the attractive one, but an effect derived therefrom. I own, that we must suppose a perfect spring in every molecule, and in every atom of matter, to have a clear conception how this change of attraction into repulsion is performed. But even this is sufficiently indicated by facts; the more matter is attenuated, the more it takes a spring. Earth and water, which are the most gross aggregates, have a less spring than air; and fire, which is the most subtle of all the elements, is also that which has the most expansive force. The smallest molecules of matter, the smallest atoms with which we are acquainted are those of light, and we are sensible of their being perfectly elastic, since the angle under which the light is reflected, is always equal to that under which it comes. We may therefore infer, that all the constitutive parts of matter in general, are a perfect spring; and that this spring produces all the effects of the expansive force, every time that bodies strike by meeting in opposite directions.

We know of no other means of producing fire, but by striking or rubbing bodies together[2]; since by supposing man without any burning glasses, and without actual fire, he will have no other means of producing it; for the fire produced by uniting the rays of light, or by application of fire already produced, had the same origin.

Expansive force, therefore, in reality might be only the re-action of the attractive, a reaction which operates every time that the primitive molecules of matter, always attracted one by the other, happen immediately to touch; for then it is necessary, that they be repelled with as much velocity as they had acquired in a contrary direction, at the moment of contact; and when these molecules are absolutely free from all coherence and only obey the motion alone produced by their attraction, this acquired velocity is immense in the point of contact. Heat, light, and

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[2] The fire, which arises from the fermentation of herbs heaped together, and which manifests itself in effervescences, is not an exception that can be opposed to me, since this production of fire depends, like all the rest, from the action of the shock of the parts of matter one against the other.

fire, which are the greatest effects of expansive force, will be produced every time that bodies are either artificially or naturally divided into very minute parts, and meet in opposite directions; and the heat will be so much the more sensible, the light so much the more bright, the fire so much the more violent, according as the molecules are precipitated one against the other with more velocity by their force of mutual attraction.

From the above it must be concluded, that all matter may become light, heat, and fire; and that this matter of fire and light is not a substance different from every other, but preserves all its essential qualities; and even most of the attributes of common matter, is evidently proved by, first, light, though composed of particles almost infinitely minute, is, nevertheless, still divisible, since with the prism we separate the rays, or different coloured atoms one from another. Secondly, light, though in appearance endowed with a quality quite opposite to that of weight, that is, with a volatility which we might think essential, is, nevertheless, heavy like all matter, since it bends every time it passes near other bodies, and finds itself inclined to their sphere of attraction. It is very heavy, relatively to its volume, which is very minute, since the immense velocity with which light moves in a direct line, does not prevent it from feeling sufficient attraction near other bodies, for its direction to incline and change in a manner very sensible to our eyes. Thirdly, the substance of light is not more simple than all other matter, since it is composed of parts of unequal weight; the red rays are much heavier than the blue; and between these two extremes there are an infinity of intermediate rays, which approach more or less the weight of the red, or the lightness of the blue according to their shades. All these consequences are necessarily derived from the phenomena of the inflection of light, and of its refraction, which, in reality, is only an inflexion which operates when light passes across transparent bodies. Fourthly, it may be demonstrated, that light is massive, and that it acts, in some cases, as all other bodies act; for, independently of its ordinary effect, which is to shine before our eyes, and by its own action, always accompanied with lustre, and often with heat, it acts by its mass when it is condensed, and it acts to the point of putting in motion heavy bodies placed in the focus of a good burning glass: it turns a needle on a pivot placed in its focus: it displaces leaves of gold or silver before it melts or even sensibly heats them. This action, produced by its mass, precedes that of heat: it operates between the condensed light and the leaves of metal in the same manner as it operates between two other bodies which become contiguous, and, consequently, have still this property in common with all other matter. Fifthly, light is a mixture, like common matter, not only of more gross and minute parts, more or less heavy or moveable, but also differently shaped. Whoever has observed the phenomena which Newton calls *the access of easy reflection*, and of *easy transmission of light*; and on the effects of double refraction of rock and Iceland chrystal, must have perceived that the atoms of light have many sides, many different surfaces, which, according as they present themselves, constantly produce different effects.

This, therefore, is sufficient to demonstrate that light is neither particular nor different from common matter; that its essence, and its essential properties are the same; and that it differs only from having undergone, in the point of contact, the repulsion whence its volatility proceeds; and in the same manner as the effect of the force of attraction extends, always decreasing as the space augments, the effects of repulsion extend and decrease the more, but in an inverted order, insomuch that we can apply to the expansive force all that is known of the attractive. These are two instruments of the same nature, or rather the same instrument, only managed in two opposite directions.

All matter will become light, for if all coherence were destroyed it would be divided into molecules sufficiently minute, and these molecules, being at liberty, will be determined by their mutual attraction to rush one against the other. In the moment of the shock the repulsive force will be exercised, the molecules will fly in all directions with an almost infinite volatility, which, nevertheless, is not equal to their velocity acquired in the moment of contact, for the law of attraction being augmented as the space diminishes, it is evident, that at the contact the space is always proportionable till the square of the distance becomes nil, and, consequently, the velocity acquired by virtue of the attraction must at this point become almost infinite: and it would be perfectly so if the contact were immediate, and, consequently, the distance between the two bodies void; but there is nothing in nature entirely nil, and nothing truly infinite; and all that I have observed of the *infinite* minuteness of the atoms which constitute light, of their *perfect* spring, and of the *nil* distance in the moment of contact, must be understood only relatively. If this metaphysical truth were doubted, a physical demonstration may be given. It is pretty generally known that light employs seven minutes and a half to come from the sun to the earth; supposing, therefore, the sun at thirty-six millions of miles, light darts through this enormous distance in that short space, that is (supposing its motion uniform), 80,000 miles in one second. But this velocity, although prodigious, is yet far from being infinite, since it is determinable by numbers. It will even cease to appear so prodigious, when we reflect on the celerity of the motion of the comets to their perihelia, or even that of the planets, and by computing that, we shall find that the velocity of those immense masses may pretty nearly be compared to that of the atoms of light.

So, likewise, as all matter can be converted into light by the division and expulsion of its parts, when they feel a shock one against another, we shall find that all the elements are convertible; and if it have been doubted whether light, which appears to be the most simple element, may be converted into a solid substance, it is because we have not paid sufficient attention to every phenomena, and were infected with the prejudice, that being essentially volatile it can never become fixed. But it is plain that the fixity and volatility depend on the same attractive force in the first case, and become repulsive in the second; and from thence are we led to think that this change of matter into light, and from light into matter, is one of the most frequent operations of Nature.

Having shewn that impulsion depends on attraction; that the expansive force, like the attractive, becomes negative; that light, heat, and fire, are only modes of the common existing matter; in one word, that there exists but one sole force, and one sole matter, ever ready to attract or repel, according to circumstances; let us see how, with this single spring, and this single subject, Nature can vary her works, *ad infinitum*. In a general point of view, light, heat, and fire, only make one object, but in a particular point of view they are three distinct objects, which, although resembling in a great number of properties, differ nevertheless in a few others, sufficiently essential for us to consider them as three distinct things.

Light, and elementary fire, compose, it is said, only one and the same thing. This may be, but as we have not yet a clear idea of elementary fire we shall desist from pronouncing on this first point. Light and fire, such as we are acquainted with, are two distinct substances, differently composed. Fire is, in fact, very often luminous, but it sometimes also exists without any appearance of light. Fire, whether luminous or obscure, never exists without a great heat, whereas light often burns with a noise without the least sensible heat. Light appears to be the work of nature while fire is only the produce of the industry of man. Light subsists of itself, and is found diffused in the immense space of the whole universe. Fire cannot subsist without food, and is only found in some parts of this space where man preserves it, and in some parts of the profundity of the earth, where it is also supported by suitable food. Light when condensed and united by the art of man, may produce fire, but it is only as much as it lets fall on combustible matters. Light is therefore no more, and in this single instance, only the principle of fire and not the fire itself: even this principle is not immediate, for it supposes the intermediate one of heat, and which appears to appertain more than light to the essence of fire. Now heat exists as often without light as light exists without heat: these two principles might, therefore, appear not to bind them necessarily together; their effects are not contemporary, since in certain circumstances we feel heat long before light appears, and in others we see light long before we feel any heat. Hence is not heat a mode of being, a modification of matter, which, in fact, differs less than all the rest from that of light, but which can be considered apart, and still more easily conceived? It is, nevertheless, certain, that much fewer discoveries have been made on the nature of heat than on that of light; whether man better catches what he sees than what he feels; whether light, presenting itself generally as a distinct and different substance from all the rest, has appeared worthy of a particular consideration; whereas heat, the effect of which is the most obscure, and presents itself as a less detached and less simple object, has not been regarded as a distinct substance but as an attribute of light and fire.

The first thing worthy of remark, is, that the seat of heat is quite different from that of light: the latter occupies and runs through the void space of the universe; heat, on the contrary, is diffused through all solid matter. The globe of the earth, and the whole matter of which it is composed, have a considerable degree of heat. Water has its degree of heat which it does not lose but by losing its fluidity. The air has also heat, which we call its temperature, and which varies much, but is never entirely lost, since its springs subsist even in the greatest cold. Fire has also its different degrees of heat, which appear to depend less on its own nature, than on that of the aliments which feed it. Thus all known matter possesses warmth; and, hence, heat is a much more general affection than that of light.

Heat penetrates every body without exception which is exposed to it, while light passes through transparent bodies only, and is stopped and in part repelled, by every opaque one. Heat, therefore acts in a much more general and palpable manner than light, and although the molecules of heat are excessively minute, since they penetrate the most compact bodies, it seems, however, demonstrable, that they are much more gross than those of light; for we make heat with light, by collecting it in a great quantity. Besides, heat acting on the sense of feeling, it is nececssary that its action be proportionate to the grossness of this sense, the same as the delicacy of the organs of sight appears to be to the extreme fineness of the parts of light; these parts move with the greatest velocity, and act in the instant at immense distances, whereas those of heat have but a slow progressive motion, and only extend to small intervals from the bodies whence they emanate.

The principle of all heat seems to be the attrition of bodies; all friction, that is, all contrary motion between solid matters produces heat; and if the same effect do not happen to fluids, it is because their parts do not touch close enough to rub one against the other; and that, having little adherence between them, their resistance to the shock of other bodies is too weak for the heat to be produced to a sensible degree; but we often see light produced by an attrition of a fluid, without feeling any heat. All bodies whether great or little become heated as soon as they meet in a contrary direction; heat is, therefore, produced by the motion of all palpable matter; while the production of light, which is also made by motion, but in a contrary direction, supposes also the division of matter into very minute parts: and as this operation of Nature is the same with respect to both, we must conclude, that the atoms of light are solid of themselves, and are hot at the moment of their birth. But we cannot be equally certain, that they preserve their heat in the same degree as their light, nor that they cease to be hot before they cease to be luminous.

It is well known, that heat grows less, or cold becomes greater, the higher we ascend on the mountains. It is true that the heat which proceeds from the terrestrial globe, is of course sensibly less on those advanced points, than it is on the plains; but this cause is not proportionable to the effect; the action of heat, which emanates from the terrestrial globe, not being able to diminish but by the square of the distance, it does not appear that at the height of half a mile, which is only the three thousandth part of the semi-diameter of the globe, whose centre must be taken for the focus of heat, that this difference, which in this supposition is only a unit and nine millions, can produce a diminution of heat nearly so considerable; for the thermometer lowers at that height, at all times of the year, to the freezing point. It is not probable, that this great difference of heat simply proceeds from the difference of the earth; and of that we must be fully convinced, if we consider, that at the mouth of the volcanos, where the earth is hotter than in any other part on the surface of the globe, the air is nearly as cold as on other mountains of the same height.

It may then be supposed that the atoms of light, though very hot at the moment of quitting the sun, are greatly cooled during the seven minutes and a half in which they pass from that body to the earth; and this in fact would be the case if they were detached; but, as they almost immediately succeed each other, and are the more confined as they are nearer the place of their origin, the heat lost by each atom falls on the neighbouring ones; and this reciprocal communication supports the general heat of light a longer time; and as their constant direction is in divergent rays, their distance from each other increases according to the space they run over; and as the heat which flies from each atom, as a centre, diminishes also in the same ratio, it follows, that the light of the solar rays, decreasing in an inverted ratio from the square of the distance, that of their heat decreases in an inverted ratio of the square of the same distance.

Taking therefore the semi-diameter of the sun for a unit, and supposing the action of light to be as 1000 to the distance of a demi-diameter of the surface of this planet, it will not be more than as 1000/4 to the distance of two demi-diameters; as 1000/9 to that of three demi-diameters, as 1000/16 to the distance of four demi-diameters; and finally, when it arrives at us, who are distant from the sun thirty-six millions of leagues, that is about two hundred and twenty-four of its demi-diameters, the action of light will be no more than as 1000/50625, that is, more than 50,000 times weaker than at its issuing from the sun; and the heat of each atom of light being also supposed 1000 at its issuing from the sun, will not be more than as 1000/16 1000/81 1000/256 to the successive of 1, 2, 3, demi-diameters, and, when arrived at us, as 1000/2562890625 that is, more than two thousand five hundred millions of times weaker than at issuing from the sun.

If even this diminution of the heat of light should not be admitted by reason of the squared square of the distance to the sun, it will still be evident that heat, in its propagation, diminishes more than light. If we excite a very strong heat, by kindling a large fire, we shall only feel it at a moderate distance but we shall see the light at a very great one. If we bring our hands by degrees nearer and nearer a body excessively hot, we shall perceive that the heat increases much more in proportion than as the space diminishes; for we may warm ourselves with pleasure at a distance which differs only by a few inches from that at which we should be burnt. Every thing, therefore, appears to indicate, that heat diminishes in a greater ratio than light, in proportion as both are removed from the focus whence they issued.

This might lead us to imagine, that the atoms of light would be very cold when they came to the surface of our atmosphere; but that by traversing the great extent of this transparent mass, they receive a new heat by friction. The infinite velocity with which the particles of light rub against those of the air, must produce a heat so much the stronger as the friction is more multiplied: and it is, probably, for this reason, that the heat of the solar rays is found much stronger in the lower parts of the atmosphere, and that the coldness of the air appears to augment as we are elevated. Perhaps, likewise, as light receives heat only by uniting, a great number of atoms of light is required to constitute a single atom of heat, and this may be the cause why the feeble light of the moon, although in the atmosphere, like that of the sun, does not receive any sensible degree of heat. If, as M. Bouguer says, the intensity of the light of the sun to the surface of the earth is 300,000 times stronger than that of the moon, the latter must be almost insensible, even by uniting it in the focus of the most powerful burning glasses, which cannot condense it more than 2000 times; subtracting the half of which for the loss by reflexion or refraction, there remains only a 300dth part intensity to the focus of the glass.

Thus, we must not infer that light can exist without any heat, but only that the degrees of this heat are very different, according to different circumstances, and always insensible when light is very weak. Heat, on the contrary, seems to exist habitually, and even to cause itself to be strongly felt without light; for in general it is only when it becomes excessive, that light accompanies it. But the very essential difference between these two modifications of matter is, that heat, which penetrates all bodies, does not appear to fix in any one, whereas light incorporates and extinguishes in all those which do not reflect, or permit it to pass freely; heat bodies of all kinds to any degree, in a very short time they will lose the acquired heat, and return to the general temperature. If we receive light on black or white bodies, rude or polished, it will easily be perceived, that some admit, and others repel it; and that instead of being affected in a uniform manner as they are by heat, they are only so relatively to their nature, colour, and polish. Black will absorb more light than white, and the rough more than the smooth. Light once absorbed remains fixed in the body which received it, nor quits it like heat; whence we must conclude, that atoms of light may become constituent parts of bodies by uniting with the matter which composes them; whereas heat not fixing at all, seems to prevent the union of every part of matter, and only acts to keep them separate. Nevertheless, there are instances where heat remains fixed in bodies, and others where the light they have absorbed re-appears, and goes out like heat.

After all there appear to be two kinds of heat, the one luminous, of which the sun is the focus; the other obscure, of which the grand reservoir is the terrestrial globe. Our body, as making part of the globe, participates of this obscure heat; and it is for this reason, that it is still obscure to us, because we do not perceive it by any one of our senses. It is with respect to this heat of the globe, as with its motion, we are subject to and participate thereof without feeling or doubting of it: from hence it happened that physicians at first carried all their views and enquiries on the heat of the sun, without suspecting that it makes but a very small part of what we really feel; but having made instruments to discover the difference of the immediate heat of the rays of the sun, they with astonishment found that the heat of them was sixty-six times stronger in summer than in winter, notwithstanding the strongest heat of our summer differs only a seventh from the strongest cold of our winter; from whence they have concluded, that, independent of the heat we receive from the sun, there emanates another, even from this terrestrial globe, which is much more considerable; insomuch, that it is at present demonstrable, that this heat, which escapes from the bowels of the earth, is in our climate at least twenty-nine times in summer, and four hundred times in winter, stronger than the heat which comes to us from the sun.

This strong heat which resides in the interior part of the globe, and which, without ceasing to emanate externally, must, like an element, enter into the combination of all the other elements. If the sun is the parent of Nature, the heat of the earth must be the mother; they both unite to produce, support, and animate organized beings, and to assimilate and compose inanimate substances. This internal heat of the globe, which tends always from the centre to the circumference, is, in my opinion, a great agent in nature. We can scarcely doubt but it is the principal influence on the perpendicularity of the trunks of trees, on the phenomena of electricity, on the effects of magnetism, &c. But as I do not pretend to make a physical treatise here, I shall confine myself to the effects of this heat on the other elements. It is alone sufficient to maintain the rarefaction of the air to the degree that we breathe in: it is more than sufficient to keep water in its state of fluidity, for we have lowered the thermometers to the depth of 120 fathoms, and have found the temperature of the water was there nearly the same as at the like depth in the earth, namely, ten degrees two thirds. We must not, therefore, be surprized, especially as salt acts as a prevention, that the sea in general does not freeze, that fresh water freezes but to a certain thickness, and that the water at bottom always remains liquid, even in the most intense frosts.

But of all the elements the earth is that on which this internal heat must necessarily have produced, and still produces the greatest effects. This heat originally was doubtless much greater than it is at present; therefore we must refer to it, as to the first cause, all the sublimations, precipitations, aggregations, and separations, which have been, and still continue to be made in the internal part of the globe, especially in the external layer which we have penetrated, and the matter of which has been removed by the convulsions of Nature, or by the hands of man. The whole mass of the globe having been melted, or liquefied, by fire, the internal is only a concrete or discreet glass, whose simple substance cannot receive any alteration by heat alone; there is, therefore, only an upper and superficial layer, which being exposed to the action of external causes united to that of the internal heat, will have undergone all the modifications, differences, and forms, in one word, of Mineral Substances, which their combined actions were enabled to produce.

Fire, which at first sight appears to be only a compound of heat and light, might also be a modification of the matter, though it does not essentially differ from either, and still less from both taken together. Fire never exists without heat, but it can exist without light. Heat alone, deprived of all appearance of light, can produce the same effects as the most violent fire; so can also light, when it is united. Light seems to carry a substance in itself which has no need of fuel; but fire cannot subsist without absorbing the air, and it becomes more violent in proportion to the quantity it absorbs; whereas light, concentrated and received into a vessel exhausted of air, acts as fire in air; and heat, confined and retained in a narrow space, subsists and even augments with a very small quantity of food. The most general difference between fire, heat, and light, appears, therefore, to consist in the quantity, and perhaps quality, of their food.

Air is the first food of fire; combustible matters are only the second. It has been demonstrated, by experiments, that a little spark of fire, placed in a vessel well closed, in a short time absorbs a great quantity of air, and becomes extinguished as soon as the quantity or quality, of this food becomes deficient. By other experiments it is proved, that the most combustible matters will not consume in vessels well closed, although exposed to the action of the greatest fire. Air is, therefore, the first and true food of fire, and combustible matters would not be able to supply it without the assistance and mediation of this element.

We have observed that heat is the cause of all fluidity, and we find, by comparing some fluids together, that more heat is requisite to keep iron in fusion than gold; and more to keep gold than tin; much less is necessary for wax, for water less than that, and still less for spirits of wine, and a mere trifle is sufficient for mercury, since the latter goes 187 degrees below what water can without losing its fluidity; mercury, therefore, is the most fluid of all matter, air excepted. Now this superior fluidity in air indicates the least degree of adherence possible between its constituting parts, and supposes them of such a figure as only to be touched at one point. It may be also imagined, that, being endowed with so little apparent energy and mutual attraction, they are, for that reason, less massive, and more light, than those of every other body; but that conclusion appears unfounded, from the comparison of mercury, the next fluid body, but of which the constituting parts appear to be more massive and heavy than those of any other matter, excepting gold. The greater or lesser fluidity, does not, therefore, indicate that the parts of the fluid are more or less weighty, but only that their adherence is so much the less, and their separation so much the easier.

Air, therefore, of all known matter, is that which heat divides the easiest, and is very near the nature of fire, whose property consists in the expansive motions of its parts; and it is from this similarity that air so strongly augments the activity of fire, to which it is the most powerful assistant, and the most intimate and necessary food. Even combustible matters will not keep it alive if deprived of air, for under this privation the most intense fire will not burn; but a single spark of air is sufficient to kindle them, and in proportion as it is supplied with that element the fire becomes strong, extended, and devouring.

Artificial phosphorus, and gunpowder, seem, at first, to be an exception, for they have no need of the assistance of renewed air to inflame and wholly consume them: their combustion may be performed in the closest vessels, but that is because those matters, which are also the most combustible, contain the necessary quantity of air in their substance, therefore they have no need of the assistance of foreign air.

This seems to indicate that the most essential difference between combustible matters and those which are not so, consists in the latter containing only a few or none of the light, ethereal, and oily matters susceptible of an expansive motion, or, at least, if they contain them, that they are fixed, so that they cannot exercise their volatility whenever the force of the fire is not strong enough to surmount the force of adhesion which retains them united to the fixed parts of matter. It may be said that this induction is confirmed by a number of observations well known to chemists; but what appears to be less so, and which, nevertheless, is a necessary consequence of it, is, that all matter may become volatile when the expansive force of the fire can be rendered superior to the attractive force which holds the parts of matter united; for though to produce a fire sufficiently strong it may require better constructed mirrors than any at present known, yet we are certain that fixity is only a relative quality, and that there is no matter absolutely so, since heat dilates the most fixed bodies. Now is not this dilation the index of a beginning separation, that may be augmented with a degree of heat to fusion, and with a still greater heat to volatilisation?

Combustion supposes something more than volatilisation; it is not sufficient that the parts of matter be sufficiently separated to be carried off by those of heat; they must also be of an analogous nature to fire; without that, mercury, being the most fluid next to air, would also be the most combustible, whereas experience demonstrates, that though very volatile it is not combustible. Matter is, in general, composed of four principal substances, called *elements*, that is, earth, water, air, and fire. Those in which earth and water predominate will be fixed, and will only become volatile by the action of heat; and those which contain most air and fire will be the only real combustibles. The great difficulty here is clearly to conceive how air and fire, both so volatile, can fix and become constituent parts of all bodies.

Fire, by absorbing air, destroys the spring. Now there are but two methods of destroying a spring, either by compressing it till it breaks, or extending it till it loses its effect. It is plain that fire cannot destroy air by compression, since the least degree of heat rarefies it; on the contrary, by a very strong heat the rarefaction of the air will be so great that it will occupy a space thirteen times more extended than that of its general volume; and by this means the spring becomes weakened, and it is in this state that it can become fixed, and unite with other bodies.

Light, which falls on bodies, is not merely reflected, but remains in quantities on the small thickness of the surface which it strikes; consequently it loses its motion, extends, is fixed, and becomes a constituent part of all that it penetrates. Let us add this light, transformed and fixed in bodies, to the above air, and to both, the constant and actual heat of the terrestrial globe, whose sum is much greater than that which comes from the sun, and then it will appear to be not only one of the greatest springs of the mechanism of Nature, but an element with which the whole matter of the globe is penetrated.

If we consider more particularly the nature of combustible matters, we shall find, that they all proceed originally from vegetables and animals; in a word, from bodies placed on the surface of the globe, which the sun enlightens, heats, and vivifies. Wood, bitumen, resins, coals, fat and oil, by expression, wax, and suet, are substances proceeding immediately from animals and vegetables. Turf, fossil, coal, amber, liquid, or concrete bitumens, are the productions of their mixture, and their decom position, whose ulterior waste forms sulphurs, and the combustible parts of iron, tin, pyrites, and every inflammable mineral. I know, that this last assertion will be rejected by those who have studied nature only by the mode of chemistry; but I must request them to consider, that their method is not that of nature, and that it cannot even approach it without banishing all those precarious principles, those fictitious beings which they play upon, without being acquainted with them.

But, without pressing longer on those general considerations, let us pursue in a more direct and particular manner the examination of fire and its effects. The action of fire depends much on the manner in which it is applied; and the effects of its motion, on similar substances, will appear different according to the mode in which it is administered. I conceive that fire should be considered in three different states, first relative to its velocity; secondly, as to its volume; and thirdly, as to its mass. Under each of these points of view, this element, so simple, and so uniform to all appearance, will appear extremely different. The velocity of fire is augmented without the apparent volume being increased, every time that in a given space and filled with combustible matters, its action and expansion is pressed by augmenting the velocity of the air by bellows, caverns, ventilators, aspirative tubes, &c. all of which accelerate more or less the rapidity of the air directed on the fire. The action of fire is augmented by its volume, when a great quantity of combustible matters is accumulated, and the heat and fire are driven into the reverberatory furnaces, which comprehend those of our glass, porcelain, and pottery manufactories, and all those wherein metals and minerals are melted, iron excepted. Fire acts here by its volume, and has only its own velocity, since the rapidity is not augmented by the bellows, or other instruments which carry air to the fire.

There are many modes of augmenting the action of fire by its velocity or volume; but there is only one way of augmenting its mass; namely, by uniting it in the focus of a burning glass. When we receive on the refracting, or reflecting mirror, the rays of the sun, or even those of a well-kindled fire, we unite them in so much the less space, as the mirror is longer, and the focus shorter; for example, by a mirror of four feet diameter, and one inch focus, it is clear, that the quantity of light, or fire, which falls on the four-feet mirror, will be united in the space of one inch, that is, it will be 2304 times denser than it was, if all the incident matter arrived to this focus without any loss, and when even the loss is two thirds or three fourths, the mass of fire concentrated in the focus of this mirror, will always be six or seven hundred times denser than on the surface. In this, as in all other cases, the mass goes by the contraction of the volume; and the fire which we thus augment the density of, has all the properties of a mass of matter; for, independently of the action of heat, by which it penetrates bodies, it impels and displaces them as a solid moving body which strikes another would do.

Each of these modes of administering fire, and increasing either the velocity, volume, or mass, often produce very different effects on the same substances; insomuch, that no reliance is to be placed on any thing that cannot be worked at the same time, or successively, by all three. In the like manner, as I divide into three general proceedings the administration of this element, I divide every matter that can be submitted to its action into three classes. Passing over for the present those which are purely combustible, and which immediately proceed from animals and vegetables; we proceed to minerals, in the first class of which we reckon those mineral matters, which this action, continued for a long time, renders lighter, as iron; in the second, such as it renders heavier, as lead; and in the third class, are those matters on which, as gold, this action of fire does not appear to produce any sensible effect, since it does not at all alter their weight. All existing matters, that is, all substances simple and compounded, will necessarily be comprized under one of these three classes; and experiments on them by the three proceedings, which are not difficult to be made, and only require exactness and time, might develope many useful discoveries, and prove very necessary to build on real principles the theory of chemistry, which has hitherto been carried on by a precarious nomenclatura, and on words the more vague as they are the more general.

Fire is the lightest of all bodies, notwithstanding which it has weight, and it may be demonstrated, that even in a small volume it is really heavy, as it obeys, like all other matters, the general law of gravity, and consequently must have connections or affinities with other bodies. All matters it renders more weighty will be those with which it has the greatest affinity. One of the effects of this affinity in the matters is to retain the substance even of fire, with which it is incorporated, and this incorporation supposes that fire not only loses its heat and elasticity, but even all its motion, since it fixes itself in these bodies, and becomes a constituent part. From which it may be imagined that there is fire under a fixed and concrete form in almost every body.

It is evident, that all matters, whose weight increases by the action of fire, are endowed with an attractive force superior to the expansive, the fiery particles of which are animated; this being extinguished the motion ceases, and the elastic and fugitive particles become fixed, and take a concrete form. Thus matters, whose weight is increased by fire, as tin, lead, &c. are substances which, by their affinity with fire, attract and incorporate. All matters, on the contrary, which, like iron, copper, &c. become lighter in proportion as they are calcined, are substances whose attractive forces, relative to the igneous particles, is less than the expansive force of fire; and hence the fire, instead of fixing in these matters, carries off and drives away the least adherent parts which cannot resist its impulsion. Those which, like gold, platina, silver, &c. neither lose nor acquire by the application of fire, are substances which, having no affinity with fire, and not being able to unite, cannot, consequently, either retain or accompany it when it is carried off. It is evident that the matters of the two first classes have a certain degree of affinity with fire, since those of the second class are loaded with fire, which they retain; and the fire loads itself with those of the first class, which it carries off; whereas the matters of the third class, to which it neither lends nor borrows, have not any affinity or attraction with it, but are indifferent to its action, which can neither unnaturalize nor even change them.

This division of every matter into three classes, relative to the action of fire, does not exclude the more particular and less absolute division of all matters into two other classes, hitherto regarded as relative to their own nature, which is said to be always vitrifiable, or calcareous. Our new division is only a more elevated point of view, under which we must consider them, to endeavour to deduce therefrom even the agent that is used by the relations fire can have with every substance to which it is applied.

We might say, with naturalists, that all is vitrifiable in Nature, excepting that which is calcareous: that quartz, chrystals, precious stones, flints, granites, porphyries, agates, gypsums, clays, lava, pumice stone, with all metals and other minerals, are vitrifiable either by the fire of our furnaces, or that of mirrors; whereas marble, alabaster, stones, chalk, marl, and other substances which proceed from the residue of shells and madrepores, cannot be reduced into fusion by these means. Nevertheless I am persuaded, that if the power of our furnaces and mirrors were further increased, we should be enabled to put these calcareous matters in fusion; since there are a multiplicity of reasons to conclude, that at the bottom their substance is the same, and that glass is the common basis of all terrestrial matter.

By my own experiments I have found, that the most powerful glass furnaces is only a weak fire, compared with that of bellows furnaces; and that fire produced in the focus of a good mirror, is stronger than that of the most glowing fire of a furnace. I have kept iron ore for thirty-six hours in the hottest part of the glass furnace of Rouelle, in Burgundy, without its being melted, agglutinated, or even in any manner changed; whereas, in less than twelve hours this ore runs in a forge furnace. I have also melted, or volatilized, by a mirror many matters which neither the fire, nor reverberatory furnace, nor the most powerful bellows furnace could cause to run.

It is commonly supposed, that flame is the hottest part of fire, yet nothing is more erroneous than this opinion; the contrary may be demonstrated by the most simple and familiar experiments. Offer to a straw fire, or even to the flame of a lighted faggot, a cloth to dry or heat, and treble the time will be required to what would be necessary if presented to a brasier without flame. Newton very accurately defines flame to be a burning smoke, and this smoke, or vapour, has never the same quantity or intensity of heat as the combustible body from which it escapes. By being carried upwards and extending, it has the property of communicating fire, and carrying it further than the heat of the brasier, which alone might not be sufficient to communicate it when even very near.

The communication of fire merits a particular attention. I found, after repeated reflections that besides the assistance of facts which appear to have a relation to it, that experiments were necessary to understand the manner in which this operation of Nature is made. Let us receive two or three thousand weight of iron in a mould at its issuing from the furnace; this metal in a short time loses its incandescence, and ceases from its redness, according to the thickness of the ingot. If at the moment its redness leaves it, it is drawn from the mold, the under parts will be still red, but this colour will fly off. Now so long as the redness subsists, we can light combustible matters by applying them to the ingot; but as soon as it has lost its incandescent state, there are numbers of matters which it will not set fire to, although the heat which it diffuses is, perhaps a hundred times stronger than that of a straw fire, which would inflame them. This made me think that flame being necessary to the communication of fire, there is therefore a flame in all incandescence. The red colour seems, in fact, to indicate it; and indeed I am convinced, that combustible, and even the most fixed matters, such as gold and silver, when in an incandescent state, are surrounded with a dense flame which extends only to a very short distance, and which is attached to their surface; and I can easily conceive, that when flame becomes dense to a certain degree, it ceases from obeying the fluctuation of the air. This white or red body, which issues from all bodies in incandescence, and which strikes our eyes, is the evaporation of this dense flame which surrounds the body by renewing itself incessantly on its surface; and even the light of the sun, which emits such an amazing brightness, I presume to be only an evaporation of the dense state that constantly plays on its surface; and which we must regard as a true flame, more pure and dense than any proceeding from our combustible matters.

It is, therefore, by light that fire communicates, and heat alone cannot produce the same effect as when it becomes very strong to be luminous. Even water, that destructive element to fire, by which alone we can prevent its progress, nevertheless communicates when in a well-closed vessel, such as Papin's digester, where it is penetrated with a sufficient quantity of fire to render it luminous, and capable of melting lead and tin, whereas when it is only boiling, far from communicating fire, it extinguishes it immediately. It is true, that heat alone is sufficient to prepare and dispose combustible bodies for inflammation, by driving off the humid parts from bodies; and what is very remarkable, this heat, which dilates all bodies, does not desist from hardening them by drying. I have an hundred times discovered, by examining the stones of my great furnaces, especially the calcareous, they increased in hardness in proportion to the time they had undergone the heat, and they also at the same time became specifically heavier. From this circumstance, I think an induction may be drawn, which would prove, and fully confirm, that heat, although in appearance always fugitive and never stable in the bodies which it penetrates, nevertheless deposits in a positive manner many parts which fixes there even in greater quantities than the aqueous and other parts which it has driven off. But what appears very difficult to be reconciled, this same calcareous stone, which becomes specifically heavier by the action of a moderate heat a long time continued, becomes near a half lighter, when submitted to a fire sufficient for its calcination, and, at the same time, not only loses all the hardness it had acquired by the action of heat, but even the natural adherence of its constituting parts.

Calcination generally received, is, with respect to fixed and incombustible bodies, what combustion is to volatile and inflammable. Calcination, like combustion, needs the assistance of air; it operates so much the quicker, as it is furnished with a greater quantity of that element, without which the fiercest fire cannot calcine nor inflame any thing, except such matters as contain in themselves all the air necessary for those purposes. This necessity for the concurrence of air in calcination, as in combustion, indicates, that there are more things common between them than has been suspected. The application of fire is the principle of both; that of air is the second cause, and almost as necessary as the first; but these two causes are equally combined, according as they act in more or less time, and with more or less power on different substances.

Combustion operates almost instantaneously; calcination is sometimes so long, as to be thought impossible; for in proportion as matters are more incombustible, the calcination is there more slowly made; and when the constituent parts of a substance, such as gold, are not only incombustible, but appear so fixed as not to be volatilized, calcination produces no effect. They must both, therefore, be considered as effects of the same cause, whose two extremes are delineated to us by phosphorus, which is the most inflammable of all bodies, and by gold, which is the most fixed and least combustible. All substances comprized between these two extremes, will be more or less subjected to the effects of combustion and calcination, according as they approach either of them; insomuch, that in the middle points there will be found substances that endure an almost equal degree of both; from which we may conclude, that all calcination is always accopmanied with a little combustion, and all combustion with a little calcination. Cinders and other residue of the most combustible matters, demonstrate that fire has calcined all the parts it has not burned, and consequently, a little calcination is found here with combustion. The small flame which rises from most matters, that are calcined, demonstrates also that a slight combustion is made. Thus, we must not separate these two effects, if we would find out the results of the action of fire on the different substances to which it is applied.

But it may be said, that combustion always diminishes the volume or mass, on account of the quantity of matter it consumes; and that, on the contrary, calcination increases the weight of many substances. Ought we then to consider these two effects whose results are so contrary, as effects of the same nature? Such an objection appears well-founded, and deserves an answer, especially as this is the most difficult point of the question. For that purpose let us consider a matter in which we shall suppose one half to be fixed parts, and the other volatile or combustible. By the application of fire to this, all the volatile or combustible parts will be raised up or burnt, and consequently separated from the whole mass; from hence this mass or quantity of matter will be found diminished one half, as we see it in calcareous stones, which lose near half their weight in the fire. But if we continue to apply the fire for a very long time to the other half, composed of fixed parts, all combustion and volatilization being ceased, that matter, instead of continuing to lose its mass, must increase at the expense of the air and fire with which it is penetrated; and those are matters already calcined, and prepared by Nature to the degree where combustion ceases, and consequently susceptible of increasing the weight from the first moment of the application. We have seen, that light extinguishes on the surface of all bodies which do not reflect; and that heat, by long residence, fixes partly in the matters which it penetrates; we know also that air is necessary for calcination, or combustion, and the more so for calcination as having more fixity in the external parts of bodies, and becomes a constituent part: hence, it is natural to imagine, that this augmentation of weight proceeds only from the addition of the particles of light, heat, and air, which are at length fixed and united to one matter, against which they have made so many efforts, without being able either to raise or burn them. This appears clearly to be the fact, for if we afterwards present a combustible substance to them they will quit the fixed matter, to which they were only attached through force, retake their natural motion, elasticity, and volatility, and all depart with it; from hence, metal, or calcinized matter, to which these volatile parts has been rendered, retakes its pristine form, and its weight is found diminished by the whole quantity of fiery and airy particles which were fixed in it, and which had been just raised by this new combustion. All this is performed by the sole law of affinities; and there seems to be no more difficulty to conceive how the lime of a metal is reduced, than to understand how it is precipitated in dissolution; the cause is the same, and the effects are similar. A metal dissolved by an acid, will precipitate when to this acid another substance is offered with which it has more affinity than metal, the acid then quits it and falls to the bottom. So, likewise, this metal calcines, that is, loaded with parts of air, heat, and fire, which being fixed, keeps it under the form of a lime, and will precipitate, or be reduced, when presented to this fire and fixed air, from the combustible matters with which they have more affinity than with the metal; the latter will retake its first form as soon as it is disembarrassed from this superfluous air and fire, at the expence of the combustible matters offered to it, and the volatile parts it had lost.

I think I have now demonstrated, that all the little laws of chemical affinities, which appeared so variable and different, are no other than the general laws of attraction, common to all matter; that this great law, always constant and the same, appeared only to vary in its expression, which cannot be the same when the figure of bodies enters, like an element, into their distance. With this new key we can unlock the most profound secrets of Nature; we can attain the knowledge of the figure of the primitive parts of different substances; assign the laws and degrees of their affinities; determine the forms which they take by re-uniting, &c. I think also I have made it appear that impulsion depends on attraction; and that, although it may be considered as a different force, it is, notwithstanding, a particular effect of this sole and general one. I have shewn the communication of motion to be impossible without a spring, whence I have concluded, that all bodies in Nature are more or less elastic, and that there is not one perfectly hard; that is, entirely deprived of a spring, since all are susceptible of receiving motion. I have endeavoured to shew how this sole force may change direction, and attraction become repulsion; and from these grand principles, which are all founded on rational mechanics, I have sought to deduce the principal operations of Nature, such as the production of light, heat, and fire, and their action on different substances; this last object which interests us the most is a vast field, but of which I can only cultivate a little spot, yet I presume I may render some assistance, by putting into more capable and laborious hands the instruments I made use of. These instruments were the three modes of making use of fire, that is, by its velocity, volume, and mass; by applying it concurrently to the three classes of substances, which either lose, gain, or are not affected by the application of fire. The experiments which I had made on the refrigeration of bodies, on the real weight of fire, on the nature of flame, on the progress of heat, or its communication, its diperdition, its concentration, or its violent action without flame, &c. are also so many instruments which will spare much labour to those who choose to avail themselves of them, and will produce an ample harvest of knowledge.

OF AIR, WATER, AND EARTH

BY our former observations it appears that air is the necessary and first food of fire, which can neither subsist nor propagate but by what it assimilates, consumes, or carries off, of that element, whereas of all material substances, air is that which seems to exist the most independently of the aid or presence of fire; for although it habitually has nearly the same heat as other matters on the surface of the earth, it can do without it and requires infinitely less than any of the rest to support its fluidity, since the most excessive cold cannot deprive it of that. The strongest condensations are not capable of breaking its spring; the active fire, in combustible matters, is the only agent which can alter its nature by rarefying and extending its spring to the point of rendering it ineffectual, and thus destroying its elasticity. In this state, and in all the links which precede, the air is capable of re-assuming its elasticity, in proportion as the vapours of combustible matters evaporate and separate from it. But if the spring have been totally weakened and extended that it cannot re-instate itself, from having lost all its elastic power, the air, volatile as it might before have been, becomes a fixed substance which incorporates with the other substances, and forms a constituent part of all those to which it unites by contact. Under this new form it can no longer forsake the fire, except to unite, like fixed matter, to other fixed matters; and if there remain some parts inseparable from fire, they then make a portion of that element serve it for a base, and are deposited with it in the substance they heat and penetrate together. This effect is manifested in all calcinations, and is the more sensible as the heat is longer; but combustion demands only a small time to completely effectuate the same. If we wish to hasten calcination the use of bellows may be necessary, not so much to augment the heat of the fire as to establish a current of air on the surface of the matters; yet it is not requisite for the fire to be very fierce to deprive air of its elasticity, for a very moderate heat, when constantly applied on a small quantity, is sufficient to destroy the spring; and for this air, without spring, to fix itself afterwards in bodies, there is only a little more or less time required, according to the affinity it may have under this new form, with the matters to which it unites. The heat of the body of animals, and even vegetables, is sufficiently powerful to produce this effect. The degrees of heat are different in different kinds of animals: birds are the hottest, from which we pass successively to quadrupeds, man, cetaceous animals, reptiles, fish, insects, and, lastly, to vegetables, whose heat is so trifling as to have made some naturalists declare they had not any, although it is very apparent, and in winter surpasses that of the atmosphere. I have frequently observed in trees that were cut in cold weather, that their internal part was sensibly warm, and that this heat remained for many minutes. This heat is only moderate while the tree is young and sound, but as soon as it grows old the heart heats by the fermentation of the pith, which no longer circulates there with the same freedom; and as soon as this heat begins the centre receives a red tint, which is the first index of the perishing state of the tree, and the disorganization of the wood. The reason naturalists have not found there was a difference between the temperature of the air, and the heat of vegetables is, because they have made their observations at a bad time of the year, and not paid attention, that in the summer the heat of the air exceeds that of the internal part of a tree; whereas in winter it is quite the contrary. They have not remembered that the roots have constantly the degree of heat which surrounds them, and that this heat of the internal part of the earth is, during all winter, considerably greater than that of the air, and the surface of the earth. They did not consider that the motion alone of the pith, already warm, is a necessary cause of heat, and that this motion, increasing by the action of the sun, or by an external heat, that of vegetables must be so much the greater as the motion of their pith is more accelerated, &c.

Here the air contributes to the animal and vital heat, as we have seen that it does to the action of fire in combustible and calcinable matters. Animals, which have lungs, and which consequently respire the air, have more heat than those deprived of them; and the more the internal surface of the lungs is extended, and ramified in a greater number of cells, the more it presents greater superficies to the air which the animal draws by inspiration; the more also its blood becomes hotter, the more it communicates heat to all parts of the body it nourishes, and this proportion takes place in all known animals. Birds, relatively to the volume of their body, have lungs considerably more extended than man or quadrupeds. Reptiles, even those with a voice, as frogs, instead of lungs have a simple bladder. Insects which have little or no blood breathe the air only by some pipes, &c. Thus taking the degree of the temperature of the earth for the term of comparison, I have observed that this heat being supposed ten degrees, that of birds was nearly thirty-three, that of some quadrupeds more than thirty-one and a half, that of man thirty and a half, or thirty-one, whereas that of frogs is only fifteen or sixteen, and that of fishes and insects only eleven or twelve, which is nearly the same as that of vegetables. Thus the degree of heat in man and animals depends on the force and extent of the lungs; these are the bellows of the animal machine: the only difficulty is to conceive how they carry the air on the fire which animates us, a fire whose focus seems to be indeterminate; a fire that has not even been qualified with this name, because it is without flame or any apparent smoke, and its heat is only moderate and uniform. However, if we consider that heat and fire are effects, and even elements of the same class; that heat rarefies air, and, by extending its spring, it may render it without effect; we may imagine, that the air drawn by our lungs being greatly rarefied, loses its spring in the bronchiæ and little vesicles, where it is soon destroyed by the arterial and venous blood, for these blood-vessels are separated from the pulmonary vesicles by such thin divisions that the air easily passes into the blood, where it produces the same effect as upon common fire, because the heat of this blood is more than sufficient to destroy the elasticity of the particles of air, and to drag them under this new form into all the roads of circulation. The fire of the animal body differs from common fire only in more or less; the degree of heat is less, hence there is no flame, because the vapours, which represent the smoke, have not heat enough to inflame; every other effect is the same: the respiration of a young animal absorbs as much air as the light of a candle, for if inclosed in vessels of equal capacities, the animal dies in the same time as the candle extinguishes: nothing can more evidently demonstrate that the fire of the animal and that of the candle are not of the same class but of the same nature, and to which the assistance of the air is equally necessary.

Vegetables, and most insects, instead of lungs, have only aspiratory tubes, by which they pump up the air that is necessary for them; it passes in very sensible balls into the pith of the vine. This air is not only pumped up by the roots but often even by the leaves, and forms a very essential part of the food of the vegetable which assimilates, fixes, and preserves it. Experience fully confirms all we have advanced on this subject, and that all combustible matters contain a considerable quantity of fixed air, as do also all animals and vegetables, and all their parts, and the waste which proceeds therefrom; and that the greatest number likewise include a certain quantity of elastic air. And, notwithstanding the chimerical ideas of some chemists, respecting phlogiston, there does not remain the smallest doubt but that fire or light produces, with the assistance of air, all the effects thereof.

Minerals, which like sulphur and pyrites, contain in their substance a quantity of the ulterior waste of animals and vegetables, contain thence combustible matters, which, like all other, contain more or less fixed air, but always much less than the purely animal or vegetable substances. This fixed air can be equally removed by combustion. In animal and vegetable matters it is disengaged by simple fermentation, which, like combustion, has always need of air for its operation. Sulphurs and pyrites are not the only minerals Which must be looked upon as combustible, there are many others which I shall not here enumerate, because it is sufficient to remark, their degree of combustion depends commonly on the quantity of sulphur which they contain. All combustible minerals originally derive this property either from the mixture of animal or vegetable parts which are incorporated with them, or from the particles of light, heat, and air, which, by the lapse of time, are fixed in their internal part. Nothing, according to my opinion, is combustible but that which has been formed by a gentle heat, that is, by these same elements combined in all the substances which the sun brightens and vivifies, or in that which the internal heat of the earth foments and unites.

The internal heat of the globe of the earth must be regarded as the true elementary fire; it is always subsisting and constant;

it enters, like an element, into all the combinations of the other elements, and is more than sufficient to produce the same effects on air as actual fire on animal heat; consequently this internal heat of the earth will destroy the elasticity of the air, and render it fixed, which being divided into minute parts will enter into a great number of substances, from hence they will contain articles of fixed air and fire, which are the first principles of combustibility; but they will be found in different quantities, according to their degree of affinity with the substance, and this degree will greatly depend on the quantity these substances contain of animal and vegetable parts, which appear to be the base of all combustible matter. Most metallic minerals, and even metals, contain great quantities of combustible parts; zinc, antimony, iron, copper, &c. burn and produce a very brisk flame, as long as the combustion of these inflammable parts remains, after which, if the fire be continued, the calcination begins, during which there enters into them new parts of air and heat, which fixes, and cannot be disengaged but by presenting to them combustible matters, with which they have a greater affinity than with those of the mineral, with which they are only united by the effort of calcination. It appears to me, that the conversion of metallic substances into dross, and their reproduction, might be very clearly understood without applying to secondary principles, or arbitrary hypotheses, for their explanation.

Having considered the action of fixed air in the most secret operations of nature, let us take a view of it when it resides in bodies under an elastic form; its effects are then as variable as the degrees of its elasticity, and its action, though always the same, seems to give different products in different substances. To bring this consideration back to a general point of view, we will compare it with water and earth, as we have already compared it with fire; the results of this comparison between the four elements will afterwards be easily applied to every substance, since they are all composed merely of these four real principles.

The greatest cold that is known, cannot destroy the spring of the air, and the least heat is sufficient for that purpose, especially when this fluid is divided into very small particles. But it must be observed, that between its state of fixity, and that of perfect elasticity, there are all the links of the intermediate states, in one of which it always resides in earth and water, and all the substances which are composed of them; for example, water, which appears so simple a substance, contains a certain quantity of air, which is neither fixed nor elastic, as is plain from its congulation, ebullition, and resistance to all compression, &c. Experimental philosophy demonstrates, that water is incompressible, for instead of shrinking and entering into itself when pressed, it passes through the most solid and thickest vessels; which could not be the case if the air it contained were in a state of full elasticity. The air contained therefore in water, is not simply mixed therewith, but is united in a state where its spring is not sensibly exercised; yet the spring is not entirely destroyed, for if we expose water to congelation, the air issues from its internal part, and unites on its surface in elastic bubbles. This alone suffices to prove, that air is not contained in water under its common form, since being specifically 850 times lighter, it would be forced to issue out by the sole necessity of the preponderance of water; neither under an affixed form, but only in a medium state, from whence it can easily retake its spring, and separate more easily than from every other matter.

Конец ознакомительного фрагмента.