ON INTELLIGENCE

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ON

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BY

H. TAINE

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PART THE SECOND.

(CONTINUED.)

BOOK II.

THE KNOWLEDGE OF BODIES.

CHAPTER I.

EXTERNAL PERCEPTION AND THE IDEA OF WHICH THE IDEA OF BODY IS COMPOSED.

I. To begin with the knowledge of bodies. What is there within us when we take cognizance by our sensations of an external body—when, for instance, experiencing tactile and muscular sensations of cold, of considerable resistance, of smooth and uniform contact in my hand, I conclude that it is resting on marble; when, casting my eyes in a certain direction and having through the retina a sensation of reddish brown, I conclude that there is a round mahogany table three paces from my eyes? A phantom or hallucinatory semblance. —The reader has already seen the main proof of this.* But the paradox is so great that it will be well to present it anew, adding to it the complementary proofs.

In order to establish that external perception, even when accurate, is an hallucination; it is sufficient to observe that its first phase is a sensation.—In fact, a sensation, and notably

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* Part ii. book i. chap. 1, p. 236.

a tactile or visual sensation, engenders, by its presence alone, an internal phantom which appears an external object. Dreams, hypnotism, hallucinations strictly so called, all subjective sensations are in evidence as to this. It matters little whether the sensation be purely cerebral and arise spontaneously, without preliminary excitation of the peripheral extremity of the nerve, in the absence of the objects which usually produce this excitation. As soon as ever the sensation is present, the rest follows; the prologue entails the drama. The patient imagines that he feels in his mouth the melting pulp of an absent orange, or the cold pressure on his shoulder of a hand which is not there, that he sees a number of passers-by in an empty street, or hears clearly articulated sounds in his silent chamber.—When, therefore, the sensation arises in consequence of its usual antecedents, that is to say after the excitation of the nerve and through the effect of an external object, it begets the same internal phantom, and necessarily, this phantom appears an external object. Consequently, if there are actually persons about in the street, the sensation I shall experience in looking at them will excite in me, as before, phantoms of persons about in the street, and necessarily, as before, these purely internal phantoms will appear to me external objects, that is to say real and true persons. Hence we see that the objects we touch, see, or perceive by any one of our senses, are nothing more than semblances or phantoms precisely similar to those which arise in the mind of a hypnotized person, a dreamer, a person laboring under hallucinations, or afflicted by subjective sensations. The sensation being given, the phantom is produced: it is produced, then, whether the sensation be normal or abnormal; it is produced, then, in perception where there is nothing to distinguish it from the real object, just as in sickness where every thing distinguishes it from the real object.

If its existence be established by its antecedents, it is confirmed by its consequents. In fact, external perception leaves a semblance behind it; when we have seen some interesting object, heard some fine music, felt a body of peculiar texture, not only does the image of our sensation survive the sensation, but more than this, it is accompanied by a more or less energetic and clear conception, representation, or phantom of the object perceived. Suppose this representation very intense, it borders on hallucination; if sleep is drawing on, it becomes a complete hallucination; in fact, this is its natural ending; we have seen that, when checked, it is by means of a supervening repression or rectification which, at the first moment, was absent. Therefore, at the first moment, that is to say during external perception, it was not checked; there was, then, a complete hallucination, of which the preserved conception, the floating representation, the posthumous phantom, is the remnant. In this state and at this second moment we distinguish the phantom, which at the first moment we had confounded with the real object.

There are other cases, again, in which we can contrive, directly, to separate them; such are the various errors of external perception, above all, those of the touch and of sight. I am not speaking of those alone which proceed from purely subjective sensations; it is abundantly clear that in such cases the apparent object is distinct from any real object, since no real object exists. I am speaking of those proceeding from ill-interpreted sensations; in which cases there is a real object, though it differs from the apparent object. For instance, when we close our eyes and touch a marble with the forefinger and ring-finger crossing one another, we imagine ourselves to be touching two marbles; this is one of the fallacies of touch. Those of sight are innumerable; we fall into them daily in ordinary life, and may fabricate them at will by optical instruments; by means of the stereoscope we give to two plane surfaces the appearance of a single body possessed of relief, and there are a hundred analogous illusions. Take the simplest of all, that produced by a figure reflected in a looking-glass; if the glass is without any flaw and fills up the whole side of a room, if the light is well arranged, and we do not know the circumstances, we shall imagine that we see a figure before our eyes at a spot where there is nothing but a wall. Now, in this and in all similar instances, what we take for the real object differs from the real object; the thing affirmed is nothing more than something apparent, there is nothing corresponding to it at the spot and with the characters assigned; in other words, it is nothing more than a simple, internal, ephemeral semblance which forms part of ourselves, and which, nevertheless, appears to us an external thing, other than ourselves, and permanent.—But when our perception was free from error, the operation was precisely the same; consequently, when our perception was free from error, we produced and projected, in a similar way, to the indicated spot, an apparent object, an internal and transient semblance forming part of ourselves, and which, nevertheless, seemed to be a body external to us, independent and stable. The only difference is that, in the first case, there was an independent body, external and stable, which actually and rigorously corresponded to our semblance, and that now, this actual and rigorous correspondence no longer takes place. Consequently, in the first case, we could not distinguish the semblance and the body, and now we are able to do so.

Thus, there are three marks which indicate to us the presence of the semblance, even in accurate external perception.—In the first place, its exciting and sufficient condition, the sensation, is found there; it, then, must necessarily be there.—In the second place, we find it surviving an instant afterwards, and repressed by an added rectification; it was there, then, an instant before, and was not repressed, that is to say, was fully hallucinatory.—In the third place we distinguish it in many instances, and, to effect this, it is sufficient if the characters of the real object do not all perfectly coincide with those of the semblance; consequently we are forced to admit its existence, even when the perfect coincidence of all its characters with all those of the real object prevents our establishing, by subsequent experience, any difference between it and the real object.—What is this real object? Is there one? And, if we recognize one, on what can we found our recognition? We shall presently look for answers to all these questions.—Meanwhile, let us simply postulate that when we perceive an object by the senses, when we see a tree ten paces from us, when we take a marble in our hand, our perception consists in the rising up of an internal phantom of the tree or marble, and this phantom appears to us an external, independent, durable thing, situated, in the one case, at ten paces from us, in the other case, in our hand.

II. In what does this internal phantom consist?—It is plain that, among other elements, it comprises *an affirmative conception.* When I see the tree or touch the marble, my sensation suggests to me a judgment, that is to say a conception and an affirmation. I conceive and I affirm, that at ten paces from me is a being possessed of certain properties, that in my hand is another such being, and the sufferer from hallucination, who has the sensation of an absent tree or of an absent marble, comes to the same conclusion. Here we have an essential element of the internal semblance; there is no external perception or hallucination which does not contain an affirmative conception, the affirmative conception of a being, thing, or substance possessed of properties. Let us analyze this conception, and attempt to mark, one by one, the distinct and connected conceptions of which it is the aggregate.

Take the case of a mahogany table to which I direct my eyes; when I perceive it, I have, with regard to my retinal sensation, an affirmative conception, which is that of something extended, resisting, hard, polished, feebly sonorous, of a reddish brown color, of certain size and shape, in short, of a being or substance possessed of the above-mentioned qualities or properties. Let the reader consider for a moment: here, as in every proposition, the substance is equivalent to the indefinite series of its known or unknown properties.

Take away all the properties, without a single exception, extension, resistance, weight, hardness, polish, sonorousness, figure, and lastly, the most general of all, existence itself; it is plain that there will be nothing left of the substance; it is the aggregate of which the properties are the details; it is the whole of which the properties are the extracts; take away all the details, there will be nothing left of the aggregate; take away all the extracts, there will be nothing left of the whole. The rule is general that—in every proposition the attributes form the analysis of the subject, and the subject is the sum of the attributes.—Consequently, my conception of substance is nothing more than a summary; it is equivalent to the sum of the conceptions composing it, just as a number is equivalent to the sum of the units composing it, or an abbreviatory sign to the things it abbreviates and signifies. Consequ ntly, what I apply and attribute to the substance is applicable and attributable to its equivalent. When, then, I say that it is a *being*, a *substance*, or in other words that it is, and that it subsists, this means that its properties are, and subsist. To conceive, then, and affirm a substance, is to conceive and affirm a group of properties as permanent and stable; I say a group: for the properties which constitute a body are not an arbitrary collection, a heap piled up at will, like a number of units, which I collect as I please and denote by a cipher; they are not merely an added sum, but more than this, they form a cluster. Any one of them involves the rest: the squared form, the reddish color, the feeble sonorousness, the polish, the hardness, combine together in the table; the perfumed smell, the rosy color, the semi-globular form, the softness, combine together in the rose. In fact, whenever I experience them they are all combined, and it is enough for me to ascertain the existence of one of them by one of my senses, smell by the sense of smell, color by the sight, to have the right to affirm the simultaneous presence of the others whose existence I have not ascertained. It is this cluster which forms the body.

III. Let us follow out successively the different threads. In what do the properties of a body consist?—With the majority of them, the answer is easy. They are *relative, relative to my sensations*, and to the sensations of every other being analogous to myself: they are nothing more than a power, the power of the body in question to excite certain particular sensations.—The rose has a certain smell, differing from that of the lily and from that of the violet; this means that it is capable of exciting in me, and in every other being constructed as I am, a certain agreeable sensation distinct from other sensations of smell, and which we term the smell of the rose.—Sugar has a certain taste; this again means that it is capable of exciting in me and in every other being similar to me, a certain special sensation of taste which we term a sugary taste.—And so it evidently is with colors and sounds. A certain vibrating cord gives a sound of a particular acuteness, a particular tone, and a particular intensity. A certain body when illuminated gives a color of certain tint and certain brightness. This means that the vibrating cord is capable of exciting a certain particular sensation of sound, that the illuminated body is capable of exciting a particular determinate sensation of color.—No doubt, in the present day we know more than this; optics and acoustics have taught us that to a particular sound there correspond a particular number of vibrations of air, and to a particula color, a particular number of vibrations of ether. But this is not the primitive or ordinary judgment; it is necessary to become scientific before we can form it; the explanation is subsequent and superadded.—Besides, the difficulty is only shifted: when provided with the theory, we say that the molecules of air or ether have the power of exciting in us, by their oscillations, sensations of sound or color. This power which the spontaneous judgment ascribed to the illuminated body, and to the vibrating cord, is now referred to the interposed molecules of air or ether; thus the color and sound still remain relative properties; whether we attribute them to the vibrating cord and the illuminated body, or to the particles of air and ether, they are nothing more than the power of exciting in us certain particular sensations.

Finally, if we pass from the four special senses to the last and most general of all, that is to say to touch, our conclusions are similar.—In the first place, it is clear that heat and cold are nothing more than the power of exciting sensations of that name.—So is it with solidity or resistance, which is nothing more than the power of exciting the muscular sensation of resistance. "When we contract the muscles of our arm, either by an exertion of will, or by an involuntary discharge of our spontaneous nervous activity, the contraction is accompanied by a state of sensation, which is different according as the locomotion consequent on the muscular contraction continues freely, or meets with an impediment.—In the former case, the sensation is that of motion through empty space. After having had (let us suppose) this experience several times repeated, we suddenly have a different experience: the series of sensations accompanying the motion of our arm is brought, without intention or expectation on our part, to an abrupt close. This interruption would not, of itself, necessarily suggest the belief in an external obstacle. The hindrance might be in our organs; it might arise from paralysis, or simple loss of power through fatigue. But in either of these cases, the muscles would not have been contracted, and we should not have had the sensation which accompanies their contraction. We may have had the will to exert our muscular force, but the exertion has not taken place.—If it does take place, and is accompanied by the usual muscular sensation, but the expected sensation of locomotion does not follow, we have what is called the feeling of Resistance, or in other words, of muscular motion impeded." *—Later on, when we have acquired the idea of our limbs, we shall translate such an uninterrupted series

* J. S. Mill, "Examination of Sir W. Hamilton's Philosophy," 219.

of muscular sensations by the idea of an unimpeded movement of our arm, and we shall translate the same series of sensations, when interrupted, by the idea of the hindered movement of our arm. In fact, the one is capable of replacing the other; when once our senses are instructed, we discover that a particular series of muscular sensations evidenced by consciousness is equivalent to a particular movement of our hand evidenced by our eyes or touch; we substitute the second fact for the first, as being more convenient to imagine and more generally applicable to nature, and henceforth, we define resistance as the power of arresting the movement of our arm, and in general of any body whatever.—But this is an ulterior conception. *Primitively*, resistance is nothing more to us than the power to arrest a commenced series of muscular sensations, and the other tactile qualities are reducible like resistance, to the power of exciting some tactile or muscular sensation more or less simple or compound, some mode or modification of a muscular and tactile sensation, or of a series of such sensations.—A body is smooth or rough; which means that it is capable of exciting a uniform and soft sensation of contact, or an irregular and harsh sensation of contact. Heavy, light, sharp, level, hard, soft, sticky, damp,* all these terms denote nothing more than the power of exciting more or less complex, intense, and varied sensations of contact, of pressure, of temperature, of muscular contraction, and of pain.

IV. There remain a group of properties which seem at first sight intrinsic and personal to bodies, and not merely relative to sensations; such are extension, form, mobility, situation, and all geometrical properties. And, in fact, it is by means of such as these that we explain the different powers we have just described; we conceive and suppose little

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* Experiments of Landry, Gratiolet, Fick, and Bain. See part i. book iii. chap. 2, *ante*, p. 148.

bodies with extension and shape which we term molecules; we assume that they move in a certain direction and with certain velocities; that two given molecules continue to approach or to separate from each other with more or less speed according to their reciprocal distance; that a collection of molecules, whose movements are mutually annulled or compensated, form a stable body, whose equilibrium becomes altered by the approach of another similarly constituted body. Such is our idea of body, a fully reduced and abstract idea; this is to us the essential and indispensable part of a body; in what do these properties consist?

We must first observe that they are reducible to a principal property, *extension*, and to one of the powers enumerated above, *resistance*.—A body is a solid or resisting extension; that is to say, an extension capable of exciting, in all its continuous and successively explored portions, the sensation of resistance; if not in us, at all events in a being with acuter senses than ours. By this, *solid* extension is distinguished from *empty* extension; that is to say from the *place* it occupies. By this, again, we define *mobility*, which is nothing more than the power of changing place. Finally, by this, we define its *limits*. It has a surface, that is to say, a limit; the surface is the limit of solid extension, as the line is the limit of the surface, and the point the limit of the line. Now, limit means cessation; the surface, the line, the point, and the figures derived from them, are nothing more than aspects of solidity, various modes of considering its cessation and its absence; that is to say, the absence and the cessation of the sensation of resistance.—Extension itself remains. We may consider it in three aspects, according to three dimensions, in length, breadth, and height. Take the case of a cube; its extension in length, breadth and height, is the *distance* separating a point taken at one of its angles from three points taken at three other angles. Distance in three senses or directions is the foundation of our idea of extension. Here we need only reproduce the admirable analysis of the latest English philosophers.*

When I contract one of my muscles, I experience one of those sensations we term muscular, and I may consider this from two points of view.—In the first place, my sensation is more or less powerful; it is extreme, if the effort approaches a strain of the muscle; its limit is the pain termed cramp; its character is of greater or less intensity, and I can compare my sensation in this respect with other more or less intense sensations of the same muscle. Thus regarded, it enables me to estimate the resistance which other bodies oppose to me; but as yet, teaches me nothing respecting their extension, distance, and position.—But there is a second point of view, and to this we owe our idea of extension. For muscular sensations vary not only in greater or less intensity, but also in greater or less duration. "When a muscle begins to contract," says Mr. Bain, "or a limb to bend, we have a distinct sense of how far the contraction and the bending are carried; there is something in the special sensibility that makes one mode of feeling for half contraction, another mode for three-fourths, and another for total contraction." Thus we distinguish in the sensation, not only an increase of intensity, but also an increase of duration. "Suppose a weight raised by the flexing of the arm, first four inches, and then eight inches." We shall obviously distinguish the second sensation from the first, and, in the first place, clearly, because, other things being equal, the second lasts twice as long as the first, and then, probably, because in the second period of effort, other muscles coming into play, produce new muscular sensations, which add themselves on to the continuation of the first sensations, not only by prolonging, but also by diversifying the operation. By these two distinct sensations, we distinguish the greater or less amplitude of our two movements; and we see how we

* Bain, "Senses and Intellect," 99 and 199. Herbert Spencer, "Principles of Psychology," 1st Edition, 304. J. S. Mill, "Examination," etc., 222.

can in a general manner distinguish the amplitude of one of our movements compared with another.—It is by means of this muscular discernment that we arrive at a knowledge of extension and space. For, "in the first place it gives the feeling of *linear extension*, inasmuch as this is measured by the sweep of a limb, or other organ moved by muscles. The difference between six inches and eighteen inches is expressed to us by the different contraction of some one group of muscles; those for example that flex the arm, or, in walking, those that flex or extend the lower limb. The inward impression corresponding to the outward fact of six inches in length, is an impression arising from the continued shortening of a muscle, a true muscular sensibility. It is the impression of a muscular effort having a certain continuance; a greater length produces a greater continuance. . . . . "—Now, "the discrimination of length in any one direction includes *extension* in any direction. Whether it be length, breadth, or height, the perception has precisely the same character. Hence superficial and solid dimensions, the size or magnitude of a solid object, come to be felt in a similar manner. . . . . It will be obvious that what is called *situation* or *locality* must come under the same head, as these are measured by distance taken along with direction; direction being itself estimated by distance, both in common observation and in mathematical theory.—In like manner *form* or *shape* is ascertained through the same primitive sensibility to extension or range.*—By the muscular sensiblity thus associated with prolonged contraction we can therefore compare different degrees of the attribute of space, in other words, difference of length, surface, situation, and form. When comparing two different lengths we can feel which is the greater, just as in comparing two different weights

* We see that the idea of form is reduced to that of position, which is reduced to that of distance. Analytical geometry is entirely founded on this observation, it translates form by the relations of two or three co-ordinates representing distances.

or resistances. We can also, as in the case of weight, acquire some absolute standard of comparison, through the permanency of impressions sufficiently often repeated. We can engrain the feeling of contraction of the muscles of the lower limb due to a pace of thirty inches, and can say that some one given pace is less or more than this amount. According to the delicacy of the muscular tissue we can, by shorter or longer practice, acquire distinct impressions for every standard dimension, and can decide at once whether a given length is four inches or four and a half, nine or ten, twenty or twenty-one. This sensibility to size, enabling us to dispense with the use of measures of length, is an acquirement suited to many mechanical operations. In drawing, painting, and engraving, and in the plastic arts, the engrained discrimination of the most delicate differences is an indispensable qualification."

A third aspect remains; for there are not merely different degrees of intensity and duration, but different degrees of velocity in our muscular movements, and the same contraction of the same muscles excites in us two different muscular sensations according as it is rapid or slow. We learn by experience that in many cases these two distinct sensations are signs of the same movement; in this they are equivalent. "A slow motion for a long time is the same as a quicker motion with less duration." We easily convince ourselves of this "by seeing that they both produce the same effect in exhausting the full range of a limb. If we experiment upon the different ways of accomplishing a total sweep of the arm, we shall find that the slow movements long continued are equal to quick motions of short continuance, and we are thus able by either course to acquire to ourselves a measure of range and linear extension."—"Suppose," says Mill, "two small bodies, A and B, sufficiently near together to admit of their being touched simultaneously, one with the right hand, the other with the left. Here are two tactual sensations which are simultaneous, just as a sensation of color and one of odor might be; and this makes us cognize the two objects of touch as both existing at once. The question then is, what have we in our minds, when we represent to ourselves the relation between these two objects, already known to be simultaneous, in the form of Extension or intervening Space —a relation which we do not suppose to exist between the color and the odor." Our answer to this is "that whatever the notion of Extension may be, we *acquire* it by passing our hand or some other organ of touch, in a longitudinal direction from A to B: that this process, as far as we are conscious of it, consists of a series of varied muscular sensations. . . . . When we say that there is a space between A and B, we mean that some amount of these muscular sensations must intervene; and when we say that the space is greater or less, we mean that the series of sensations (amount of muscular effort being given) is longer or shorter. If another object, C, is farther off in the same line, we judge its distance to be greater, because, to reach it, the series of muscular sensations must be further prolonged, or else there must be the increase of effort which corresponds to augmented velocity. Now this, which is unquestionably the mode in which we became *aware* of extension, is considered by the psychologists in question to *be* extension. The idea of Extended Body they consider to be that of a variety of resisting points, existing simultaneously, but which can be perceived by the same tactile organ only successively, at the end of a series of muscular sensations which constitutes their *distance;* and are said to be at different distances from one another because the series of intervening muscular sensations is longer in some cases than in others. . . . . An intervening series of muscular sensations before the one object can be reached from the other, is the only peculiarity which (according to this theory) distinguishes simultaneity in space from the simultaneity which may exist between a taste and a color, or a taste and a smell: and we have no reason for believing that Space or Extension in itself, is any thing different from that which we recognize it by."*

Thus, in our cases, time is the parent of space, and we conceive simultaneous magnitude by means only of successive magnitude. When our arm moves, it traverses a space; but we do not estimate the magnitude of what is traversed except by the two factors measuring it, on the one hand by the amount of our muscular exertion, on the other hand by the duration of our successive muscular sensations. In transit through space there are three terms—the magnitude of the motive force, the length of time employed, the extent of space traversed—and each of these is determined by the other two. Now, the two first we find in ourselves, and they are together equivalent to the third, since the third is completely determined by them. It is by the first two, then, that the space traversed is translated into our minds, and such space is in itself nothing more to us than the power of exciting them. Thus, greater or less space is nothing more than the power of exciting in us, with an equal amount of muscular effort, a longer or shorter series of successive muscular sensations.—Add to this solidity, that is to say the power of exciting the sensation of resistance, and we have body.—In fact, its three dimensions are the three distinct aspects to which all the sensations measuring its extension are reduced. Its continuity is the power of exciting the sensation of resistance, throughout the whole duration of these sensations. Its limit is the moment at which the sensation of resistance ceases. Its figure is the aggregate of these limits. We conceive it as composed of parts, because the sensation, whose duration measures it, is itself composed of parts. So too it is infinitely divisible, because this duration is itself infinitely divisible. Though the elements of our sensation be successive, the elements of the body appear to us as simultaneous; in fact, they are, as the body itself, permanent pow-

* Mill, "Examination," etc., pp. 228–30.

ers, whose permanence, like that of the body itself, is attested to us by the regular return of the sensations they excite; being permanent, they are contemporaneous; though we perceive them successively they exist together, and the succession disjoining their effects is not applicable to their existence. I pass my hand several times heavily along the side of the table, from left to right, then from right to left, and always with the same speed; that is to say with the same amount of motive effort. Now, in all these experiences, the sensation given me by my contracted arm is the same in duration, and has, as accompaniment, at every moment, the uniform sensation of resistance. Whether I begin at the right or left, it does not matter; the double muscular sensation remains the same in the two cases. It forms, then, a severed group among my recollections and previsions; it is distinguished from the others by the precise degree of intensity of the first component muscular sensation, by the precise degree of duration of the second component muscular sensation, and further, by the particular shade of the conjoined sensation of touch; the power of exciting this group is what we term the resistance and extension of the table.—Hence, we see that all the sensible properties of bodies, including extension, and consequently form, situation, and other tangible qualities, are, in final analysis, nothing more than the power of exciting sensations.

V. This leads us to a new notion of the nature of bodies; a body is a collection of such powers as we have just described. But what are these powers?—This rose has power to excite a certain sensation of smell; which means that, when within reach of it, this sensation of smell will be aroused. This table has power to excite a certain strong sensation of resistance; which means that, if it is pressed with the hand, a strong sensation of resistance will be aroused. A power, then, is nothing intrinsic and personal to the object to which we attribute it. We simply mean by the word that certain effects are possible, future, proximate, necessary under certain conditions. We simply mean, in this instance, that certain sensations are possible, future, proximate, necessary under certain conditions. Consequently, a collection of powers is nothing; consequently a body, that is to say a collection of powers, is also nothing. At the foundation of the affirmative conception, by which, having passed and pressed my hand over this table, I conceive and affirm an independent and permanent body, there is nothing more than the affirmative conception of analogous muscular and tactile sensations, these sensations being conceived and affirmed as possible for any being similar to myself, who might come within their range, as future, proximate, certain, and necessary, for any being similar to myself, who might pass and press his hand or other organ in the same manner. All I conceive and affirm is their possibility under certain conditions, and their necessity under fuller conditions. They are possible when all these conditions, but one, are given. They become necessary when all these conditions, and in addition the missing condition, are given; and here the possibility becomes necessity, by the addition of the last condition. This is what constitutes for us the object. When, with closed eyes, I experience a sensation of the smell of a rose, and thereupon conceive and affirm the presence of a rose, I simply conceive and affirm the possibility for myself, and for every other being similar to myself, of a certain muscular and tactile sensation of soft resistance, of a certain visual sensation of colored form; a possibility would become a necessity, if, to the existence and presence of the sentient person indicated, were added a final condition, a certain movement of his exploring hand, a certain direction of his open eyes.—*Certain possibilities and certain necessities of sensations*, to these are reducible the powers, consequently the properties, consequently the very substance of bodies.

This conclusion seems paradoxical. How can we admit that bodies, that is to say permanent substances independent of us, and which we conceive as causes of our sensations, are, at bottom, and in themselves, nothing more than possibilities and necessities of sensation?—To remove this difficulty, let us consider successively the principal characters of these possibilities and necessities, and we shall see that they possess all the characters of substance.—They are permanent, in fact, the proposition by which I affirm the possibility and necessity of a certain sensation under certain conditions is general, and holds good for all moments of time. Whatever be the moment of duration I am considering, this possibility and this necessity are found there; they are, then, persistent and stable.—On the other hand, they are independent of me, and of all sentient individuals who are living, have lived, or will live. For the proposition by which I affirm the possibility and necessity of certain sensations under certain conditions is abstract, and holds good, not only in my case and in that of every actual person, but for all possible persons. Even were there not in fact any sentient individual in the world, they would exist; they exist, then, apart and by themselves.—For these two reasons, they are opposed, first, to sensations which are transient and not, like them, permanent; then, to sentient individuals themselves who are other than they. These are the essential characters of substance; consequently, there is nothing astonishing in our terming these possibilities substances, and in their playing a predominant part in our mind.

Let us see how it is they assume this part. "I see a piece of white paper on a table. I go into another room, and though have I ceased to see it, I am persuaded that the paper is still there. I no longer have the sensations which it gave me; but I believe that when I again place myself in the circumstances in which I had those sensations, that is, when I go again into the room, I shall again have them; and further, that there has been no intervening moment at which this would not have been the case."—This is a specimen of the ordinary operations of our mind, and it is plain that the analysis would be the same, in the case of any other perception of sight, or of another sense.—Now, in accordance with this analysis, it appears "that my conception of the world at any given instant consists, in only a small proportion, of present sensations. Of these I may at the time have none at all, and they are in any case a most insignificant portion of the whole which I apprehend. The conception I form of the world existing at any moment, comprises, along with the sensations I am feeling, a countless variety of possibilities of sensation; namely, the whole of those which past observation tells me that I could, under any supposable circumstances, experience at this moment, together with an indefinite and illimitable multitude of others which though I do not know that I could, yet it is possible that I might experience in circumstances not known to me. These various possibilities are the important thing to me in the world. My present sensations are generally of little importance, and are moreover fugitive: the possibilities, on the contrary are permanent, which is the character that mainly distinguishes our idea of Substance or Matter from our notion of sensation.— These possibilities, which are conditional certainties, need a special name to distinguish them from mere vague possibilities, which experience gives no warrant for reckoning upon. Now, as soon as a distinguishing name is given, though it be only to the same thing regarded in a different aspect, one of the most familiar experiences of our mental nature teaches us, that the different name comes to be considered as the name of a different thing.

"There is another important peculiarity of these certified or guaranteed possibilities of sensation; namely, that they have reference, not to single sensations, but to sensations joined together in groups. When we think of any thing as a material substance, or body, we either have had, or we think that on some given supposition we should have, not some *one* sensation, but a great and even an indefinite number and variety of sensations, generally belonging to different senses, but so linked together that the presence of one announces the possible presence at the very same instant of any or all of the rest. In our mind, therefore, not only is this particular Possibility of sensation invested with the quality of permanence, when we are not actually feeling any of the sensations at all; but when we are feeling some of them, the remaining sensations of the group are conceived by us in the form of Present Possibilities, which might be realized at the very moment. And as this happens in turn to all of them, the group as a whole presents itself to the mind as permanent, in contrast not solely with the temporariness of my bodily presence, but also with the temporary character of each of the sensations composing the group; in other words, as a kind of permanent substratum, under a set of passing experiences or manifestations: which is another leading character of our idea of substance or matter, as distinguished from sensation.

"Let us now take into consideration another of the general characters of our experience, namely, that in addition to fixed groups, we also recognize a fixed Order in our sensations; an Order of succession, which, when ascertained by observation, gives rise to the ideas of Cause and Effect .... Now, of what nature is this fixed order among our sensations? It is a constancy of antecedence and sequence. But the constant antecedence and sequence do not generally exist between one actual sensation and another. Very few such sequences are presented to us by experience. In almost all the constant sequences which occur in Nature, the antecedence and consequence do not obtain between sensations, but between the groups we have been speaking about, of which a very small portion is actual sensation, the greater part being permanent possibilities of sensation, evidenced to us by a small and variable number of sensations actually present. Hence, our ideas of causation, power, activity, do not become connected in thought with our sensations as *actual* at all, save in the few physiological cases where these figure by themselves as the antecedents in some uniform sequence. Those ideas become connected, not with sensations, but with groups of possibilities of sensation. The sensations conceived do not, to our habitual thoughts, present themselves as sensations actually experienced, inasmuch as not only any one or any number of them may be supposed absent, but none of them need be present. We find that the modifications which are taking place more or less regularly in our possibilities of sensation, are mostly quite independent of our consciousness, and of our presence or absence. Whether we are asleep or awake the fire goes out, and puts an end to one particular possibility of warmth and light. Whether we are present or absent the corn ripens, and brings a new possibility of food. Hence we speedily learn to think of Nature as made up solely of these groups of possibilities, and the active force in Nature as manifested in the modification of some of these by others. The sensations, though the original foundation of the whole, come to be looked upon as a sort of accident depending on us, and the possibilities as much more real than the actual sensations, nay, as the very realities of which these are only the representations, appearances, or effects.—When this state of mind has been arrived at, then, and from that time forward, we are never conscious of a present sensation without instantaneously referring it to some one of the groups of possibilities into which a sensation of that particular description enters; and if we do not yet know to what group to refer it, we at least feel an irresistible conviction that it must belong to some group or other; *i. e.* that its presence proves the existence, here and now, of a great number and variety of possibilities of sensation, without which it would not have been. The whole set of sensations as possible, form a permanent background to any one or more of them that are, at a given moment, actual; and the possibilities are conceived as standing to the actual sensations in the relation of a cause to its effects, or of canvas to the figures painted on it, or of a root to the trunk, leaves, and flowers or of a substratum to that which is spread over it, or, in transcendental language of Matter to Form.

"When this point has been reached, the Permanent Possibilities in question have assumed such unlikeness of aspect, and such difference of apparent relation to us, from any sensations, that it would be contrary to all we know of the constitution of human nature that they should not be conceived as, and believed to be, at least as different from sensations as sensations are from one another. Their groundwork in sensation is forgotten, and they are supposed to be something intrinsically distinct from it. We can withdraw ourselves from any of our (external) sensations, or we can be withdrawn from them by some other agency. But though the sensations cease, the possibilities remain in existence: they are independent of our will, our presence, and every thing which belongs to us. We find, too, that they belong as much to other human or sentient beings as to ourselves. We find other people grounding their expectations and conduct upon the same permanent possibilities on which we ground ours. But we do not find them experiencing the same actual sensations. Other people do not have our sensations exactly when and as we have them: but they have our possibilities of sensation; whatever indicates a present possibility of sensations to ourselves, indicates a present possibility of sensations to them, except so far as their organs of sensation may vary from the type of ours. This puts the final seal to our conception of the groups of possibilities as the fundamental reality in Nature. The permanent possibilities are common to us and to our fellow-creatures; the actual sensations are not. That which other people become aware of when, and on the same grounds as I do, seems more real to me than that which they do not know of unless I tell them. The world of Possible Sensations succeeding one another, according to laws, is as much in other beings as it is in me; it has therefore an existence outside me; it is an External World.

"Matter, then, may be defined, a Permanent Possibility of Sensation. . . . . We believe that we perceive a something closely related to all our sensations, but different from those which we are feeling at any particular minute; and distinguished from sensations altogether, by being permanent and always the same, while these are fugitive, variable, and alternately displace one another. But these attributes of the object of perception are properties belonging to all the possibilities of sensation, which experience guarantees. The belief in such permanent possibilities seems to me to include all that is essential or characteristic in the belief in substance. I believe that Calcutta exists, though I do not perceive it, and that it would still exist if every percipient inhabitant in it were suddenly to leave the place, or be struck dead. But when I analyze the belief, all I find in it is, that were those events to take place, the Permanent Possibility of Sensation which I call Calcutta would still remain; that if I were suddenly transported to the banks of the Hooghly, I should still have the sensations which, if now present, would lead me to affirm that Calcutta exists here and now.*—We may infer, therefore, that both philosophers and the world at large, when they think of matter, conceive it really as a Permanent Possibility of Sensation. But the majority of philosophers fancy that it is something more; and the world at large, though they have really, as I conceive, nothing in their minds but a Permanent Possibility of Sensation, would, if asked the question, undoubtedly agree with the philosophers; and though this is sufficiently explained by the tendency of the human mind to infer difference of things from difference of names I acknowledge the obligation of showing how it can be possible to believe in an existence transcending all possibilities of sensation, unless on the hypothesis that such an existence actually is, and that we actually perceive it.

"The explanation, however, is not difficult. It is an ad-

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* For analysis to be wholly exact, it should read, I think:—"If any being whatever, analogous to myself, were transported to the banks of the Hooghly, he would have, etc." The permanent possibility is absolutely general.

mitted fact that we are capable of all conceptions which can be formed by generalizing from the observed laws of our sensations. Whatever relation we find to exist between any one of our sensations and something different from *it*, that same relation we have no difficulty in conceiving to exist between the sum of all our sensations and something different from *them*. The differences which our consciousness recognizes between one sensation and another give us the general notion of difference, and inseparably associate with every sensation we have, the feeling of its being different from other things: and when once this association has been formed, we can no longer conceive anything, without being able, and even being compelled, to form also the conception of something different from it. This familiarity with the idea of something different from *each* thing we know makes it natural and easy to form the notion of something different from *all* things that we know, collectively as well as individually. It is true we can form no conception of what such a thing can be; our notion of it is merely negative; but the idea of a substance, apart from its relation to the impressions which we conceive it as making on our senses, *is* a merely negative one. There is thus no psychological obstacle to our forming the notion of a something which is neither a sensation nor a possibility of sensation, even if our consciousness does not testify to it; and nothing is more likely than that the Permanent Possibilities of sensation, to which our consciousness does testify, should be confounded in our minds with this imaginary conception. All experience attests the strength of the tendency to mistake mental abstractions, even negative ones, for substantive realities; and the Permanent Possibilities of sensation which experience guarantees are so extremely unlike in many of their properties to actual sensations, that since we are capable of imagining something which transcends sensations, there is a great natural probability that we should suppose these to be it.

"But this natural possibilty is converted into certainty, when we take into consideration that universal law of our experience which is termed the law of Causation, and which makes us mentally connect with the beginning of every thing some antecedent condition or Cause. The case of Causation is one of the most marked of all the cases in which we extend to the sum total of our consciousness, a notion derived from its parts. It is a striking example of our power to conceive, and our tendency to believe, that a relation which subsists between every individual item of our experience and some other item, subsists also between our experience as a whole, and something not within the sphere of experience. By this extension to the sum of all our experiences, of the internal relations obtaining between its several parts, we are led to conceive sensation itself—the aggregate whole of our sensations—as deriving its origin from antecedent existences transcending sensation. That we should do this, is a consequence of the particular character of the uniform sequences, which experience discloses to us among our sensations. As already remarked, the constant antecedent of a sensation is seldom another sensation, or set of sensations, actually felt. It is much oftener the existence of a group of possibilities, not necessarily including any actual sensations, except such as are required to show that the possibilities are really present. Nor are actual sensations indispensable even for this purpose; for the presence of the object (which is nothing more than the immediate presence of the possibilities) may be made known to us by the very sensations we refer to it as its effect. Thus, the real antecedent of an effect—the only antecedent which, being invariable and unconditional, we consider to be the cause—may be, not any sensation really felt, but solely the presence at that or the immediately preceding moment of a group of possibilities of sensation. Hence it is not with sensations as actually experienced, but with their Permanent Possibilities, that the idea of Cause comes to be identified: and we, by one and the same process, acquire the habit of regarding Sensation in general, like all our individual sensations, as an Effect, and also that of conceiving as the causes of most of our individual sensations, not other sensations, but general possibilities of sensation. . . . . It may perhaps be said that the preceding theory gives, indeed, some account of the idea of Permanent Existence which forms part of our conception of matter, but gives no explanation of our believing these permanent objects to be external, or out of ourselves. I apprehend, on the contrary, that the very idea of anything out of ourselves is derived solely from the knowledge experience gives us of the Permanent Possibilities. Our sensations we carry with us wherever we go, and they never exist where we are not; but when we change our place we do not carry away with us the Permanent Possibilities of Sensation: they remain until we return, or arise and cease under conditions with which our presence has in general nothing to do. And more than all—they are, and will be after we have ceased to feel, Permanent Possibilities of Sensation to other beings than ourselves. Thus, our actual sensations, and the permanent possibilities of sensation, stand out in obtrusive contrast to one another: and when the idea of Cause has been acquired, and extended by generalization from the parts of our experience to its aggregate whole, nothing can be more natural than that the Permanent Possibilities should be classed by us as existences generically distinct from our sensations, but of which our sensations are the effect. . . . . If all these considerations put together do not completely explain and account for our conceiving these Possibilities as a class of independent and substantive entities, I know not what psychological analysis can be conclusive."*

In my opinion, this is so, save in a point we have already indicated. These *possibilities* of sensation constituted by the presence of all the conditions of the sensation, but one, are transformed into *necessities*, when this last absent condition becomes added to the rest. I see a table; which means that,

* Mill, "Examination," etc. pp. 192–205.

having a particular visual sensation, I conceive and affirm the possibility of certain sensations of muscular movement, resistance, and feeble sound in every sentient being; but it also means that if to the existence of a sentient being we add a further condition, some movement which will put his hand in contact with the table, there will be, in his case, no longer a simple possibility, but further than this, the necessity of these sensations. These necessities, set apart and considered separately, are what we call forces.* Force or necessity, these two terms are equivalent; they indicate that the event in question *must* become accomplished; both one and the other are particularities, modes of being extracted from the event and isolated by a mental fiction. But as the law predicting the event under certain conditions is general, and therefore permanent, both one and the other appear as permanent, and are found to be erected into substances, which puts them in opposition to transient events and classes them apart.—At present, under the name of forces, permanent possibilities are reducible without difficulty to what we term matter and body; we have no hesitation in admitting that the world in which we are placed is a system of forces; at all events, this is the conception of the most profound physicists. Various forces, which, under various conditions, excite in us various sensations: in this we have bodies in their relation to ourselves, and to all beings analogous to us.

VI. What a body is with relation to another remains to be investigated.—We must first observe that the majority of bodies which we perceive change, at least in many respects, and that daily experience has no difficulty in ascertaining these changes. They change, which means that, in the group of permanent possibilities constituting them, some particular possibility perishes; in other words again, among the possible sensations which denote a body, some particular sensation ceases to be possible. The top of this stove was cold a

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* Part i. book iv. ch. iii. p. 216

short time ago; now the fire has been lighted, it is hot. This ball of wax is spherical, hard, odorous, capable of rendering a slight sound; when placed on the hot stove it becomes soft, loses its sonorousness and smell, and becomes a thick liquid. This green leaf has no longer any color in the dark. I left this book on my table, and find it on one of the shelves of the bookcase.—In all these cases, one or more of the possibilities of sensation constituting the object have disappeared, but are replaced or not by others of the same kind.—All these changes of bodies are, at bottom, conceived and conceivable only with relation to sensations, since they are all reduced, in final analysis, to the extinction or arising of a possibility of sensation. But, from another point of view, though bodies are but possibilities of sensation, these changes are none the less changes of bodies, and it is from this point of view that we usually consider them. When we no longer find a sensation on which we were accustomed to reckon, we do not ascribe the change to ourselves, but to the body; we say that it has changed its position, figure, size, temperature, color, taste, smell, and though its history may be only definable by us through ours, we confront its history with ours, as a series of events opposed to another series of events.

On this two new series of properties become added to it, and perfect its being.—On the one hand we observe that it is capable of certain precise changes under certain precise conditions; it may change place, figure, magnitude, consistence, color, smell; may be divided, may become solid, liquid, gaseous, be heated, cooled, etc. We conceive it with relation to its possible events as we conceived it with relation to our possible sensations, and, to the first group of possibilities and permanent necessities by which we constituted it, we associate a second.—On the other hand we observe that certain of its events excite certain changes in other bodies. The marble in motion displaces another marble. An acid solution reddens litmus paper. The heated stove evaporates water placed on it. A scrap of heated iron brought near a thermometer dilates the alcohol. By these various observations we prove that certain bodies are capable, under certain precise conditions, of exciting certain changes in other bodies, and we no longer define them by reference to our events, nor by reference to their own events, but by reference to the events of the other bodies. In this respect, too, a body is still a group of permanent possibilities and necessities, and, with these three relationships, we have completely constituted it.—It can, and under certain conditions it must, excite in us certain muscular and tactile sensations of resistance, extension, figure, and situation, certain sensations of temperature, color, sound, taste, and smell: these are its sensible properties.—It can, and under certain conditions it must, go through certain changes of consistence, extension, figure, position, temperature, taste, color, sound, and smell: these are what we may call its intrinsic properties.—It can, and under certain circumstances it must, excite in some other body some change of consistence or extension, or figure, or position, or temperature, or of taste, smell, color, and sound: these are its properties with relation to other bodies.—All these properties exist only with relation to events; to state them is to predict some event of ourselves, of the body in question, of another body, to enunciate it as possible under certain conditions, as necessary under the same conditions with a complementary one added to them, in short, to state a general law; and all these events, our own, those of the body in question, those of the other bodies, are defined in final analysis by our events.

The case is altered, when, from among this enormous multitude of properties, we attempt to set aside fundamental properties. Sentient beings are but a rank in the prodigious army of distinct beings which we observe or divine in nature, and our events are but a trifling quantity in the enormous mass of events. The Ego is a single reagent among a hundred million others, one of the most perishable, one of the most easily deranged, one of the most inaccurate, one of the most insufficient. In the place of its notations we substitute other equivalent notations, and we define the properties of bodies, not by our events, but by certain of their events. Instead of our feeling of temperature we take as guide the elevation or lowering of the alcohol in the thermometer. Instead of the muscular sensation we experience in raising a weight, we take as guide the elevation or lowering of the scale of the balance. Among these indicating events, there is one which is very simple and more universally spread through nature than any other —motion, or passage from place to place, with its different degrees of velocity.—We first observe it in ourselves; the primitive notion we have of it is that of the more or less energetic muscular sensations, whose longer or shorter series accompanies the bending or extension of our limbs. Just as, by analogy and induction, we attribute to organized bodies, sensations, perceptions, emotions, and other events similar to our own, so we attribute to all bodies motion similar to our own. But, as by verification and rectification, we gradually limit the too close resemblance we at first imagined between the inferior animals and ourselves, so we gradually limit the too great resemblance which we at first imagined between the motion of inanimate bodies and our own. The child believed, and has ceased to believe, that its hoop jumped and ran away, that its ball ran at it and tried to hurt it. Men imagined and have at last ceased to imagine the flight of the projectile as an effort* analogous to their own; they have recognized the metaphor for a metaphor, and have reduced it so that it may correspond with a body incapable of intention and sensation. Instead of conceiving motion as a series of successive sensations interposed between the moments of departure and arrival, he now conceives it as a series of successive states interposed between the moments of departure and arrival; by this retrenchment, the kind and quality of the elements which compose the series are omitted; nothing remains but their number and order, and the notion is applicable, not merely to sentient bodies, but to all bodies.

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* *Nisus.*

This being settled, he gradually discovers that, in his definitions of bodies and their properties, a mode or particularity of motion so conceived may take the place of his sensations. He called that solid which excited in him the sensation of resistance; he now calls solid whatever arrests the progress of any body in motion. He conceived empty space by his muscular sensations of free locomotion; he now conceives it by the unarrested motion of any body whatever. He represented lines, surfaces, and solids by more and more complex groups of which his sensations of locomotion, contact, and resistance formed the elements; he now defines the line by the motion of a point; the surface by the motion of a line; the solid by the motion of a surface. He estimated force by the magnitude of his sensation of effort; he now measures it by the velocity of the motion it impresses on a given mass, or by the magnitude of the mass on which it impresses a motion of a given velocity.—He thus attains the conception of body as a *movable motor*, of which velocity and mass are equivalent aspects. Thus, all the events of physical nature are motions, each of them being defined by the mass and velocity of the body in motion; and each being a quantity which passes from body to body without ever increasing or diminishing. Such is at present the mechanical idea of nature. Among the various classes of events by which we can define things, man chooses one, refers to it the majority of the others, and imagines that some day he will be able so to refer the rest. But if we analyze the one he has chosen, we discover that all the original and constituting elements of his definition are, like the definitions of all the rest, nothing more than sensations, or more or less elaborated extracts from sensations.

VII. Among these extracts from sensation by which, in final analysis, we invariably conceive and define bodies, is there any one which we may legitimately attribute to them? Or are bodies, indeed, nothing more than a simple collection of permanent powers or possibilities, of which we can affirm nothing except the effects they excite in us? Or, indeed, as Bain and Mill, following Berkeley, think, are they pure non-entity, erected by an illusion of the human mind into substances and external things? Is there nothing more in nature than series of transient sensations which constitute sentient subjects, and the durable possibilities of these same sensations? Is there nothing *intrinsic* in this stone? Do we only discover in it *relative* properties, for instance, the possibility of certain tactile sensations for a sentient subject, the necessity of these same tactile sensations for the sentient subject who will give himself a certain series of muscular sensations, that is to say the series of muscular sensations in consequence of which his hand will arrive at touching the stone?—We have already seen that what constitutes a distinct being, is a distinct series of facts or events. Consequently, in order that this stone may be, not the simple permanent possibility of certain sensations of a sentient subject, a vain and ineffectual possibility in case all sentient subjects were suppressed, it is necessary that it should be, in addition, a distinct series of facts, or of real or possible events—events which would still be produced in the absence of all sentient beings. May we by induction and analogy attribute to it such a series?—All followers of Berkeley are agreed that we may legitimately do so by induction and analogy, when, instead of a stone, we are dealing with a sentient subject, man or animal, other than ourselves. In this case not only do we conceive the object perceived by our senses as a collection of permanent possibilities, but more than this, we rightly attribute to it a series of sensations, images, and ideas, more or less analogous to our own, and we legitimately transfer to it events which pass in us. By this transfer, instead of the simple possibility which it was, it becomes an actual thing in the same way as ourselves, and we recognize in it a distinct existence, independent of ours, since the events which constitute it, though proved by us, have no need of our events for their production and succession.

Is there any series of internal events which we may, still by induction and analogy, transfer from ourselves to the stone, in order to confer on the stone the independent and distinct existence which we have conferred on the being similar to ourselves or on the animal?—Yes, certainly, at least in my opinion, and by means of preliminary eliminations. As we have seen just now, from the series of muscular sensations by which we conceive motion, we cut away all the characters which can distinguish it from another series. After this great suppression, it is nothing more for us than an abstract series of successive states, interposed between a certain initial moment and a certain final moment. Each of these component states has been stripped of all qualities, and is defined only by it position, in the series, as being nearer or more distant from the initial or the final moment. It is this series, more or less short, of successive states comprised between an initial moment and a final moment, and defined only by their reciprocal order, that we term pure motion.—Now, we have all the reasons in the world to attribute this to the unknown things we term bodies, to be certain that it passes from one to another of them, and to lay down the laws of such communication. In fact, if all sentient beings were suppressed, our stone would still subsist; and this does not merely mean that the possibility of certain visual, tactile, and other sensations would still subsist; it also means that the unknown things we term molecules, and which make up the stone, would still subsist; in other words that the movable motive powers of which the stone is the aggregate would continue to weigh on the ground proportionately to their mass, and would go through the same internal oscillations as they do at present. Whatever be the being, animate or inanimate, we may consider it in two aspects, with relation to others, and in itself.—In relation to others, it is a condition of events for the others, and, especially with relation to us, it is a condition of sensations for us; in this respect it is determined, but solely with relation to us, and we can say nothing more of it than that it is the permanent possibility of certain sensations for us.—On the other hand, in itself, it is a series of events which, in certain conditions, tend to be accomplished; in this respect it is determinate in itself, and we may say of it that it is this series conjoined to the tendencies by which it is accomplished. —This man is, first, the permanent possibility of tactual, visual, and other sensations, which I experience in his neighborhood; and further, he is a distinct series of sensations, images, ideas, and volitions, conjoined to the tendencies by which this series is accomplished. So, too, this stone is, first, the permanent possibility of visual, tactile, and other sensations, which I experience in its neighborhood; and further, it is a distinct group of tendencies to motion, and of distinct motions in way of being accomplished.

No doubt, we know nothing of animate or inanimate beings except from the sensations they give us. No doubt, too, the various materials with which we internally construct their idea are our sensations, or more or less elaborated extracts from our sensations. But we may, upon authentic evidence, refer to things external, some of these more or less transformed and reduced materials, and attribute to such things a distinct existence without us, analogous to that which they have within us. We are naturally inclined by imagination and sympathy to this operation. At the sight of a rocket fired off, just as at the sight of a flying bird, we involuntarily put ourselves in the place of the object; we mentally repeat its flight; we imitate it by our attitude and gestures. Infant nations, in whom this aptitude is intact, carry it out to far greater extents than we do. The primitive man, Aryan or Greek, bestowed his soul upon fountains, rivers, mountains, clouds, the air, upon all the aspects of the heavens and the day; he saw in inanimate things, living beings similar to himself. Gradually, by means of experiences and verifications, we have restrained this too complete transference of ourselves to external things. At present, we have reduced it to a minimum; we have suppressed even the last vestiges of the primitive error; we no longer attribute to inanimate things, attractions, repulsions and efforts, conceived on the model of our mental states denoted by these words; when we use such language, we know that it is merely by approximation and metaphor. If we attribute motion to bodies, it is after stripping its elements of all human qualities, after taking from them all the characters by which they were at first sensations, by carefully leaving nothing of them but their relative order, their position in relation to the inital and final moment, their more or less speedy succession in the same interval of time. In this state of extreme attenuation and curtailment, the continuous series of successive events constituting the motion of a stone we throw, is nothing more than a very slight extract, the slightest possible extract, of that continuous series of successive muscular sensations first constituting to us the motion of our hand. But we may justly attribute such a series to the stone, and in this respect, it is to us a being as real, as complete, as distinct from us, as any particular man or horse.*

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* By this addition to the theory of Bain and Mill, we restore to bodies an actual existence, independent of our sensations. But the theory, with the aid of this addition, leads us much further, and enables us to complete the views we have already presented upon the relations of physical and mental events. (See part i. book iv. ch. ii. p. 200.)

It follows, from the analysis of motion, that it is not absolutely heterogeneous to sensation: for our idea of it is formed from the materials supplied by our muscular sensations of locomotion. In the series of successive muscular sensations which make up a whole sensation of locomotion, strip the component sensations of all intrinsic quality and difference; consider them abstractedly, as pure successive events, determined solely by their relative order in the series, and by the whole time they take to succeed one another in this order from the initial to the final moment; it is this abstract series which constitutes to us the movements of our arm, and which we attribute by induction and analogy to the stone our hand carries with it.—Now, the elements of this abstract series being thus brought down to the maximum degree of possible simplicity, may be considered as *elementary* sensation at their maximum of possible simplicity. In such a case the most simple motion, such as we attribute to a movable point, would be precisely the most simple series of those elementary mental events, whose degraded forms we have seen extending, while becoming still more degraded, under the compound mental events, sensations,

VIII. We now know the materials by whose assemblage the conception of a body is formed. All these materials are images of sensations, possible under certain conditions, and necessary, under the same conditions, with a complementary one added. When nothing contradicts this conception, and when, instead of being repressed and negative, it is excited and sustained by the actual sensation, it is affirmative and becomes a judgment. Therefore, we now see the part it plays in an external perception. I lay my hand in the dark on this marble table, and I have an actual sensation of contact, of resistance, and of cold. Upon this sensation, images arise of many distinct and interconnected sensations, that of the precisely similar sensations of contact, resistance, and cold, which I should experience if I repeated the trial, that of the nearly

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and images, of which we are conscious. Sensations and images would thus be but more complex cases of motion.—By this reduction, the two idioms, of consciousness and of sense, by which we read the great book of Nature, would be reduced to a single one ; the mutilated text and the mutilated interlinear translation which mutually supply one another would be one and the same tongue, written in different characters, with more complex characters in the supposed text, with more simple characters in the supposed translation, and the link connecting the translation and the text would be found in the relation discovered between our idea of motion and the muscular sensation of locomotion which supplies the elements of this idea.

If this be admitted, we are enabled to include nature in a general glance. The simultaneous series of successive events composing it would be all homogeneous. Their type would be furnished us by the sensation as we observe it in ourselves, and in the elementary sensations, more and more degraded and simplified, of which this whole sensation is made up. *At the extreme limit* of simplicity all would be reduced to motions, which would themselves be nothing more than continuous series of infinitesimal sensations, stripped of all quality, and definable only in respect of quantity, that is to say by the duration employed in their accomplishment, and by the magnitude of the succeeding effect. In this respect, all the facts and events of nature might be reduced to motions, and our sciences, all of which have for their object the discovery of simple elements, might all be reduced, as indeed all tend to be reduced, to mechanics.—But this would be so, from the analytical aspect only. Motion itself would be conceivable only by the series of muscular sensations of which it is the most slender extract, and, directly, the type of existence would be the mental event, sensation, or image, just as consciousness presents it to us.

similar sensations of contact, resistance, and cold, which I should experience if I placed my hand beyond the spot I touched, that of the muscular sensations of locomotion, during which these tactile sensations would be received, and at whose expiration they would be no longer received, that of the visual sensations of color and form, which would arise in me if there were light and my eyes were open, etc. I further believe that, by placing myself under the required conditions, not only might I experience the sensations in question at any moment of the future, but, moreover, that I might have experienced them at any moment of the past, and that the same would happen at any moment of the present, past, or future, with every being analogous to myself.

In this group of images called up by the sensation, two things must be distinguished, the images themselves, and the reflection by which I remark the permanent possibility, at all times and for every sensibile being, of the sensations which they represent. The first of these two things is animal, the second is human.—In fact, animal experience is sufficient to attach the group of images to the sensation; we have seen the laws of revival and association which form and arouse it. When a dog touches the table, all the images we have enumerated arise in him as in us; consequently he can foresee, as we do, that if he runs against the table he will be bruised, that if he lies down on it he will feel cold, that if he opens his eyes to look at it he will have a certain visual sensation. This is sufficient to enable him to avoid danger, to provide for his wants, to direct his proceedings. If he sees, smells, or touches a piece of meat, he has, by revival and association, the image of a sensation of pleasant taste, and this image induces him to snap it up. When he sees a lifted stick or hears the crack of a whip, he has, by revival and association, the image of a painful sensation of touch, and this image induces him to run away. In his case there is nothing more; he is not possessed of language, he has not the means of discerning and isolating the characters of his image.—We have these means, and avail ourselves of them. The child learns the words *table*, *stick*, *meat*, *stone*, *tree*, and others; they gradually become equivalent for him to the group of animal images which first constituted his whole perception. He incessantly avails himself of them; when grown up, he enquires into their meanings and couples them. The man then observes that the sensation of which he has the image was possible just before, that same morning, the day before, that it will be possible presently, this evening, to-morrow, and at every intervening moment, and not only for him, but for evey being analogous to himself. He notes this possibility; he disengages it from the sensations in which it is included; he is struck by the singularity of its independence and permanence in the midst of the continuous flow and manifest dependence of the sensations. He denotes it by the words property, power, force. As it is independent and permanent, it seems to him alone worthy of attention, and henceforth, to fill the scene of being, he puts it into the first rank with other similar Possibilities.—He correspondingly discards or lays aside as of small importance fugitive sensations, and, owing to their omission, forgets that properties, powers and forces are but extracts from them. He attempts to consider, apart and in itself, this permanent and independent thing which he has only isolated by an oversight. Thus, he creates an empty substance; metaphysics sets to work and builds her card-castles upon this entity; in order to upset them the most rigorous analysis is hardly sufficient.—There remains, then, to constitute the perception of a body, first, an actual sensation and an associated group of images, next, the conception, that is to say the extraction and notation by means of a sign, of a character common to all the sensations represented by these images, a permanent character which, when interpreted by metaphysical illusion, becomes isolated and appears a separate being. Sensations and images, these form the crude and primitive materials; gradual and superadded abstraction completes the edifice.—Here we have the first foundation of the hallucinatory semblance which arises in us, when, upon a sensation, we conceive and affirm an extended, resisting, movable substance, localized, and possessed of other sensible properties. The operation which completes it and opposes it to ourselves, by casting it into the distance and situating it without us, remains to be described.

CHAPTER II.

EXTERNAL PERCEPTION AND THE EDUCATION OF THE SENSES.

I. ALONG with the great mental process of which we have been speaking, another is accomplished, as involuntary, as silent, and as fruitful in illusions and cognitions. Every special sensation becomes transformed, and acquires an apparent position. We never now experience a sensation without assigning it a place. As soon as we have an impression of cold, of heat, of pain, of contact, of muscular contraction, of taste, of smell, we can point out more or less precisely the spot at which we feel it, as—in the hand, the cheek, the middle of the arm, the nose, the tongue.—There is no appreciable interval between this judgment and the sensation itself; we are even tempted to believe that the two events are one, and that we observe, at the same moment, the twitch of pain and its locality. There is, though, an interval between these two observations, and the delicate processes employed by physiologists have recently succeeded in measuring it;* the fact is that the operation by which we localize our sensation in a particular spot of one of our limbs is a subsequent and more or less complex addition, whose more or less numerous moments require for their succession a longer or shorter time.†

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* Experiments of Helmholtz, Marey, De Bezold, Hirsch, Van Deen, Donders, De Jaager, Wolf. Collected and summed up by M. Radau, in the "Revue des Deux Mondes," 1 Aug. 1867, p. 794.

† M. de Jaager told the person on whom he was experimenting to touch the key of the electric machine with his left hand, when he received the shock on his right side, and with his right hand when he received the shock on his left side. Thus, two cases were presented. Sometimes the person was told beforehand that

—By this localizing operation our sensation receives a false appearance, and this appearance begets others, which are, in themselves, illusions, but which, by their correspondence with things, constitute the perfectionment or education of the senses.—When once the sensation has arrived at this state, the bodies it reveals to us correspondingly receive new characters; the hallucinatory semblance which constitutes external perception is completed; and the object, which appeared only as something permanent and fixed, now appears as something *beyond us* and *without us*.

II. I put my foot to the ground; I experience a sensation of pressure, and determine that it is situated in my left foot,

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the shock would be received on a particular side, the right, for instance; in this case, the interval between the shock he received and the consecutive signal he gave amounted to ·2 of a second. Sometimes he was not told on what side he would receive the shock, and the shock came, for instance, from the right; in this case the interval between the shock he received and the consecutive signal he gave amounted to ·27 of a second. The difference, then, between the two cases amounted to ·07 of a second.—It is clear that in each case the crude sensation was produced at the same instant; but, in the first case the image of the shock on the right was fully prepared to enter on the scene, and was not counterbalanced, as in the second case, by the equal readiness of the image of the shock on the left. To upset this equilibrium, and to permit the image of the shock on the right to attach itself by selection to the supervening sensation, required a certain time, and by the experiment the time required is ·07 of a second.—In general, between a sensation and a consecutive signal there elapses two-tenths of a second, and, if the sensation, that of a momentary sound, of an electric shock, of a spark, requires to call up an auxiliary image, it employs, when this image is not in readiness or is counterbalanced by another, one-tenth of a second longer than when this auxiliary image is in readiness, or has no antagonist.—Images, then, require an interval of time to connect themselves to the sensation, and this interval is increased when their calling up is less prepared or more disputed.

MM. Donders and De Jaager made the experiment in a slightly different manner. One of them pronounced a syllable, the other repeated it as soon as he heard it; the vibrations of the word were registered by a phonautograph; when the repeated syllable had been agreed on beforehand, the difference observed was two-tenths of a second; in the other case, it was three-tenths.—Analogous results were obtained by an observer noting the appearance of a white or red light, and being, in turn, informed and not informed which would be shown.

that it is strong in the middle of the foot, light at the heel, scarcely perceptible at the toes. Let us consider this conclusion; taken in itself, it is false; the sensation is not in my foot. In this case, physiologists long ago detected the error and established the theory. The truth is that a disturbance is produced in the nerves of the foot, of greater extent in the sole, and of less at the toes and heel, that this disturbance is communicated throughout the whole course of the nerves to the sensory centres of the encephalon, and that the sensation really takes place in the encephalon. We are mistaken in situating it in the periphery of the nervous system, it is at the centre; what is produced in the foot is not the sensation, but the commencement of the nervous disturbance of which the sensation is the final result.

There are superabundant proofs of this. They may be all summed up by saying that, in many instances, the sensation appears situated in a place where it certainly is not. By means of these instances we prove a general law: that, in our present state, as soon as a sensation arises, it is accompanied by a judgment in which we pronounce it to be situated in some particular spot. It may be that, in such a case, there actually is a nervous disturbance at this spot, or, it may be, that there is no such disturbance there. It matters little; the judgment takes place in the second case as well as in the first, the sensation, by itself, is sufficient to give rise to the judgment, and acquires through the judgment an apparent situation. The situation, then, was acquired in the first case, when nervous disturbance was existing at the indicated spot, just as in the second case, in which no nervous disturbance was existing there. When once it is established, in accordance with the second case, that a certain position attributed to a certain sensation is apparent only, it invincibly follows that, in the first case, the same position attributed to the same sensation is also apparent only. If, then, in the first case, we find anything at all at the indicated spot, it is not the sensation, but one of its antecedents or consequents, an event connected with it, and which it denotes, a real event, no doubt, but other than the sensation, and which, by a happy correspondence, usually accompanies the sensation in the normal state.

Let us now consider the cases by which we are undeceived. There is, first, a class already mentioned, that of persons who have lost limbs. "It is a fact," says Mueller, "known to all surgeons, and subject to no exception, that when a limb has been removed by amputation, the remaining portion of the nerve which ramified in it may still be the seat of sensations, which are referred to the lost part. It is usually said that the illusion continues for some time, namely, as long as the patient is under the care of the surgeon; but the truth is, that in most cases it persists throughout life: of this it is easy to convince oneself by questioning a person whose limb has been amputated, at any period after the operation. The sensations are most vivid while the surface of the stump and the divided nerves are the seat of inflammation, and the patient then complains of severe pain felt as if in the whole limb which has been removed. When the stump is healed, the sensations which we are accustomed to have in a sound limb are still felt; and frequently throughout life there is a tingling, and often pain, felt, which are referred to the parts that are lost. These sensations are not of an undefined character; the pain and tingling are distinctly referred to single toes, to the sole of the foot, to the dorsum of the foot, to the skin, &c. . . . . I have convinced myself of the constancy of these sensations—of their continuance throughout life—although patients become so accustomed to them as to cease to remark them. . . . . A man whose thigh had been amputated, still had, after the expiration of twelve years, feelings which seemed to be in the toes and sole of the lost foot, and occasionally severe pains referable to the sole. . . . . I applied a tourniquet to the stump, so as to press upon the ischiatic nerve; and he immediately said that he felt his leg asleep, and a very distinct tingling in the toes. . . . . Another, who had his arm amputated above the elbow, thirteen years ago, has never ceased to have sensations as if in the fingers. He imagines that he feels the hand in a bent position. He feels a pricking in the fingers, particularly when he lies upon the stump, so as to press the brachial nerves. I applied pressure to the nerves in the stump; and he immediately felt the whole arm, even the fingers, as if asleep. . . . . Another, whose right arm had been shattered by a cannon-ball in battle, above the elbow, twenty years ago, and afterwards amputated, had still, at changes of the weather, distinct rheumatic pains, which seemed to him to exist in the whole arm; and though removed so long ago, the lost part was, at those times, felt as if sensible to draughts of air. This man also completely confirmed our statement, that the sense of the integrity of the limb is never lost." *—These illusions are strongest at night; the patients are sometimes then compelled to put their hands to the spot where their limb ought to be, to convince themselves of its absence. When the subsisting portions of the nerves become painful, they have still more difficulty in rectifying their error; one man, after eight months had elapsed, could only undeceive himself by feeling at night and looking by day at the empty place left by the amputation of his left arm.—It is plain that in all these cases the sensation of twinging, of the limb being asleep, of tingling, of pain, is not situated in the absent limb, therefore *the same* sensation is not situated in the limb, when the limb is there; thus, in the two cases, in the normal and the abnormal state, the sensation has not the situation we attribute to it; it is elsewhere; it is not the sensation, but a nervous disturbance which, in the normal state, occupies the place at which the sensation seems to be. The nerve is a simple conductor; from whatever point its disturbance may start on its way to arouse the action of the sensory centres, the same sensation is produced, and involves the play of the same internal mech

* Mueller, "Physiology" (tr. Baly), i. 694, 695, *n.*

anism, that is to say, the attribution of the sensation to some spot other than the sensory centre.

Numbers of facts are explicable by this observation: a violent blow on the cubital nerve excites a pain which appears to be situated through all the ulterior course of the nerve, especially at the back and palm of the hand, in the fourth and fifth fingers.—The same thing happens, if the elbow be plunged into a mixture of water and pounded ice.—Again, when the cubital or sciatic nerve is compressed, the feeling of pricking or of being asleep seems to be experienced by the internal parts of the limb. "In an amputation," says Mueller,* "at the moment of the division of the nerves, the most violent pains are felt, as if in the part which is being amputated, and to which the divided nerves are distributed. The experienced surgeon of the Hamburg hospital, Dr. Fricke, assures me that this is a constant phenomenon."—For the same reason, disease of the nervous trunk, or of the marrow, excites pains or tinglings which the patient believes to be situated in the healthy extremities of his limbs.—So, too, certain paralyzed persons, whose external parts are wholly insensible to pricking and burning, still feel in them pains and twitchings.—Lastly, take the cases in which the peripheral parts of the nerve are not paralyzed, but displaced, as happens in the transposition of portions of skin. The sensation, being the same as before the transposition, will be accompanied by the same localizing operation, and will appear situated in the original spot. In fact, "when, in the restoration of the nose, a flap of skin is turned down from the forehead and made to unite with the stump of the nose, the new nose thus formed has, as long as the isthmus of skin by which it maintains its original connections remains undivided, the same sensations as if it were still on the forehead; in other words, when the nose is touched the patient

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* Mueller, op. cit. (tr. Baly), i. 691.

feels the impression on the forehead."* We may confidently decide, then, that the sensation, though really situated in the sensory centres, has the property, at least in our present state, of invariably appearing to be situated elsewhere.

Let us follow out the examination; our assurance will be further strengthened, and we shall begin, at the same time, to distinguish the law which regulates the localizing operation.—In all the foregoing cases it localized our sensation at the periphery of the nerve, from which the nervous disturbance resulting in the sensation usually starts. But this is not always so. There are parts of our bodies, like the teeth and hair, which are not provided with nerves, and which are, in themselves, wholly insensible; but still we situate many of our sensations at the external extremities of these parts, where no nervous disturbance can possibly be produced.† "If some part of the beard," says Weber, "for instance, at the side of the cheek, be lightly touched, where do we imagine that we feel this pressure exercised on the hairs of our skin? Not in the sensible parts, to which it is propagated through the horny cylinders, and at which it acts on our nerves, but at some distance from the skin. . . . . If we put a little piece of wood between our teeth, and press it with them, we imagine the resistance it offers to be situated at the surface of the teeth, where, however, there are no nerves, and where, consequently, we can feel nothing. On the other hand, we have no feeling whatever of the pressure exercised on the internal surface of the root of the tooth in the alveolus in which it is hidden; though this is where the propagated pressure is actually exercised upon the highly nervous membrane surrounding the root of the tooth, and is the only spot at which it acts on our nerves."—Further than this: "not only do we wrongly situate pressure acting on the sur-

* Mueller, op. cit. (tr. Baly), i. 697.

† Weber, Article *Tastsinn* in the "Handwörterbuch" of Rudolph Wagner, iii, part ii. p. 488 et seq.

face of the insensible substances growing from our skin, but we also make the same error when we place a little stick between our fingers and feel with it a resisting body, as for instance, the table." In this case, two sensations are simultaneously produced, one which appears to be situated at the extremity of our fingers, the other at the extremity of the stick. If the stick be fixed to the extremity of our fingers and movable at the other end, the first sensation is effaced and the second predominates. If the stick is movable at the extremity of our fingers and fixed at the other extremity, the inverse is the case.—By this experiment we determine the law of the operation; evidently, the localizing judgment situates each of our sensations in the spot in which we are accustomed to meet with the cause or condition which is accustomed to excite it.* If, from birth, the stick had been attached to one of our hands, like the long sensitive exploring whiskers of a cat are attached to its cheeks and lips, like the stag's horn is attached to its brow, and our beard and teeth are attached to our membranes, we should situate things we came into contact with at the end of the stick, as the cat probably situates what it touches at the end of its whiskers, and the stag at the end of its horns, as it is very certain we situate our contacts at the extremities of our beard and teeth.

III. The consequence is that when a sensation has for its usual condition the presence of an object more or less distant from our bodies, and experience has once made us acquainted

* Vulpian.—"Leçons sur la Physiologie du Système Nerveux," 287. Experiment of Paul Bert.

The tail of a rat is cut raw with a bistoury and implanted in the animal's back, where it becomes grafted. The tail is then divided at about a centimetre from its root. The rat will then have it growing backwards, out of its back. For the first three months, there are feeble signs of sensibility when the tail is pinched. "After six or nine months, the sensibility is much increased, but the animal does not yet recognize the spot in which he is pinched. After a year, he is perfectly aware of the spot, and will turn round to bite the pincers." We see here the proof that experience must intervene to enable the animal to localize its sensations.

with this distance, we shall situate our sensation at this distance.—This, in fact, is the case with sensations of hearing and sight. The peripheral extremity of the acoustic nerve is in the deep-seated chamber of the ear. That of the optic nerve is in the most inner recess of the eye. But still, in our present state, we never situate our sensations of sound or color in these places, but without us, and often at a considerable distance from us. The ringing of a great bell seems to vibrate high in the air and very far off; a railway whistle seems to pierce the air at some fifty paces to the left.—The position, even when distant, is clearer still in the case of visual sensations. This extends so far that our sensations of color seem detached from us; we no longer observe that they appertain to us; they seem to form a part of the objects; we believe that the green color which seems extended three paces from us on the surface of this arm-chair is one of its properties; we forget that it only exists in our retina, or rather in the sensory centres which the disturbance of the retina disturbs. If we look there for it, we shall not find it there; physiologists may prove indeed that the nervous disturbance which results in a sensation of color commences in the retina, just as the nervous disturbance which results in a sensation of contact commences in the nervous extremities of the hand or foot; they may prove that the vibrating ether strikes the extremity of the optic nerve, as a vibrating tuning-fork strikes the surface of the hand: "we have not the least consciousness of this impression on the retina, even when we direct the whole force of our attention to the spot. *—All our sensations of color are thus projected out of our body, and clothe more or less distant objects furniture, walls, houses, trees, the sky, and the rest. This is why, when we afterwards reflect on them, we cease to attribute them to ourselves; they are alienated and detached from us, so far as to appear different from us. Projected from the nervous surface in which we

* Weber, ibid. 482.

localize the majority of the others, the tie which connected them to the others and to ourselves is undone, and it is undone in accordance with a well-known mechanism, by the obliteration of the imaginative operation which situates the sensation in some particular spot.

In fact, as far as we are concerned, this operation is but a means: we pay no attention to it; the color and the object denoted by the color are what alone interest us. Consequently, we forget or omit to observe the intermediate steps by which we localize our sensation; they are to us as though they did not exist; and we thereupon consider that we directly perceive the color and colored object as situated at a certain distance off.—In consequence of this, a contrast is established between this sensation and others. The others seem to be situated in a body belonging to us and specially connected with us, which we move at will, which accompanies us in all our changes of place, which answers to all our touchings by a sensation of contact, in which we situate ourselves in such a way that it extends over, encloses, and circumscribes our personality. Our sensations of color seem, on the contrary, situated beyond this, on the surface of bodies foreign to ours, beyond the limited constant circle in which we are enclosed. There is nothing strange, then, if we cease to consider them as belonging to us, and end by considering them as something foreign to us. If they are fugitive as a flash of lightning, the ring of fire described by whirling round a burning coal, or an impalpable meteor, they seem to us a simple event with position and shape. If, as usually happens, they are stable like the color of a stone, of a flower, of a tangible object, they seem to us a more or less permanent and fixed quality of that object.

The reason of this is evident. As long as we rest our eyes on the gilded frame of this mirror, the long yellow stripe persists unchanged; the uniform, incessant, prodigiously rapid renewal of the vibrations of ether maintains it without alteration or discontinuity; it does not disappear unless, by a voluntary and foreseen movement of which I have sensation and recollection, I turn away my eyes and head.—Moreover, whenever I look again for this yellow stripe, I invariably find it in the same relative position, to the right of the dark glittering surface presented by the mirror, to the left of the striped gray presented by the paper of the wall.—Further still, the little bright or dark bands formed by the reliefs and hollows of the chasing always preserve the same relative positions in the whole yellow stripe. Consequently, this yellow is not a transitory momentary thing like a flash of lightning; it does not cease of its own accord. Experience shows me that I am sure of finding it again whenever I please; from finding it present, whenever I have turned my eyes towards it in the light, I conclude by induction that it is constantly present, all circumstances remaining the same, at whatever moment of time I have turned or may turn my eyes towards it, in any moment whatever of the past or the future; therefore it occupies them all. Its existence past and future is thus prolonged indefinitely, and it is the same in all these distinct instants. It seems, then, a permanent quality in that group of permanent possibilities we term body.

The truth, however, is that all the colors with which the surrounding world seems decked are within us, and are sensations of our optic centres; the consideration of the sensations of sight we term *subjective* is sufficient to convince us of this. These sensations undeceive and instruct us with respect to sight, just as the illusions of persons who have suffered amputations do with respect to touch. Color is not in the object, nor in the luminous rays which spring from it; for, in many instances, we see it when the object is absent, and when the luminous rays are wanting. The presence of the object and of the luminous rays contribute indirectly only to cause it to rise; its direct necessary and sufficient condition is the excitation of the retina, or which is more important of the optic centres of the encephalon. It matters little whether this excitation be produced by an impingement of luminous rays, or otherwise. It matters little whether it be spontaneous or not. Whatever be its cause, as soon as it arises, the color arises, and, at the same moment, that which we term the visible figure. Consequently, the color and visible figure are but internal events, which appear external. The whole of physiological optics rests on this principle, and, to convince ourselves of its soundness, we have but to look at a few, among the hundreds of cases in which apparent color and figure arise of themselves, without any external object or pencil of luminous rays directly or indirectly setting the nerve in action.

When we have been looking steadfastly at a luminous or strongly illuminated object the excitation of the retina persists after we have ceased to look.* Hence arise the singular phenomena termed *consecutive images.* These, in fact, are complete visual sensations which survive and are prolonged in the absence of their object. According to circumstances, in some cases the brighter portions of the consecutive image correspond to the brighter portions of the object, and the darker portions of the image to the darker portions of the object, and in some cases the inverse. In the second case, the colors of the consecutive image are the complementaries of the colors of the object ; that is to say, where the object is red, the image is of a greenish blue; where the object is yellow, the image is blue ; where the object is green, the image is rose-colored, and *vice versâ.*—A number of analogous phenomena have been observed, and are explained by the persisting excitation and diminished excitability of the retina after undergoing the action of light.—But there are other phenomena of the same kind, which are produced without there being any need for the intervention of light. It is enough in these cases if the retina be set in action by some other cause.† If the eye be compressed with the finger we see luminous figures "sometimes annular, sometimes radiated, sometimes di-

* Helmholtz, "Physiologische Optik," 356 ; Mueller, "Physiology" (tr. Baly), ii. 1394.

† Helmholtz, ib. 418 ; Mueller, op. cit. (tr. Baly), ii. 1163.

vided regularly into squares. If in a room otherwise dark, a lighted candle be moved to and fro, or in a circle, about six inches from the eyes, we soon see a dark arborescent figure whose branches extend over the whole field of vision, and which is nothing more than the expansion of the central vessels of the retina, or that of the parts of the retina covered by those vessels." Sometimes, after compressing the eye, this arborescent figure appears luminous. "Luminous moving points appear in the field of vision when we look fixedly at a surface uniformly illuminated, as, for instance, the sky, or a field of snow, and especially during a brisk walk or some other movement of the body." In cases of plethora or congestion, "when we have been lying down and suddenly rise up, we see a number of little black bodies with tails to them jumping and moving in all kinds of directions."—Different narcotics, digitalis especially, excite flashings in the eyes.—And so, when disease inflames or irritates the retina, flashes and sparks are perceived, and, in surgical operations, which necessitate the section of the optic nerve, the patient sees great masses of light at the moment the instrument cuts the nerve. —But the retina and the whole optic nerve are themselves but intermediate conductors; they serve to excite the optic centres of the encephalon, that is all. Suppose the centres are excited and the conductors inactive; the colored figure will arise and appear internal. This is the case with hallucinations of sight strictly so called, in which a reflected excitation propagates the images of the hemispheres to the visual centres of the encephalon. This is the case with the appearance following the prolonged use of the microscope, when the visual centres of the encephalon re-enter several times spontaneously into the state in which the action of the retina has set them too often and retained them too long. These cases all resemble that in which a spontaneous disturbance of the acoustic nerve causes us to hear and localize at a particular distance, and in a particular direction, a sound which there is no vibration of the external air to produce.

Now it is plain that the color, like the sound, is then within us, and cannot be elsewhere; and still we project it without us, and situate it at a spot where it cannot be. We may know, indeed, by reasoning that this situation is illusory; the appearance is too strong for us; we perceive the luminous bluish circle excited by a pressure at the inner corner of the eye, as if it were situated a little above the outer corner, not in the retina, but without the pupils. Thus when we are given a visual sensation to which no external object corresponds, it excites the play of an internal mechanism which transports it without us, and which, according to its kind, and as it is provided with certain particular accompaniments, situates it in one spot or another, always at the place in which, under ordinary circumstances, its ordinary cause or condition usually is: the law is a general one, and explains all the illusions of optics.—Consequently, even under ordinary circumstances, when the ordinary cause or condition, that is to say the object, is present, and occupies the spot denoted, when a red arm-chair or a green tree is really six paces from me, the internal mechanism acts just as in the exceptional case in which I have a consecutive impression on the retina, or in the exceptional case in which I have an hallucination proper in the cerebral centres. Consequently, too, the red color with which the arm-chair is clothed, the green color which seems to me incorporated with the tree, is nothing more than my sensation of red or of green, detached from myself and carried, in appearance, to a distance of six paces from my eyes.

Thus, all our sensations are wrongly situated, and the red color is no more extended on the arm-chair than the sensation of tingling is situated at my fingers' ends. They are all situated in the sensory centres of the encephalon; all appear situated elsewhere, and a common law allots to each of them its apparent situation. The law is—that a sensation appears to us to be situated at the spot in which we are accustomed to meet with its usual cause or condition, and this spot is the one at which the explorations of touch are capable, by acting there, of checking or modifying the commenced sensation. The singularities, errors, and diversities of the localizing judgment are all explained by this law.

In the first place, we see that this judgment must invariably be false; for the touch can never arrive at the sensory centres, to check or modify the commenced sensation; the sensory centres are in the box of the cranium in a place our hands cannot reach.—Secondly, we see that in most cases the localizing judgment must situate the sensation somewhere near the peripheral extremity of the nerves; for, though the excitation of the whole course of the nerve is the normal antecedent of sensation, our touch can only attain the parts adjoining the peripheral extremity. It is, then, at this point and no other of the nervous cord, that the localizing judgment must situate the sensation. And this is true for all sensations, even for sensations of sight, at least in the first stage of their localization; in fact, we shall presently show that persons born blind, at the moment a surgical operation restores their sight, situate colors near the periphery of the optic nerve; it is later on, after a further apprenticeship, that they refer them beyond this, to the place where the objects are situated.—Thirdly, we see that the localizing judgment cannot situate sensations at the exact spot of the periphery of the nerve in action, but in its neighborhood, and in general a little beyond it; for the touch cannot reach the exact spot. The finger cannot reach the retina at the back of the eye, nor the pituitary membrane at the inner part of the nose, nor the acoustic nerve in the labyrinth of the ear, nor, in general, any nervous periphery. What it reaches, are the envelopes and appendages of the nerve, the eyeball, the vestibule of the ear, the anterior chamber of the nose, the surface of the skin. There it is that it checks and modifies the commenced sensation, or associates with it a sensation of contact. There, then, it is that we must situate the sensation, and it is the same with sensations of sight as with all the rest; persons born blind, who have lately been operated on, situate their new sensations at the surface of the eyeball, and not at the back of the orbit.—Fourthly, we see that in many cases the localizing judgment must be vague; for there are places which touch cannot reach, for instance, the internal parts of the limbs and trunk; consequently, we situate approximately and vaguely all the sensations whose starting point is in the belly, the chest, the stomach, just as we do the partial sensations of which a total muscular sensation is composed.—Numbers of strange appearances are explained in the same way. If the exploration of touch is brought to a stop by a fixed eminence like the teeth, the sensation will appear to be situated at the surface of the eminence, though the nervous disturbance is much lower down.—If the exploration of touch cannot verify the positions of the two nervous disturbances, one of which is situated above, the other below, as happens with impressions of the retina, and if, at the same time, it finds the two external conditions of these two impressions situated in an inverse order with relation to each other, as happens with visible objects, we shall situate in the inverse order the two sensations derived from them. In fact, images of objects are reversed upon the retina; the feet of a figure are above and the head below, and nevertheless, we situate the head above and the feet below. The apparent position of our two sensations is thus found to be the inverse of the real position of the two disturbances.

It remains to be shown how, in accordance with the same law, the localizing judgment situates certain kinds of sensations beyond our nervous superfices. The fact is, there are two stages, and the judgment, according to the nature of the sensation, stops at the first or goes on to the second.—Two kinds of sensations, the visual and auditory, can alone pass through both stages; they alone are clearly projected from their first position to some particular spot or other of the outside world. The fact is, they alone furnish materials for an ulterior localization.—Take, for instance, two visual sensations. Not only have they a common organic condition, the modification of the open eye, but besides they have each of them a special external condition, the presence in a particular spot of the outer world of an illuminated body, a condition to which there corresponds in them some precise and notable character, according as the body is in one place or another. When by feeling with the hand or by closing the eyelids, we have proved their common organic condition, we prove, by other feelings, and by changing our position, their different external conditions. We have interrupted all our visual sensations by the same act—by closing our eyelids; we interrupt our different visual sensations in different manners, by extending our arm more or less, by increasing our change of position, by covering with our hand the illuminated surface of the body which emits the rays. Now, these are the only differences which can interest us; for these are the only indications which direct our action; they alone suggest to us the number of steps and the extent of the movement, by which, through reaching the object, we reproduce in ourselves some anterior state which was agreeable or useful to us, or, by which, in removing ourselves from the object, we avoid some anterior state which was displeasing or hurtful.—Our attention, then, is directed solely to these; the general association which had first joined our different visual sensations to the idea of the movement by which our hand reaches our eye, is effaced as useless; the education of the eye is accomplished; useful associations become established and alone subsist. Each distinct visual sensation is combined with the idea of a distinct movement of more or less length, effected in one or another direction; it takes this idea as its associate; henceforward, it is inseparable from it. By this combination, it becomes situated at a greater or less distance, in one place or another, but always in the outer world.

The same reasoning applies to the place of auditory sensations.—Now, if these two sorts of sensations have this singular peculiarity, it is because, by a special peculiarity, there corresponds to each variation in the situation of their distant cause, a precise variation in the sensations themselves. We shall see later on how the precise variations of the sensation of sight are effected by the adjustment of the crystalline lens, the greater or less convergence of the two eyes, the contraction of the motor muscles of the eye. With respect to hearing, whose localizations are less exact, variations less precise, but still precise, are furnished by the greater or less intensity of the whole sensation entering both ears, and by the greater intensity of one of the two component sensations.—It is not the same with the other senses. Their sensations indicate nothing, or next to nothing, as to position. For, first, a sensation of contact, of pressure, of taste, is only produced when the external cause touches the skin, the mouth, or the palate; at a distance, this cause does not operate: this is how the sensation which it excites does not vary according to distance; the localization remains checked at its first stage, and we situate the sensation at or near the place, in which the explorations of touch meet with its organic condition.—As to sensations of smell and heat, in certain cases, and up to a certain point, we are capable of appreciating vaguely, by the force or feebleness of the sensation, whether its origin is near or distant; sometimes we can even distinguish whether it is on our left hand or right; but it is nearly always necessary to make a new examination. When our eyes are shut, we discover by smelling about, by turning the head in different directions, that the smell comes from a bouquet placed on a particular side of us, that the cold comes from a particular chink. But we do not know this with precision and at once; the idea of a certain movement of measurement does not present itself immediately, by virtue of an ancient and fixed connection, and attach itself to the sensation so as to localize it in one spot rather than another of the outer world. Consequently, we remain in suspense; we are tempted to consider our sensation, sometimes as a sensation, sometimes as an unknown thing which starts from without and enters us. The words smell, cold, heat, remain ambiguous, and denote, in ordinary language, sometimes the one, sometimes the other; this is because the second stage of localization has commenced and broken down. It would not break down if the nostrils were placed like the ears, on the two opposite sides of the head, and could thus discern in a whole sensation of smell, two sensations, one stronger than the other, or if there were two symmetrical, distinct and opposed portions of the body charged to receive sensations of heat.—We see that the same law explains both the definite and the indefinite situation we attribute to our sensations, sometimes in the neighborhood of the peripheral extremities of the nerves, sometimes elsewhere and at a greater distance.

To sum up, in our present state, the situation we attribute to our sensations is always false; that which is situated at the spot in which we place them is their usual cause or condition, sometimes, the organ in which the primary nervous disturbance of which they are the result is effected, sometimes, the external object which excites the nervous disturbance. This cause or condition may be absent, as its presence is usual only; in any case, whether present or absent, the localizing judgment is an illusion, since we invariably situate the sensation where it is not. Usually, this judgment is practically effective, through the provisions it suggests and which direct our conduct; in itself it is nothing more than an illusion, which is generally useful, a fundamental error which nature and experience have constructed within us and established in us perpetually, to act as a preservative of our life, and an organ for our action.

IV. The localizing judgment remains itself to be studied. —To see of what elements it is composed, let us revert to our first example. I have just put my foot to the ground, I feel a sensation of pressure, and at the same time determine the place of the sensation; it is in my left foot, strong in the middle of the foot, slight towards the heel, almost imperceptible at the toes. In what do these last observations consist?—Each one of us may observe in his own case that, in order to make them, we imagine with more or less clearness the foot in question, and imagine it *visually*, that is to say by images of the optical sensation it would excite in us, if we were then looking at it with our eyes open. We picture to ourselves the foot at a certain distance from our eyes, the curvature of the sole, the form of the heel, the row of toes. We even, if we persist, see mentally the color of the flesh, browner towards the heel, whiter at the sole, and redder beneath the toes. In fact, we have within us a *visual chart* of our body. We represent it to ourselves just as we should any other object of which we have ocular experience. To each distinct sensation there is in the chart a distinct corresponding point, which has been associated with the sensation by experience. When the sensation arises, this point revives, and their junction situates the sensation in some particular one of the different points of the field which actual, or simply mental sight is accustomed to traverse.

But it is evident that a chart like this is an ulterior and special acquisition. It is wanting to persons born blind, and still they are perfectly able to denote the position of their sensations. They have then another chart which fulfils the same office, and, as we have all their sensations, in addition to the sight which they do not possess, it follows that we possess a second and wholly different chart, which is common to us with them, in addition to the visual chart, which is special to ourselves.—This second chart has as its elements muscular and tactile sensations. It is composed of the images of these sensations, and, in many instances, we prove their existence in ourselves, as, for example, with respect to portions of our body which we cannot observe with our eyes, and as to which the visual chart is consequently not clear.—Such, for instance, is the inside of the mouth, which we can only see by the aid of a glass, the back of the head, of the neck, of the trunk, of the thighs, which we can only see by the aid of two glasses. In fact, for all these spots, we form, from others, a sort of approximate chart of ourselves. But this plate of our visual atlas is vague, and we seldom have recourse to it. I experience an itching at a point of my back, and I know the spot; but I do not know it, or only know it imperfectly, by the visual representation; I do not picture clearly to myself the vertebra or the rib, the swelling of the muscle or spinal hollow, near which the feeling is; it is not associated, as in the hand, the foot, the arm, or the face, with some precise point of an outline pictured by the mental eye. It is by means of another atlas, *the tactile and muscular atlas*, that I am enabled to situate it precisely.

In fact I give it a situation by means of the special, longer or shorter muscular sensation of the hand and arm, which move towards it and reach it. Its position is denoted by the nature and duration of this sensation. If at a greater distance, a greater movement would be required to reach it, consequently a longer muscular sensation; if at a less distance, a less movement, consequently a shorter muscular sensation; if at the same distance, but in a different direction, a movement equal in extent, but different, consequently a muscular sensation of equal duration, but different. By means of these repeated and diversified experiments, when a sensation, whether of tingling or any other, is aroused in any part of my body, even in a point with respect to which the visual atlas, fails, it calls up its inseparable associate, the image of a special muscular sensation, a sensation of a precise duration, longer than some other similar one, shorter than some other similar one, different from some other one of equal length. By this attachment and consolidation, my sensation of tingling finds itself denoted by a distinctive sign. This sign, having a certain duration, is a continuous magnitude; therefore it is, like a line, capable of comparison with any other magnitude of the same kind, it differs only from such other magnitude in being more or less, suggests the idea of its double or of its fraction, and is capable of measurement; here we have the conditions of a representative chart.—This is but an instance of a general operation, which has already been described. We localize our sensations as we do objects, by the associated image of certain muscular sensations of greater or less length. The sensation, by means of the associated image, is arrested in an order, and, so to speak, in a rank; there it is situated, that is to say denoted by a precise quantity, less than this, greater than that, by a muscular reminiscence which intercalates it between two series of muscular sensations, one of longer sensations, the other of shorter ones.—If we add the reminiscence of the tactile sensations experienced upon contact with the point which the exploring organ has just touched, the associated image becomes precise while completing itself; we situate our sensation, not only at a particular distance from some other, but at such a rib, at such a hollow of the arm, at such a joint of the finger.—Such is the tactile and muscular atlas, the first of all; the instinctive and unregulated movements of the new-born child, its feelings about, the incessant experience it acquires of its touch and muscles, commence at once to construct this atlas; the visual atlas is derived from it, and is not formed till afterwards.

Thus the localizing judgment consists in the adjunction to the sensation of certain images, sometimes visual, sometimes tactile and muscular. This coupling may be innate; the chicken will pick up food immediately it comes out of the shell; the new-born foal springs on his legs almost immediately and goes to suck its dam. But in man it is acquired, and the internal mechanism, which in other animals is fabricated at the moment of birth, is in his case fabricated gradually. At all events, it is for the most part a work of experience. "There is ground," says Weber,* "for admitting that primitively, by pure sensation, we know nothing of the place in which the nerves which communicate the sensation to us are disturbed. Primitively, all sensations are simple states of excitation perceptible to consciousness; these may differ in quality and degree, but do not directly furnish to consciousness any notion of place. They only furnish this indirectly, by exciting the

* Article "Tastsinn," ibid. 486.

activity of our mind, through the means of which we represent our sensations as comprised in a whole, and possessed of mutual relations." There is then an ulterior and superadded process, the adjunction of a series of muscular images, whose duration measures the distance, the adjunction of a group of tactile and muscular images which denote the consistence, shape, and magnitude of the organ to which the sensation is referred, the adjunction of a group of visual images which denote this organ from the other organs and other objects denoted in the same manner. All this is the work of experience, and experience, pushed further, is capable of associating with the sensation representations of greater exactness. An anatomist who bends his hand imagines the contraction of each of the muscles which concur in effecting it, the longer and shorter palmar muscles, the anterior cubital, and the rest. If he is pricked, he pictures to himself the form, color, and distribution of the little whitish flabby threads termed nerves, which the puncture has touched. He represents his sensation of contraction as being situated in the nerves of the contracted muscles, and his sensation of pain as being situated in the punctured extremity of the little whitish threads. This association, less fixed than ours, is identical with ours, and is like a second stage of less solidity based on a first indestructible stage. But they are both of them added constructions, and did not exist on the primitive soil.

V. If we now compare the two atlases, we shall find them very different. That the first, the tactile and muscular atlas, is effective for the purpose of localizing our sensations in some particular part of our bodies is explainable without difficulty; for we have seen that we conceive extent, distance, and position by a series of muscular sensations interposed between a point and another point—between a sensation and a sensation. I have many times experienced a feeling of touch in my neck or cheek; I have determined its position by the series of muscular sensations which my hand must go through to reach it, and have characterized its seat by the group of tactile sensations of my hand afforded by my neck, when it is pressed, felt, and traversed. A stable association is thus formed between the sensations, whose starting-point is in the nerves of the neck, and this series of muscular images joined to this group of tactile images. Consequently, whenever a similar sensation is produced, I shall imagine its position and seat.—This is not the case with the visual atlas, and we must examine how it is that sensations of the eye, which, taken alone, seem fit only to instruct us as to colors, are capable of further instructing us, as to distance, extension and position. This arises from their being themselves transformed, and turned into equivalents of tactile and muscular sensations, by the association they have acquired with tactile and muscular sensations. Primitively, and in itself, the retina, when impressed, arouses sensations only of light, of obscurity, of successive and simultaneous colors. It is by an ulterior process—the adjunction of auxiliary images—that this pure visual sensation receives an apparent situation, and that we see objects at a certain distance, in a particular direction, with particular form and dimensions.

The accounts of persons born blind, who have been restored to sight by operations, is decisive as to this. From the moment they recover their sight, they experience the same visual sensations as we do. But their eyes have not been educated like ours; consequently, what is then wanting to their eyes is what ours have acquired; the missing parts of their perception afford a measure of the additions which have gone to complete our perception.—Still, for the purpose of explaining the different results of experience, it is necessary first to determine whether the education of their eyes has been absolutely nothing or only amounting to nothing.* In most cases, the crystalline lens, though

* See the cases recorded by Cheselden, "Philosophical Transactions" for the year 1728.—Ware, ib. 1801.—Home ib. 1807.—Wardrop, ib. 1826.

opaque, still permitted the passage of a small portion of light; Cheselden's patient could distinguish three colors, black, white, and scarlet; Ware's patient could distinguish strongly-marked colors when held close to his eye. Consequently, some of them had learned to direct their looks towards an object, and could judge to a certain extent of distance by the colors growing feebler. This explains how, in certain cases, the patient was able immediately after the operation to take hold of the surgeon's hand and to say, by sight only, whether it was brought nearer to or carried further from him. But this is unusual, and when the patient has not learned to interpret the meaning of the color growing feebler, he has no idea of the position of visible objects. Usually, at the moment he first sees clearly, he imagines "that all the objects he sees touch his eyes, just as the objects he feels touch his skin."† So said the patients of Cheselden and Home; they situated their new sensation in acordance with their accustomed sensations of touch, and applied their former experience to the new instance.‡ Besides this, Home's patient had always done so; before the operation, when he looked at the sun through his opaque crystalline lenses, he said it appeared to touch his eye. The operation performed, the same localizing judgment remained; when asked, soon after, what he had seen, he said: "Your head, which seemed to touch my eye," but he could not tell its shape. It was not till three months afterwards, and a month after the lowering

† In a case reported by Mr. Nunnely, "the young patient said that the objects touched his eyes, and walked about cautiously, keeping his hands raised before his eyes, to prevent these objects from touching and hurting them."—J. S. Mill, "Exam. etc." Third edition, p. 285.

‡ Before the operation the blind person has opened and shut his eyelids, and has certainly known their situation as that of other parts of his body. Usually, when the operation is performed, the light is too keen for his eyes and compels him to close them, and to contract the pupil.—Here are two muscular sensations whose situation he knows, and which no doubt contribute to make him situate his new visual sensation against his eyeball.

of the second cataract, that objects did not seem as before to touch his eyes, but appeared to be at a short distance from him. Not one of the blind persons so operated on was able at first to interpret his new sensations, to decide on the situation, form, and magnitude of objects, or to recognize them. It was requisite for the touch, slowly and gradually, to instruct the eye. Home's second patient was asked, ten minutes after the operation, the shape of a round piece of card, and said, "Let me touch it, and I will tell you." He was not allowed to do so, and, after thinking for some time, said it was round. But a moment afterwards, he said the same thing of a little square piece of card, and again of a triangular piece. The experiment was repeated some hours afterwards. At first the boy called the different cards round; but upon being shown a square, and asked if he could find any corners to it, he was very desirous of touching it. This being refused, he examined it for some time, and said at last that he had found a corner, and then readily counted the four corners of the square. Thus commenced the first education of the eye. All the patients resembled Cheselden's, who "knew not the shape of anything, nor any one thing from another, however different in shape, or magnitude; but upon being told what things were, whose form he before knew from feeling, he would carefully observe, that he might know them again; but having too many objects to learn at once, he forgot many of them; and (as he said) at first he learned to know, and again forgot a thousand things in a day. . . . . Having often forgot which was the cat, and which the dog, he was ashamed to ask; but catching the cat (which he knew by feeling), he was observed to look at her steadfastly, and then setting her down, said, 'So, puss! I shall know you another time.'" Later on, when he had learned to know his parents by sight, "being shown his father's picture in a locket at his mother's watch, and told what it was, he acknowledged a likeness, but was vastly surprised; asking how it could be that a large face could be expressed in so little room, saying, 'It should have seemed as impossible to him, as to put a bushel of anything into a pint.'"*

They require time to reconcile the different visual sensations which the same object presents according to its different distances, and to reconcile all these with the muscular and tactile sensations with which the object has already furnished them. The most instructive case in this respect is that of the lady operated on by Wardrop.—Her blindness was more complete than that of the others; for not only was she born with cataracts in each eye, but, when six months old, an unskilful surgeon had destroyed the right eye and closed up the pupil of the left. She could not recognize any color, she was able merely to distinguish a very light from a very dark room, but without having the power to perceive even the situation of the window, through which the light entered; though in sunshine or in bright moonlight she knew the direction from whence the light emanated. When placed under Wardrop's care she had reached her forty-sixth year. He opened the

* "Caspar Hauser, in a detailed account of his own experience in this respect states, that upon his first liberation from confinement, whenever he looked through the window upon external objects, such as the street, garden, etc., it appeared to him as if there were a shutter quite close to his eye, and covered with confused colors of all kinds, in which he could recognize or distinguish nothing singly. He says farther, that he did not convince himself till after some time during his walks out of doors, that what had at first appeared to him as a shutter of various colors, as well as many other objects, were in reality very different things; and that at length the shutter disappeared, and he saw and recognized all things in their just proportions."—Franz, "On the eye," p. 34–6. Dr. Franz adds:—Since ideas are gained by reflection upon sensation, it is further necessary in all cases in order that an accurate idea of objects may be formed from the sense of sight, that the powers of the mind should be unimpaired and undisturbed in their exercise. A proof of this is afforded in the instance related by Haslam ('Observations on Madness and Melancholy,'—Second edition, p. 192), of a boy who had no defect of sight, but was weak in understanding, and who in his seventh year was unable to estimate the distance of objects, especially as to height; he would extend his hand frequently to a nail on the ceiling, or towards the moon, to catch it. It is, therefore, the judgment which corrects and makes clear this idea, or perception of visible objects."

iris, she was able to see, and "returned home in a carriage, with her eye covered only with a loose piece of silk. The first thing she noticed was a hackney-coach passing, when she exclaimed, 'What is that large thing that has passed by us?' In the course of the evening, she requested her brother to show her his watch . . . . and looked at it for a considerable time, holding it close to her eye. She was asked what she saw; and she said there was a dark and a bright side." In fact, these two sensations of brightness and darkness alone corresponded to her former sensations, since till then she had never been able to do more than distinguish light and darkness.—She was seen hourly to observe first one point, then another, then again others in the numbers of sensations of color which besieged her. But she was bewildered by them; "I feel stupid," she said. She voluntarily remained silent, not being able to make out the chaos of impressions which were as yet destitute of meaning to her inexperienced eye.—A fortnight later, she still said, "I see a great deal if I could only tell what I do see; but surely I am very stupid." Nevertheless, she learned by degrees the names of colors, and was soon able to distinguish them; but as to the perception of figures, that is to say for the transcription into the new visual atlas of the old tactile and muscular atlas, the apprenticeship was very long.—On the seventh day she was examining the teacups and saucers, and was asked, "What are they like?" "I don't know," she replied; "they look very queer to me, but I can tell what they are in a minute when I touch them."—"She distinguished an orange on the chimney-piece but could form no notion of what it was till she touched it." On the eighteenth day the experiment was made "of giving her a silver pencil-case and a large key to examine with her hands; she discriminated and knew each distinctly; but when they were placed on the table side by side, though she distinguished each with her eye, yet she could not tell which was the pencil-case, and which the key." On the twenty-fifth day, being in a carriage in the Regent's Park, she inquired continually as to the meanings of her visual sensations, such as—"'What is that?' 'It is a soldier,' she was answered. 'Who is that, that has passed us just now?' It was a person on horseback. 'But what is that on the pavement, red?' It was some ladies who wore red shawls."—It was constantly necessary to translate for her into the language of touch, which she understood, the unknown language of the eye.—As, before the operation, she knew from what direction the light proceeded, she was probably already capable of approximately directing her head and eyes to the side at which the illuminated objects appeared; but even this art was entirely rudimentary. On the eighteenth day, "she seemed to have the greatest difficulty in finding out the distance of any object; for when an object was held close to her eye, she would search for it by stretching her hand far beyond its position, while, on other occasions, she groped close to her own face for a thing far removed from her . . . ."—When at the end of six weeks she left London, she had acquired a pretty accurate knowledge of colors and their different shades and names, and also of many objects, but "had not yet acquired anything like an accurate knowledge of distance or of forms, and up to this period she continued to be very much confused with every object at which she looked. Neither was she able, without considerable difficulty and numerous fruitless trials, to direct her eye to an object; so that when she attempted to look at anything, she turned her head in various directions, until her eye caught the object of which it was in search." In fact the least movement of the head changes all our visual sensations for other ones; a precise movement is required, neither too great, nor too small; to attain a preconceived visual sensation, we must direct our glance correctly. Just as an infant does not distinguish or retain, till after many trials, the precise nature and exact amount of the effort required to throw a stone ten paces and not nine or eleven; so was this lady unable to distinguish and fix in her memory, until after many incessantly corrected attempts, the particular nature, the degree of intensity, and the precise duration of the muscular sensation which her neck must experience in order for the inclination to right or left; the raising or lowering of her head, and so of her eye, to be three degrees and not two, four, or five.

All these particulars result in one conclusion—our pure visual sensations are nothing more than *signs*.—Experience alone acquaints us with their meanings; in other words, experience alone associates with each of them the image of the tactile and muscular sensation corresponding to it.—At the present day, the analysis of physiologists and physicists has noted, by a multitude of proofs and counter-proofs, the various stages of this association.* The sensations which the retina procures us are those of different colors, and of different degrees of light and shade; and further, as it is a sheaf of distinct nervous fibres, each of its fibres, in accordance with the general law of the nervous system, excites, when impressed, a distinct sensation. In these three respects, and in these three respects alone, can we distinguish a pure visual sensation from others similar in kind, and this is the first layer on which will be established later on the whole fabric of our visual perceptions.—In this state, which is that of the person born blind immediately after the operation, the eye has the sensation only of variously colored patches more or less clear or obscure; and, in a whole patch, it can observe some distinct portion, but simply, as a partial patch.† Wardrop's pa-

* Helmholtz, "Physiologische Optik," 797.

† With respect to this, it is curious to observe very young children. I have lately been able to apply and verify the theory in the case of a little girl whom I saw every day from her birth. It is certain to my mind that, during the first two months, the surrounding world was composed for her of sounds and patches of color, which she did not know how to situate. At two months and a half, she evidently recognized the direction of certain sounds; for instance, hearing her grandmother's voice, she turned her head towards her. At three months she knew, in some cases, how to direct her looks by turning her head and eyes towards the object she wished to see, and among others, to my face. But she could not do this with every object.—Plainly, what she first distinguished, noted in her memory, and recognized, were sounds and faces. In fact, among the hundreds of sounds and

tient, looking at a watch, on the evening of the operation, observed the figure 12, the figure 6, and the hands, but simply as patches upon a patch, without knowing what they were. So again, on the third day, looking at her brother's face, she distinguished in this round flesh-colored patch, a special patch produced by the prominence of the nose, and guessed, in fact, that it was the nose.—Painters in color are well aware of this state; they revert to it; their art consists in seeing their model as a *patch*, the only element of which is the more or less diversified, deadened, vivid, and mingled color. At this stage, there is no idea of the distance or position of objects, except that an induction derived from touch places them in contact with the eye. No doubt, at this stage, an object may be recognized by the color, vividness, and characters of its patch, as Wardrop's patient was able to distinguish the grass from the water, but nothing is known as to its situation. The second layer of the edifice is not constructed; it is now necessary to add, little by little, to pure retinal sensations, auxiliary and additional ones.

The sensations so added are those of the muscles of the eye; for the form and position of the eye are susceptible of changes, and these changes are the effect of its muscular appendages.—In the first place, we adjust the eye to the distance of the object, by disposing it in such a way that the luminous image falls precisely on the retina, and not before or behind it; otherwise, the vision is not distinct; to effect this, we alter the curvature of the crystalline lens, probably by contracting the ciliary muscle, and the muscular fibres of the iris. —Besides this, when we look at an object with both eyes, our two eyes converge more or less, according as the object is at a

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colored forms which impressed her senses were the tones of five or six voices, and the colored forms of five or six faces, and these, being the most frequently repeated, intruded, by their frequency and identity, on the rest.—At about three months old, she commenced to feel about with her hands, to move her arms to reach objects, consequently, to associate with the colored patches tactile and muscular impressions of distance and form.

greater or less distance. Now this greater or less convergence is produced by the greater or less contraction of the muscles which move the eye. Consequently, according to the greater or less distance of the object, we have a particular muscular sensation of the eye.—On the other hand, according as the object is in one or the other direction, with reference to our eye, one or other of the muscles which move the eye is more or less contracted, in order to turn it upwards or downwards, to the right or left; in such a way that when the distance remains the same, a distinct muscular sensation corresponds to every change of direction.—We learn to observe and engrave on our memory these innumerable distinct muscular sensations of our eyes. At the same time, and by means of touch, we associate some one of them with a certain movement of our hand, another with the semi-extension of our forearm, others with two, three, six, ten, twenty strides of our legs. Henceforward, when a pure visual sensation follows some particular voluntary muscular sensation of the eye, this compound calls up the idea of some particular movement of the hand, the forearm, or the arm, of some particular number of steps, in short, of some portion of the tactile and muscular atlas which the experience of our limbs has constructed within us, and by which the person born blind estimates distance and determines positions.—At the end of three weeks, the lady operated on by Wardrop was able to recognize a grass-plot by the large and beautiful green patch it formed in her field of vision. But she had not yet distinguished and observed what muscular sensation of her eye had resulted in the apparition of this green patch, and above all, had not ascertained, from the nature of the muscular sensation, the number and direction of the steps which would be required to lead her up to the grass-plot; so that, though she saw it, she did not know where it was, and perhaps extended her foot to find out whether it was not close to her.—To us who have noted the various muscular sensations of our eyes, and have associated them to the recollection of the movements of our limbs "the feeling that we have when the eyes are parallel and vision distinct, is associated with a great and prolonged effort of walking, in other words, with a long distance. . . . . The change from an inclination of the eyes of 30° to an inclination of 10° is associated with a given sweep of the arm, carrying the hand forward over eight inches and a half."* In this way, muscular sensations of the eye become in our cases signs, each of which has power, when produced, to call up with it the image of some particular muscular movement of the limbs, in other words, the precise idea of a certain distance measured in a certain direction.

To these auxiliaries add the rest—I mean the muscular sensations of the neck and body in turning, bending, and drawing back, so as to enable the retina to receive a distinct luminous image; these are so many complementary signs which, in connection with the first, effect the determination of the direction of the object by the association they have contracted with the image of some special movement of the limbs carried out in some particular direction.—The reader now sees how the eye is capable of perceiving the figure of a body. The visible figure of a body is nothing more than a double series of optical sensations, a retinal series and a muscular series, both of which are parallel and continuous, and are experienced whenever the eye follows the outline and runs over the illuminated surface of a body. Experience associates to this double series of sensations a series of images, that is to say, images of the tactile and muscular sensations which the hand would experience in following the outline, and feeling the surface of the bodies.—Other experiences teach us that, according to the distance, this double optical series undergoes regular alteration, without the other series being altered; and we express this by saying that the same tangible object passes regularly, according to distance, through an infinite series of visible appearances; and it fol-

* Bain, "Senses and Intellect," 2nd edition, 374.

lows from this, that when we see it at a particular distance, the row of its other visible appearances is ready to revive in us, and to take up a position in the mental background.—I leave further explanation to treatises on optics and physiology,* in which will be found the enumeration and explanation of all optical judgments and errors. They are the subject-matter of a whole science, but are all reduced to one principle. "By experience," says Helmholtz,† "we can evidently learn what other sensations of the sight or other senses, an object we see will excite in us, if we advance our eyes or body, if we look at the object from different directions, if we feel it, etc. The concept of all these possible sensations combined in a whole is our representation of the body; and, when it is sustained by our actual sensations, it is what we term *the perception* of the body. . . . . It includes all the distinct possible groups of sensations which the body when looked at, touched, experimented on in various ways, can excite in us; these are its real effective contents; it has no others, and these contents may undoubtedly be acquired by experience. The only physical activity required for this purpose is the constant and reviving association of the two representations, which were already connected together, an association which becomes the more solid and more constrained in proportion to the number of times the two representations have reappeared together."

From this, we understand in what our visual atlas consists.—There is a square mahogany table three paces from me, to the right. I turn my eyes, and have, through the retina, a sensation of a certain somewhat glistening brown patch; and I have at the same time, by means of the accommodation of the crystalline lens and the contraction of the muscles which move the eye, a certain muscular sensation which, by an acquired correspondence, calls up in me the image of three

* See the admirable work of Helmholtz; above all the third part, "Die Lehre von den Gesichts-Wahrnehmungen."

† Ibid., p. 798.

paces, taken to the right.—My eyes follow the outline of the table, in other words, my retina experiences in succession a continuous series of impressions in proportion as the luminous rays starting from the sides of the table successively impinge on its yellow centre; now, in the meantime, the accommodation and contraction of the muscles of the eye give me a parallel and continuous series of muscular sensations, which, by an acquired correspondence, call up in me the images of the tactile and muscular sensations which my hand would experience in passing over its side from corner to corner.—Let us remark the character of these re-excited images. If my glance has been a rapid one, they are not express; they remain in the nascent state; I am compelled to prolong my glance to call them up precisely and completely, to imagine the muscular sensations of my three steps, the muscular and tactile sensations of my hand, passed along the edge of the table. I only get at this by dwelling on it, by silently inquiring of myself *what it is I mean* by this distance and this form. Even when dwelling on it, I commence by imagining the first step I should take, the sensation which my hand would receive from the first corner; these two images serve as type for the rest. In fact, my operation is the same as when in a written sentence I read the word *tree;* if I read it rapidly, I simply understand it; it does not call up express images in my mind; it is necessary to weigh it, to reflect, in order to cause the image of a beech, an apple, or other tree to appear; even then, it will be vague and mutilated; at the most, I shall get a view of some lineaments of a colored form, the obliterated sketch of a green dome or pyramid; it will only be by dwelling strongly on it for some time that I shall cause images of trees to spring up sufficiently clear and numerous to be equivalent to the generic word which sums up and denotes them all.—Thus our optical sensations are, like our words, *signs*. Every retinal and muscular sensation has, like every word, its group of associated images; it represents this group; it replaces and denotes it; in other words, it is always associated with it, and never otherwise associated, so that in use and practice it is equivalent to it. In fact, when the sensation arises, the group is at hand, ready to revive. Give it a little time, and it will partially revive. Give it enough time, and it will wholly revive. It forms part of the train of the sensation; but, as the operations are rapid, it most usually remains in the background; the sensation alone occupies the stage. As the sensation is there for an instant only, and the train requires time to pass in procession, the train remains behind the scenes.—We know something of this world behind the scenes.* The reader had a view of it when we pointed out the silent persistence of images, their latent existence, their rudimentary state, the obliteration they undergo, and the life they preserve, often for whole years, until the indistinct vibration, which was perpetuated in some only of the cells of the hemispheres, receives from some unforeseen circumstance a universal ascendancy, and becomes suddenly propagated through the majority of the chords of the cerebral instrument.

The better to comprehend their obliteration and the part they still play, though in this latent state, let us consider greater distances, and generally, the process by which distances are estimated.—In a geographical map we look at the myriametre traced at the foot, and applying compasses to this myriametre, we pass about the map, measuring in this manner if Paris is farther from Bourges than from Tours or Dunkirk.—At the outset of the operation we estimated the myriametre in muscular sensations, and found it equivalent to some walk we have been accustomed to take, to 12,000 paces, to two hours' walking. But, soon after, we forgot the muscular signification we attached to this expansion of the compasses; we left it behind us, in reserve; all we kept in mind was degree of expansion and its multiples; we directly compared a series of expansions to a series of expan-

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* See part i. book iv. chap i. pp. 190–92

sions, a series of greater ones to a series of less. We follow the same process in all our estimations of quantities, and the spontaneous operations of our eye do but precede the artificial operations of our instruments.—In the first stages of our observation, as at the limit of our science, we prove a constant relation between two quantities, just now between our more or less numerous steps and the greater or less expansions of the compasses, at present between the more or less long and repeated muscular sensations of our limbs, and the muscular sensations which we receive from the greater or less convergence of our eyes, the greater or less flattening of the crystalline lens, the greater or less contraction of some one of the muscles which move the eyes, the greater or less movement of our body and head in some particular direction. The second quantity increases or decreases with the first, according to a fixed law.—This being settled, we take a standard of the second, just now a certain expansion of the compasses, for instance the expansion which measures the myriametre, now a certain muscular sensation of our optical apparatus, for instance, the muscular sensation which the eye must experience in order to have the retinal sensation of an object situated at thirty centimetres distance. At this moment, too, the standard and its signification, that is to say the expansion of the compasses and the recollection of our walk, that is to say again, the muscular sensation of the eye and the image of the muscular sensation of the arm carried thirty centimetres forward, are together in our mind. But a moment afterwards the standard alone remains; the image or the recollection to which it is equivalent becomes thin, and fades away; we simply observe that a certain expansion is greater than another, that a certain muscular sensation of the eye is stronger and more prolonged than another; we no longer perceive the signified quantities but only the significant ones.—This is enough; for, by means of the indicated association, the signified quantities remain within call, and their proximity is as good as their presence. At any moment we can recall them, can observe that a certain expansion of the compasses, that is to say one of three times the extent of the first, would require of us three times as many steps, or six hours' walking, that a smaller muscular sensation of the eye would require a double extension of our arm.—We know how a map serves us on a walking tour; by applying to it compasses we foresee the length of our walks, and the amount of muscular effort we shall be compelled to expend. Our visual atlas is of the same use; by translating certain of its indications into the corresponding indications of the tactile and muscular atlas, we foresee the distance, the magnitude and duration of the muscular effort by which our limbs will reach some particular object.

VI. We see now how it is that a visual sensation, so short as to appear instantaneous, can give us the idea of very diversified and very great extension. This arises from its being equivalent to the very diversified and very long tactile and muscular sensations by which we should perceive this extension. It sums them up, and so becomes their substitute, and signifies them while replacing them.

But, even were we incapable of having this sensation, we should still contrive to represent to ourselves in combination, and as simultaneous, a great number of the parts of space.—I have questioned many blind persons as to this,* their answer is unanimous, wholly precise and decided. No doubt the perception of a new object requires more time in their cases than in ours, since they are compelled to explore it in detail by touch. But, having done so, they think of the object, whatever it be, a sphere, a circle, or even a considerable space, for instance, a street, all at once, and represent it to themselves in mass. "All there is wanting to us," they say, "is what you call the idea of color; the object is to us just what an un-

* At the Institut des Jeunes-Aveugles at Paris, thanks to the kindness of the Professors and Director of the establishment.

shaded drawing or photograph is to you, speaking more precisely, *a combination of lines.* We conceive a whole group of diverging or intercrossing lines simultaneously, and that is to us figure." Above all, they expressly deny that in order to imagine a line or a surface, they require to represent to themselves the successive sensations of their hand passed in some particular direction. "That would be too long, and we have no need whatever to think of our hand: it is but an instrument of perception of which, after perception, we cease to think."

In fact, if, at the origin of the idea of distance, we find a longer or shorter series of muscular sensations of the arm or leg, it is *at the origin* only. It matters little whether these sensations appertain to one limb or the other, whether they are muscular or not; this is but a detail and an accessory; it is obliterated, we cease to attend to it. We leave aside, as the blind say, all the circumstances and intrinsic qualities of our sensations; we preserve only the essential part, and the essential part here, is that they form a series interposed between the two points whose distance we are estimating. Taken thus abstractedly, these sensations become, as it were, uncolored and neutral; they are any sensations whatever; we consider them not as to their quality but as to their quantity; what we observe in them is the greater or less duration of their series: nothing more. Henceforward, we are able to imagine them with great promptitude, and to compare series to series. Such is the process employed by a person born blind; he may, like Saunderson, become a geometrician, may conceive longer or shorter series, diverging according to such and such an angle; these are lines, and, by a combination of such lines, he conceives geometrical bodies. For our own parts, we avail ourselves of this process when we define lines by the motion of a point, the surface by the motion of a line, the solid by the motion of a surface, and when we estimate a line, a surface, or a solid by the greater or less prolongation of the muscular operation, which engenders its perception. Now we can imagine these movements with extreme rapidity; we may, then, thus, by these means alone conceive many lines, therefore a surface, and even an entire solid, almost in an instant.

But, fortunately, we have a second aid, the visual atlas, which is added in our cases to the tactile and muscular atlas. Thanks to it, we have at our disposal new series which may be compared together, and whose elements succeed in us with prodigious velocity. These are the little muscular sensations of the eye, which are extremely short, and able, therefore, to denote, in an imperceptible portion of time, very great distances, and positions as numerous as various. They take the place of the muscular and tactile images corresponding to them, and, as they pass in a moment, it seems as if the much longer series of tactile and muscular sensations has also taken effect in a moment. Their muscular and tactile signification springs up with them, and we imagine that we perceive at once a number of distant and co-existing points.—The reader has already met with many operations of this kind; it is what happens with all abbreviatory substitutes. The muscular sensations of the eye serve us in sight as words do in abstract reasoning.* When I contemplate the different views of an extensive landscape, these sensations alone are in my mind, just as, when I read a chapter on political economy or moral philosophy, there are words alone in my mind, and yet, in the first case, I believe that I directly perceive magnitudes and distances, as, in the second case, I believe that I directly perceive pure qualities and general relations.—To employ the expressions of Mr. Herbert Spencer, these little simultaneous or nearly simultaneous muscular sensations are to us "symbols of other tactile and muscular sensations, which were slowly successive. This symbolic relation, being far briefer, is habitually thought of in place of that it symbolizes: and by the continued use of such symbols and the union of them with more complex ones, are generated our ideas of visible exten-

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* See part i. book i. chap. ii.

sion—ideas which, like those of the algebraist working out an equation are wholly unlike the ideas symbolized; and which yet, like his, occupy the mind to the entire exclusion of the ideas symbolized."*—Hence it follows that, in our present state, during the working of the optical substitutes, the image of the long muscular and tactile sensations they replace must be absent. Consequently, we do not now find it within us, even if we look for it; our perception of visible extension will no longer comprise any of the muscular and tactile sensations of the limbs and hand. Such is, in fact, the conception we now have of visible extension; in this state, we no longer find any thing in it to recall its origin. In truth, what is now within us is not the image of the original successive sensations of the hand and limbs, but their optical sign. The visual atlas, constructed by means of the muscular and tactile atlas, is wholly different from it; it is not a copy, but a reproduction on another scale, with other notations, far more convenient for use, comprising in one chart what is dispersed in the other atlas over twenty several maps, and presenting, at one glance, a group so vast that, in the other atlas, we should be obliged to arrive at it, discursively and slowly, over twenty different leaves.

This visual atlas has such great advantages over the other that we constantly, and almost exclusively, employ it.—In the first place it is, as we have seen, extremely abbreviatory for all distances of any magnitude. In an instant, by a simple diminution of the convergence of the eyes, we pronounce that one object is twenty paces further from us than another. In an instant, by a simple continuous movement of the eye, we pronounce that a particular surface is square or triangular. This frees us from the necessity of imagining in detail the long muscular sensation of twenty steps, the long tactile muscular sensation of the hand passed over the whole outline of the surface.—Thanks to this rapidity of optical operations, we can seize in a very short time, and by a perception which ap-

* "Principles of Psychology," first edition, p. 224.

pears instantaneous, a whole entire object, a chair, a table, a person, and more, if the object be distant, a whole meadow, a group of trees, a building, the façade of a street.—You are placed at a window, you open your eyes, and at once, by means of a very small movement of the eyes and an imperceptible movement of the head, the whole landscape appears to you, with its different levels, meadows, woods, sky, clouds, with their innumerable details of form, relief, and shade. Your eye is at the converging point of the luminous rays which start from the objects—that is to say at the angle of the compasses formed by two divergent rays, as they reach the retina. Now, a very trifling distance, measured near the angle of the compasses, corresponds to an immense, and sometimes enormous distance measured at their points. This is how we estimate, at a glance, hundreds of metres, and sometimes of leagues; it seems to us at the time that all the sensations we had during this glance are simultaneous, and in this manner, all the external objects they reveal to us are perceived, so to speak, together; which renders far easier for us the task of recalling and comparing them; in short, of practising on them the various ulterior operations of which we have need.

On the other hand, very small distances and very minute objects are also within the province of sight. In this respect the skin, compared with the retina, is a coarse instrument, even at the places in which its sensibility is most delicate.—At the dorsal vertebræ, at the middle of the arm, of the thigh, of the neck, when two adjacent points are touched, we do not distinguish them as being two, unless they are from sixteen to twenty-four lines apart; at the palmar surface of the last joints of the fingers, it is sufficient for the points to be seven-tenths of a line apart; at the point of the tongue, where the power of discrimination is most perfect, a little less than half a line is a sufficient distance.*—On the contrary, according to Weber and Volkmann, on the yellow spot, which is

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*See the complete Table, Mueller, "Physiology" (tr. Baly), i. 701.

the most sensitive point of the retina, two brilliant specks may be distinguished when separated only by an interval of from .002 to .001 of a line.—In this way, the retina is a thousand or two thousand times as sensitive as the most sensitive organ of touch.—Add to this advantage the indications afforded by color. A level surface for instance, a printed or written page, affords one uniform sensation only to touch, and the same surface affords to the sight as many distinct sensations as there are black letters written or printed on the white ground. So the tactile and muscular atlas does not comprise images corresponding to very minute objects, to the form and proximity of two threads in a piece of fine muslin, nor images corresponding to the diversity of colored surfaces, to the presence, form, and movement of the various objects placed beyond the reach of our hand, like the clouds, the sky, and the stars; primitively, at least, these images were all absent from the tactile and muscular atlas; if they have found an entrance, it has been but subsequently and approximately, by means of the reciprocal translation which we are able to establish between the two atlases.

We need not be surprised, then, at the enormous part played by the visual atlas in ordinary life. For our parts, to recollect, to imagine, to think, is to *see* internally; and to call up the more or less enfeebled and transformed visual image of things. So, too, the word *image* is borrowed from the history of vision; strictly, it only denotes the cerebral revival of the optical sensation; it is by extension that we have applied the same name to the cerebral revival of muscular and tactile sensations, of sensations of sound, taste, and smell.—By the same encroachment the visual atlas, being infinitely more extended and much more readily dealt with than the other, becomes our general resort; all our sensations are transcribed into it, and find a place in it, the muscular and tactile ones with the rest. In fact, I have internally the visual representation of my body, and even of the parts, like the back, which I have not seen; and when I contract a muscle, or undergo a contact, I localize the contraction and contact, not only by imagining the longer or shorter sensation, which would conduct my hand as far as the spot of contraction and contact, but, further, and above all, by imagining the visual form and color of the part affected. "It is on the right side, at the crown of the head, on the knee, between the bones of the left elbow." When we mentally pronounce a judgment like this, we mentally see the colored form of the parts.—This extends so far that, usually, in order to represent to ourselves the movement of the arm which would be required to measure a distance, we make use, not of muscular images, but of visual images, and represent to ourselves, not the prolonged contraction of our arm, but the colored form of our arm passed through the air from one visible point to another.—And so, to estimate the distance of a sound, we represent to ourselves by visual images the space which surrounds us, and situate the sonorous trembling at a particular height, in a particular direction, at a particular point of distance or proximity, in the huge field surrounding our body and traversed by the glance of the external or the internal eye.

As to sensations of taste and smell, the two atlases come at once into play, in order to situate them; we have the visual representation, as well as the tactile and muscular representation of our nose and mouth. In fact, as to the inside of the mouth, it is the second representation which is of most service, since the tongue plays the part of the hand; for instance, we discern and imagine by tactile and muscular sensations only the movements which we must make to emit the various sounds and articulations of language. Here, sight and visual sensations do not intervene; it is later on, by the aid of physiology, that our eye takes account of the tongue, and other appendages which modify the sound proceeding from our larynx,* it is then only that we can visually imagine

* This accounts for M. Jourdain's astonishment when he learned that, to say U, it was requisite to make a face.

the pronunciation of a guttural or dental.—And so, too, the tactile and muscular atlas is solely, or almost solely, employed to note the short movements of the trunk on its base, and sometimes all the movements of walking; for instance, when we mount, in the dark, a staircase with which we are not acquainted, all that we imagine is the regular recurrence of the same tactile and muscular sensations; the visual atlas of the staircase is wholly wanting, and the visual atlas of our legs and body is almost absent.—These are remnants or revivals of its primitive predominance; in such cases, we situate our sensations somewhat in the fashion of persons born blind; but here we have fragments only.

In fact, not only is the visual atlas almost entirely substituted for its rival, but, further than this, it has hindered its rival from acquiring all the perfection of which it is capable. Evidently, at present, as to muscular and tactile sensations, we have rough discrimination only; we can hardly distinguish their shades of difference, for want of being compelled to do so. Platner observed that the blind man, whose case he described, was far more skilful than we are in this respect, and this is true of all blind persons; with some of them the perfection of the sense of touch surpasses all imagination. "Saunderson, the blind mathematician," says Abercrombie,* "could distinguish, by his nand, in a series of Roman medals, the true from the counterfeit."—"Mention is made," says Bayle,† "of a blind organist who was very skilful in his profession, and who could readily distinguish all kinds of money and colors. He even played at cards, and was very fortunate, especially when it was his turn to deal, since he could recognize by touch the cards he gave each player.‡ Aldrovandus says that a certain Jean Ganibasius, of Volterra, an able sculptor, having lost his sight at the age of twenty, determined ten

* "Inquiry," etc. p. 51.

† Bayle, cited by Garnier, "Traité des Facultés de l'âme," i. 354.

‡ If this be true, it must be owing to the painting on cards having differences of grain and relief corresponding to the different colors.

years after to attempt what he could in the way of his profession. He felt over very carefully a marble statue of Cosmo I., Grand Duke of Tuscany, and modelled from it a plaster one, which resembled Cosmo so much as to astonish everybody. The Grand Duke Ferdinand sent him to Rome, where he made a plaster statue resembling perfectly Urban VIII." —Joseph Kleinhaus, who died at Nauders (Tyrol) on the 10th July, 1853, had become blind with small-pox at five years old. He at first amused himself by carving wood to pass the time, then obtained lessons and models from Prugg; at twelve years old he carved a crucifix the size of life, and became a pupil of the sculptor Nissl, improved greatly and became celebrated. He is computed to have carved four hundred crucifixes, and a bust of the Emperor Francis Joseph.* —It is enough to see blind men read with their fingers books printed in relief almost as rapidly as we read books printed in black and white, to comprehend all the power of discrimination which our touch might have, but has not, acquired.†—

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* Schopenhauer, "Les quatre racines du principe du raison suffisante," p. 61.

† "An analogous fact is observed in the habit acquired by the deaf and dumb, of understanding what is said to them by watching the motion of the lips of the speaker."—Abercrombie, "Inquiry," etc. 53.

I can myself mention a young man who became deaf when about four years old, and who, having very good eyesight, *saw* a conversation at a distance, which was inconvenient enough for persons who were whispering privately in a corner at the other end of the room. He could thus understand German and French, by the movement of the lips. Only it was necessary that the conversation should not contain many proper names which he was not acquainted with; for the visible movement of the lips showed him the consonants, and not the vowels.

The hearing and other senses are capable of acquiring an equal delicacy.—"Dr. Rush relates of two blind young men, brothers, of the city of Philadelphia, that they knew when they approached a post in walking across a street, by a peculiar sound which the ground under their feet emitted in the neighborhood of the post; and that they could tell the names of a number of tame pigeons, with which they amused themselves in a little garden, by only hearing them fly over their heads."—Abercrombie, ibid.

When we add to these facts the cases of hyperæsthesia so common in somnambulism and hypnotism, we see that it is impossible to put a limit to the innate or

Thus, in our cases, the tactile and muscular atlas has remained in a rudimentary state. This is why when we at present situate one of our sensations of touch, of sound, of smell, of taste, it is almost always through the visual atlas alone, or with its supplementary concurrence; in other words, the image of an optical sensation is now incorporated with sensations which do not reach us by the eyes, and it is this agglutination which situates them in the places in which they appear to us.

VII. Here, then, are all our sensations situated, that is to say provided with an apparent position and seat, all, primitively, by the adjunction of a series of muscular images, determining the position, and, by the adjunction of a series of tactile images characterizing the seat, almost all, finally, by the adjunction of visual images, which have become equivalents of this series and signs of this group.—We are now able to explain our present conception of extension. Suppose a great number of these localized sensations to be simultaneously produced, and the points to which we refer them to seem to us at once distant and continuous; then, the whole sensation, composed of partial, coexistent, distinct, and continuous sensations, that is to say of such that between the

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acquired acuteness of our senses. As to this, see Braid, "Neurhypnology," p. 62. "A patient who could not hear the tick of a watch beyond three feet when awake, could do so when hypnotized at the distance of thirty-five feet, and walk to it in a direct line, without difficulty or hesitation . . . . Some will feel a breath of air from the lips, or the blast from a pair of bellows, at the distance of fifty or even ninety feet, and bend from it, and, by making a back current, as by waving the hand or a fan, will move in the opposite direction."—These experiments have been repeated and varied by Dr. Azam of Bordeaux, "and the hearing," he says, "attains such acuteness that a conversation may be heard on the floor below. The ticking of a watch is heard at twenty five feet distance."—So with the smell, taste, sensations of heat, and the rest. "I have seen a person write correctly with a book placed between him and the paper; I have seen a fine needle threaded in the same position; have seen a person walk about a room with his eyes entirely closed and bandaged, and all this without any other real guide than the resistance of the air, and the perfect precision of the movements guided by the muscular sensations in their hyperæsthetic state."—"Annales Médico-psychologiques," 3e série, vi. 434.

position of one and that of another, we could not imagine any intermediate, will appear to us *extended*.—Let the reader be good enough to observe his own case; he will see that this is so with the sensations of heat and cold, which seem to us to occupy a whole limb, with the sensation of contact and pressure which we experience in laying our hand flat on a table, with the sensation of color which we experience when we keep the eye steadily fixed on a green leaf placed at six feet distance. In all these cases, the sensation seems extended. This arises from its consisting in a number of simultaneous sensations, which the education of the touch causes to appear as situated in distinct and continuous points.—Here there is a double error, first, because, as we have seen, sensations are situated in the sensory centres, and not in the nervous peripheries, next, because, as physiologists show, the nervous axes or cylinders, whose disturbance excites our sensations, form, at their terminations, discontinuous lines and surfaces. The extension of our sensation is thus, in two senses, an illusion.

From this illusion there springs another. With reference to sensations localized in points of our body, we conceive and affirm the existence of objects situated beyond our body, that is to say external, and we determine their situation by the situation of the sensation which reveals them to us. For instance, a sensation of smell reaches me, and I at once conceive and affirm a rose to be situated in the neighborhood of my nose. I experience a sensation of heat which I refer to my left leg; and I at once conceive and affirm some heated object, a current of hot air, a stove, a fire-place, as situated near my left leg.—The more determinate and precise the locality of my sensation, the more precisely do I determine the locality of the object. This is what happens with sensations of contact, and especially at the surface of the skin, and more particularly at the lips, the point of the tongue, the hand, the fingers, the tips of the fingers;* at these parts

* See Weber's Measurements, Mueller, "Physiology" (tr. Baly), i. 701.

the power of discrimination is very delicate, and two points separated by a line, or even half a line, give two distinct sensations. By means of such sensations, we are able to situate an object very exactly; their position is very precise; consequently, the position of the object is no less precise.—This position is still more precise in the case of sensations of color; consequently, in this case, the position of the object is still more precise.—If, now, we consider a sharply circumscribed portion of these very sensitive surfaces, and admit that, when all the nervous points capable of affording us a distinct sensation are disturbed at once, we may have a sensation apparently extended and continuous; we shall conceive and affirm the external object as extended and continuous. This is at present our usual proceeding. This is why, by means of a total sensation, composed of partial and simultaneous sensations, we perceive as extended and continuous the ground on which our foot is resting, the portion of the table on which our hand is extended, the distant object which our sensation of color denotes. We start from the extension and continuity of our sensation, to ascribe to the object a similar extension and continuity; now, the continuity and extension of the sensation being apparent only, that of the object can only be apparent. Consequently, the extension and continuity of bodies are illusions only; and, in fact, physicists arrive at conceiving atoms, if they exist, as separated by enormous intervals, in such a way that in a surface which appears to us continuous, the vacant part is far more extensive than the occupied part; going deeper still, they define bodies as a system of mathematical points, with relation to which effects increase or decrease according to distance.—At all events, there is nothing to prove that bodies are really extended and continuous; in this respect, our assertion is entirely gratuitous. Thus, the extension which we ascribe to bodies is, in fact, an apparent property of our sensation, a property which, by a natural illusion, we transfer to bodies. But this transfer is not, as Kant teaches, the effect of the innate and inexplicable structure of the mind; it is the effect of an acquired disposition, instituted in us by experience, and we have been able successively to show the various steps of this acquisition.

Other consequences follow. By the position and extension we attribute to our sensations, our being itself seems to us situated, extended, circumscribed in a precinct. This precinct is attached to the personality, and henceforward, the idea I have of myself is inseparable from the idea I have of my body. In fact, this body is the only thing that accompanies me everywhere. It is the only thing which answers to my touch by a sensation of contact. It is the only thing which my will sets directly into motion. It is the only thing in which I place the sensations I attribute to myself. In all these respects it appears to me so tied up and confounded with myself, that, when I refer a sensation to any point whatever of the nervous surface, my being and my personality seem to me for the moment situated at the spot in question. Such is the present state.—Hence it follows that when I now touch a table, the object touched must appear to me not only as other than myself, but, further, as without me and without my sentient surface. It is thus opposed, not only to myself, but also to the enclosed space in which I situate my personality, and in this way, for the first time, it is really *external.*

In fact, it is this character which strikes us when we now perceive a body. We conceive it as *a thing beyond us;* to this first characteristic, the others attach themselves.—On moving my hand about in the dark, it meets with an unknown obstacle in a table; upon this sensation, I conceive and affirm beyond my hand *a thing beyond it,* which excites in me a continuous and extended sensation of resistance, and which, being capable, as I suppose, of exciting it again, presently and still later on, in others as well as in myself, thus possesses the permanent and general property of being resisting and extended. At the same time, the shades of my sensation and the accompanying sensations of uniform contact, cold and sound, add to my conception the idea of a conical form, of a metallic and sonorous substance, that is, of a bell.—Thus determined and qualified by the group of sensations it excites, *this thing beyond me* is opposed to me as a thing without, to a thing within.—The separation is still more readily effected when the perception comes through the eyes; and observe that, at present, this is the most usual process. We have shown how, in sight, the sensation of the retina finds itself projected in appearance beyond our sentient surface, to become incorporated with the object which excites it, in such a way that color, which is an event of our being, seems to us a quality of the object. When I perceive this silver bell at three paces from me, the white shining patch in its centre, which appears to me to be three paces off, is a sensation of the retina transported from its seat by the education of the eye. In this case, our sensation itself appears to us as a thing beyond us; consequently the object to which we attribute it, and which, under the name of color, it seems to clothe, is opposed to our self and its precinct as a thing external and more or less distant.—Sensations apparently projected beyond the nervous surface in which we situate our personality, lodged in a determinate point of this outer region, detached from us by this projection, constituted apart as events foreign to us, erected into permanent qualities by the continuity and uniformity of their repetition, erected into qualities of a solid body by the presumed possibility of a sensation of contact and resistance at the spot in which we situate them: such are the visual, and really internal, phantoms which, when we open our eyes, seem to us external objects, and we now comprehend without difficulty how it is that, being compounds of the kind, they appear to us, not only as other than ourselves, but as situated *without* us.

VIII. Here we have the appearances, and it is time to inquire if there be any thing real corresponding to so many illusions. We have found that the objects we call bodies are but internal phantoms, that is to say fragments of the Ego, detached from it in appearance and opposed to it, though fundamentally they are the Ego under another aspect; that, strictly speaking, this sky, these stars, these trees, all this sensible universe which each of us perceives, is the work of each of us, or rather his emanation, or rather his creation, an involuntary creation, effected by him spontaneously without his consciousness of it, and extended to infinity around him like the shade of a little body whose outline goes on increasing in proportion as it becomes distant, and ends by covering the whole horizon with its immensity.—We have then found that no one of our sensations is situated in that part of the body in which we place it, that many of them, though belonging to us, appear as foreign to us, that among these some appear as permanent qualities of a being other than ourselves, while they are in fact transient moments of our being.—Thus, illusion shows itself in all our judgments, whether they refer to the external or the internal world, and we are no longer astonished at finding the Buddhist Philosopher reduce the Real to momentary events of his Ego. But analysis, after destroying, is able to reconstruct, and in observing the manner in which our illusions are formed, we have already discovered how they lead us on to truths.

Let us first take the sensations which we still attribute to ourselves, but which we project from their cerebral seat to situate them in the organs, and in general, at some point of our nervous periphery—namely, those of taste, smell, contact, pressure, muscular contraction, pain, heat, and cold. No doubt, these sensations are not at the spot in which they seem to us situated; but there is usually found at this spot the commencement of the nervous disturbance which excites them. For, as a general rule, each variation in this disturbance and in its real position is represented by a proportionate variation in the sensation and its apparent position, so that, as a general rule, our false judgment results in the same conclusion as a true judgment. It serves us as well;

it suggests to us the same provisions. If the nervous disturbance which excites the sensation of pressure increases in strength, the sensation of pressure increases in strength. If the nervous disturbance which excites pain actually changes place, the pain seems to change place. The differences of position which our ordinary judgment incorrectly supposes to exist between two sensations, are precisely the differences of position which physiological experiment correctly establishes between the starting points of the two corresponding nervous disturbances.—Thus our mind hits the mark, though its aim is bad, and what we erroneously allege of our sensations *applies* with an almost absolute and almost constant exactitude to the nervous disturbance connected with them. Except in those rare cases in which the nervous trunks and centres enter spontaneously into action, this application is always correct. This is from its being the effect, not of a coincidence, but of a harmony. In fact, the sensation is almost always connected with the disturbance of the extremity of the nerve; and this almost constant connection was necessary to establish in me the constant association of images by which I now situate the sensation in the neighborhood of the nervous extremity. Consequently if, on the one hand, this connection invariably leads me astray by making me invariably situate my sensation in a wrong spot, on the other hand it almost invariably retrieves the error, by almost invariably determining a disturbance of the nervous extremity. It has two consequences, the one unfailing and indirect, my mental illusion, the other direct and almost unfailing, the disturbance of the extremity of the nerve; they are two streams starting from the same source; that is why they correspond. If to the mental illusion there almost invariably corresponds the disturbance of the nervous extremity, it is from their both arising by virtue of the same law.

The same observation applies to sensations which we project beyond our sensible precinct, and which we consider to be events foreign to us, as for instance sounds, or qualities of objects foreign to us, as for instance colors.—No doubt it is erroneously that a particular sound, which is a sensation of my acoustic centres, appears to me to float in the air, at twenty paces to the right; but to its regular or irregular sound corresponds, element for element, a vibration of the air which is propagated from this point, at this height, this distance, and in this direction.—No doubt, again, it is erroneously that the white and blue rays, which are a sensation of my optic centres, seem to me extended on the paper with which my room is hung; but to these rays of color correspond, element for element, differences of structure in the surface of the paper, and consequently differences of aptitude to absorb or reflect the different luminous rays. Except in the rare cases in which the ear and eye have subjective sensations, the correspondence is perfect. So, here again, our judgment, invariably false in itself, is almost invariably true by correspondence and coincidence. What we erroneously affirm of our sensations is found true of something else; the variations and differences of the object coincide with the variations and differences of our sensations.—The fact is, that our sensations are adjusted to things, and the internal order to the external. Here, as before, the illusion of the sense proceeds from its education, and its education from the laws which connect the origin of a particular sensation to the almost constant presence of a particular external condition; so that, at present, when the illusion is produced, the external condition is almost invariably present. The law which has resulted in exciting the illusion within us usually occasions the condition without us. Admirable mechanism, which deceives to instruct us, and leads us through error to truth.

The disturbance of the extremity of a little whitish fibre, the vibration of the particles of a gas, the special structure of an illuminated surface—these are the real equivalents met with under the illusion which displaces and disfigures our sensations. But these equivalents themselves are bodies considered in the aspect of a movement they undergo, or of a quality they possess.—There remains then for us to distinguish the sense and value of a deeper illusion—that which constitutes external perception, and by which we affirm the existence of bodies. Is there any thing real corresponding to this phantom which sensation excites in us, and which we term a body? We have said that external perception is an accurate hallucination. In what does it differ from hallucination strictly so called, which is deceptive?—Analysis has already replied. To this internal and transient phantom which appeared as a permanent and independent thing there usually corresponds, characteristic for characteristic, a permanent and independent Possibility and Necessity, the possibility of certain sensations under certain conditions, the necessity of the same sensations under the same conditions with the addition of a complementary one. What I am legitimately and truly entitled to assert when I touch this ivory ball, is a group of relations between certain conditions and certain sensations; by virtue of these relations, every sentient being, who at any moment of time shall place himself under the conditions in which I am, will have the sensation I have, and the other sensations I imagine. The law is a general one, independent of my presence, of my absence, of my existence. Its permanence causes me to imagine a metaphysical entity—substance. Its efficacy causes me to imagine a metaphysical entity—force. These are convenient symbols, but we must retain them in the state of symbols. Taken in this sense, we may say that to our phantom corresponds a substance, independent of us, permanent, possessed of effective force, capable of exciting in every sentient being a certain group of sensations, more generally still, capable of exciting and undergoing an event which we have recognized as the equivalent of our most important sensations, that is to say motion, or change of place.

But while availing ourselves of these phrases, we carefully preserve the recollection of their inner meaning. We remind ourselves that our external perception, reduced to what truth it contains, is but a general assertion, the enunciation of a law, a kind of *prediction*, valid for the past as for the future, the prediction of certain events, sensations, or equivalents of sensations, as possible under certain conditions, as necessary under the same conditions, with the addition of a complementary one. We announce that every sentient being, who shall touch or shall have touched the ball, will have or will have had the group of muscular, tactile, visual sensations which we ourselves had; that everybody which shall come or shall have come into collision with the ball, will lose or will have lost a portion of its motion. There is hallucination proper, when the thing announced is not accomplished, when the white spherical form, which appears situated three paces from me, does not excite in me or in others the muscular and tactile sensations on which I reckoned, when a body which passes through the spot at which it appears to me situated, does not, in spite of my expectation, undergo any diminution of its motion. But this case is very rare, and the agreement between the preliminary announcement and the subsequent effect is almost constant. This means that there is, in fact, an almost constant connection between the visual sensation of this whitish spherical body on the one hand, and a certain group of muscular and tactile sensations on the other; the first is the indication of the second; when the sensation is given, the group is almost invariably possible; when the first is given, in almost every case, if there be added the complementary condition—the transport of the hand to the proper place—the second becomes necessary. Now my constant prediction is in my case the fruit of this almost constant connection. Consequently, the infallible springing up of the prediction supposes the almost infallible presence of the group, and the course of events, which, by its regularity, has created my attempt, finds, in this very regularity, cause to justify it.

All this mechanism is admirable, and the reader now sees the length of the elaboration, the perfection of the adjustment, which permit us to form, effectually and successfully, an act so usual, so short, so easy, as external perception. The operation resembles digestion or walking; apparently, there is nothing more simple; in reality, there is nothing more complex.—There is, in front of me, three paces off, a book bound in brown leather, and my eyes are open. A certain sensation of brown color rises in my optic centres; in other centres rise muscular sensations excited by the adjustment of my eye to the distance, by the convergence of the two eyes, by the direction of the convergent eyes; these sensations vary with the sensation of brown color, in proportion as the eye, in its movements, follows the outline and variously illuminated portions of the book. There are two series of sensations, whose position is in the box of the skull: these are the crude materials.—All the ulterior process consists in a coupling of images. Thanks to the associated image of the muscular sensations which would conduct the exploration of touch up to and along the book, the sensation of color, which belongs to us, ceases apparently to belong to us, and appears an extended patch situated three paces from our eyes.—Thanks to the associated image of the sensations of contact and resistance which our exploring touch would then experience, the patch seems to us a solid extension.—Thanks to the associated image of the sensations which would be experienced at any time by any being similar to ourselves, it seems to us that there is at that spot, something permanent, independent, and capable of exciting sensations, and which we term matter.—Thus arises the internal semblance, composed of an alienated and wrongly situated sensation, of associated images, and, moreover, in the man who reflects, of an interpretation and a name which isolate and set apart a permanent character included in the group.—This semblance changes at every moment with the sensations which form its support. On each new support the associated images construct a new semblance, and the mind is filled with innumerable inmates, a transient population to which corresponds, each to each, the fixed population of the outer world.

BOOK III.

THE KNOWLEDGE OF MIND.

CHAPTER I.

THE KNOWLEDGE OF MIND.

I. HERE, then, we have reached the unextended centre, a species of mathematical point, by relation to which we define all the rest, and which each of us calls *I* or *me*. We revert to it at every instant of our life; a very intense contemplation, almost amounting to ecstasy, is requisite to detach us wholly from it, and to cause us to forget it for some minutes; even then, by a sort of rebound, we re-enter upon ourselves with greater energy; we mentally review all the foregoing scene, and say, mentally, twenty times in a minute: "Just now I was in such a place, I looked in such a direction, then in another, I had such an emotion, I made such a gesture, and now I am here."—Besides this, the idea of ourselves is comprised in all our recollections, in almost all our previsions, in all our pure conceptions or imaginations.—Moreover it is called up by all our sensations in any way strange or vivid, especially those of pleasure or pain, and we often forget the external world almost completely and for a considerable length of time, to recall some agreeable or interesting passage of our life, to imagine or desire some great good fortune, to observe in the distance, either past or future, some series of our emotions.—But this *ourselves*, to which, by a perpetual recurrence, we attach each of our successive events, is far more extensive than any one of them. It is drawn out before our eyes with certainty, like a continuous thread, backwards, over twenty, thirty, forty years, up to the most distant of our recollections, and further still, up to the beginning of our life, and it is drawn out too, by conjecture, forwards, into other indeterminate and obscure distances. For each new link we add to it we review a longer or shorter fragment, a minute, an hour, a day, a whole year, many years, sometimes an enormous portion in the twinkling of an eye, and as if in a flash of lightning. This is why, when compared to our transient events, this Ego assumes a sovereign importance in our eyes.—We must now examine what idea we have of it, of what elements this idea is composed, how it is formed within us, why it is called up by each of our events, what thing corresponds to it, and by what adjustment this correspondence of the thing and idea is effected.

II. What do we understand by an Ego, in other words by a person, a soul, a spirit? When we conceive some living man, Peter, Paul, or ourselves, what idea is there within us, and of what elements is this idea composed?—What we affirm is, in the first place, a something, a being; I purposely employ the vaguest language, so as not to prejudice the matter. But, in pronouncing these words, we affirm nothing of this thing, except that it is; we say nothing of what it is, that question we reserve.—What we affirm is, secondly, that it is a permanent being; there is something in it which lasts and remains the same. I exist to-day, but I existed yesterday and the day before; and so with Peter and Paul. If both they and I have changed in some respects, in other respects they and I have not changed, and I conceive, in them as in myself, something which has remained fixed. But, in saying this, I do but affirm the permanence of something in them and me; I do not say what this something is; I state its durability, not its quality; that question we also reserve.—What we affirm is, thirdly, that this something is connected with a particular organized body; I have mine, Peter and Paul have each their own, and we mean thereby to say that, as a general rule, certain alterations of my body excite in me directly some particular sensations, and that certain events in me—emotions or volitions—excite directly in my body certain alterations; the same being the case with Peter, Paul, and their respective bodies. But this rule only states a constant relation between certain changes of a particular body and certain states of the unknown something; what that relation is, still remains to be examined; that question we again reserve.—After having stated its existence, its permanence, and its principal relation, we must now inquire into the qualities which determine it.

These qualities are its capacities and faculties. I am capable of feeling, of perceiving external objects, of recollecting, of imagining, of desiring, of willing, of contracting my muscles, and in this respect, Peter, Paul, and other men are similar to myself. Moreover, in addition to these capacities common to all men, I have others special to myself; for instance, I am able to understand a Latin book; this porter can carry a weight of 300 pounds; here are precise capacities which determine the unknown something. Let us reunite in one group and one bundle all these capacities and faculties, common or special, which are met with in any one, and we shall know what he is, in knowing what he contains. The vague and empty sketch, which we had of the Ego or of the person, becomes limited and is filled out.

III. Here, then, we are led to inquire into what we mean by capacities and faculties. I have the capacity or faculty of feeling; this means that I am capable of having sensations, sensations of various kinds, of smell, taste, cold, heat, and, for instance, of sound. In other words, sensations of sound which, if they arise, will be mine, are possible. They are possible because their condition is given, that is, a certain state of my acoustic apparatus and of my sensory centres; if this condition ceased to be given, they would cease to be possible; I should no longer be able to hear sounds; I should be deaf.—And so, a man has the faculty or power of perceiving external bodies, especially by sight; this means that sensations of sight, which, if they arise, will be his, are possible. They are possible upon two conditions; his optical and cerebral apparatus must be in the proper state, and the education of the sight must have associated in him with optical sensations the image of certain muscular sensations; as these two conditions are given, his perceptions are possible; if one or the other were suppressed, his perceptions would cease to be possible he would lose or would incompletely possess the faculty of sight.—So it is in all other cases, whether we consider a faculty common to all men or a faculty special to an individual. I have the power or faculty of moving my limbs, and of retaining my ideas persistently. This means that this movement of my limbs and this persistence of my ideas is possible; the movement is possible because its condition—a certain state of my muscular and nervous system—is given; this persistence is possible because its condition—a certain equilibrium of my images—is given.—I have the faculty of understanding a Latin book, and my neighbor the porter has the faculty of carrying a load weighing 300 pounds; this means that if I read a Latin book, I shall understand it; that if the porter has a load of 300 pounds weight on his back, he will carry it. The first act is possible to me, because its condition—the knowledge of the Latin words—is given; the second is possible to the porter, because its conditions—the development of his muscles and the habitude of bodily exercise—are given. Suppress one of these conditions; the possibility disappears, and the faculty perishes, until the missing condition is re-established. Soften and waste away the porter's muscles by a month's low diet; he will no longer be able to lift his load. If paralysis benumbs the nerves of my arm, I shall no longer be able to lift that arm. If an hallucination prevents my sensory centres from receiving the impression produced on my retina by the rays emanating from the table; as long as the hallucination lasts, I shall be unable to perceive the table by sight.—On the other hand, cure the hallucination and the paralysis, and strengthen the weakened muscles; the possibilities, and with them the suspended faculties, will re-arise as they were before.

Thus, faculty and capacity are wholly relative terms; and here we fall again into a similar analysis to that which we effected with the properties of bodies. All these words are equivalent to that of *power*; and, whatever be the power, that of a dog which can run, that of a mathematician who can solve an equation, that of an absolute king who can cause heads to be cut off, the word never does more than state that the conditions of an event or of a class of events are present. —There is nothing more useful than the knowledge of such conditions; it permits us to foresee events, those of others as well as our own. Consequently, we attach a great importance to these powers; they are to us the principal and essential part of things; we are tempted to form of them distinct entities, to consider them as a primitive foundation, a stable groundwork, an independent and productive source from which events flow.—The truth, however, is that a power is nothing in itself, except an aspect, an extract, a particularity of certain events, the particularity they have of being possible because their conditions are given. If these events are mine or a consequence of mine, the power appertains to me. In saying that I have such a power, I do but announce as possible such an event, sensation, perception, emotion, volition, which will, perhaps, form part of my being, and some other event, muscular contraction, carriage of a load, execution of an order, which will follow, sooner or later, a possible state of my being. But these events and states are supposed, not given; they do but form part of my possible being, they do not form part of my real being. One only of them will arise at any particular moment; the others, in unlimited number, will not arise. The others will remain on the threshold, or outside; this single privileged one will enter alone, and will alone form part of myself. I find, then, by way of real elements and positive materials, to constitute my being, nothing but my events and states, future, present, and past.

What there is actually in me is their series or web. I am, then, a series of successive events and states, sensations, images, ideas, perceptions, recollections, previsions, emotions, desires, volitions, connected together, excited by certain changes of my body and of other bodies, and exciting certain changes of my body and of other bodies. And, as it is plain that my events, past, future, or possible, are all more or less analogous to the daily events which I can seize at the moment, or almost at the moment, at which they are produced, these last, the clearest and most near to us of all, are what I proceed to study to know what constitutes the Ego.

IV. Let us, then, consider one of these events, or groups of present events, some sensation of pain or pleasure, of contact, of temperature, of taste or smell, some tactile and muscular sensation, some preponderant image, some preponderant mental word, some emotion, desire, or volition.—At the present moment I suffer from headache, or I taste a fine fruit, or enjoy myself by warming my limbs in the chimney-corner; I imagine or recollect, I am vexed or enlivened by an idea, I decide on taking some step. These are the events I find within me; active or passive, voluntary or involuntary, whatever be their shades, it is of no importance; they constitute my present being, and I attribute them to myself. Now, all the events I attribute to myself have a common character; they appear to me as *internal*.

Let us begin with the most frequent of all, that is to say the representations, ideas, and conceptions which we have of objects, and especially of external bodies: for instance, I represent to my myself an old time-piece in the adjoining room. Furniture, interiors of rooms, human or animal figures, trees, houses, streets, landscapes—it is representations of this class whose series composes the ordinary current of our thought. By a mechanism we have described, their hallucinatory tendency is checked: they are affected by a contradiction which negatives them as external objects; they are thus opposed to external objects; in other words, they appear internal.—

So it is with every idea, sensible or abstract, simple or compound. For an idea is always the idea of some thing, and consequently comprises two phases, the first an illusory one, in which it seems the thing itself; the second a rectified one, in which it appears a simple idea. This transformation it undergoes opposes to each other the two phases which constitute it; we express this passage by saying that we re-enter upon ourselves, and that, from the object, we revert to the subject; it is, then, the same event or group of events which, according to its successive states, constitutes, first, the apparent object, then the actual subject.—Thus the rectifying operation, by which an idea appears as an idea, is also the reflection by which this idea appears as something internal; and the contradiction which negatives it as a fragment of the outer world gives it at the same time a position as a fragment of the inner world.

We must now observe that every idea, conception, and representation has a double face. On the one hand, it is a cognition; on the other hand, it is an emotion. It is agreeable, painful, surprising, startling, tender, consoling. Its energy, its weakenings, its intermittences, are precisely the energy, the weakening, the intermittences of the emotion. There is but one and the same fact with two aspects, one intellectual, the other affective and impulsive.—You are told that some one whom you left yesterday in good health has suddenly died, and this idea upsets you. You are told that a near relation is seriously ill, and this idea afflicts you. It excites a general shock, or kind of sharp pain, which continues, though growing feebler, and thus causes a lasting disorder. There is nothing strange in this long trouble, which starts from an idea and lasts over a series of ideas, seeming to us, like the ideas, internal; in the desires and volitions which spring from it being similarly referred to within; in the sequences and characters of the ideas being opposed, like the ideas, to the outer world, and incapable of finding a place there.

There remains for inquiry, why the sensations which we localize in our bodies also appear to us as internal, and are referred by us to ourselves.—To find the reason of this, it is sufficient to compare them with those equally belonging to us, and which nevertheless we do not attribute to ourselves, those of color and sound. We have seen the mechanism which projects these in appearance beyond our body; if they are alienated from us, it is because they are projected out of our precinct. It is, then, because the others, those of contact, of pressure, of heat, of muscular effort, of local pain, of taste, and smell, are not projected beyond our body, that they are not alienated from us; their position is the cause of their attribution; we refer them to ourselves because our body, compared with others, has singular and special characters.—In fact, it is by its medium that we perceive other bodies and act upon them. Whether the action comes from us or them, it is always between them and us. In order for us to know other bodies, it is first necessary for one of the organs of our body to be disturbed; in order for us to impress motion on other bodies, it is first necessary for one of the muscles of our body to be contracted. It is our first movable thing, and first motive power; with relation to other things, it is always *inside;* with relation to it, other things are always *outside.* It is our immediate precinct, in such a way that, if we compare it to other things, it is *a within* and they are *a without.*—This is why the sensations of which we have been speaking, though placed by us in our organs, appear as internal, and are referred to self.—Such is our conception of the actual subject; these are the present and real facts it comprises. That which I actually am, that which constitutes my real being, is a certain present real group of sensations, ideas, emotions, desires, volitions; my conception of my actual being comprises these events only, and all these events, on analysis, present this common character, that they are pronounced internal, whether because, as ideas and sequences of ideas, they are opposed to objects and deprived of situation, or because their apparent position is met with in our body.

V. Now, at the preceding moment, the subject being wholly similar, contained events only of the same class; the same observation is to be made for each of the anterior moments. And, in fact, when we consider any of these moments by recollection, we find they are all similar to the present moment; just now, when in the other room, I felt cold, and walked, I looked at the clock, I foresaw, I desired, I willed, as at this moment. Consequently, my past, as my present events, have all this character of appearing internal.—In this way they form a chain, whose links, all composed of the same metal, appear at once united and distinct. For, according to the mechanism we have described and explained, on the one hand the image which constitutes a recollection seems projected backwards, and recedes beyond the repressive images or sensations, which separates it from them; and, on the other hand, the same image, becoming precisely situated, seems to be joined by its posterior extremity to the anterior extremity of the repressive images or sensations, and is thus joined to them; so that our events appear to us as *a continuous line of contiguous elements.* We pass without difficulty from one link to another; according to the well-known law which governs the revival of images, the images of two successive sensations mutually tend to call each other up; when, therefore, the image of some one of our anterior moments revives in us, the image of the preceding and that of the succeeding moment tend to revive by association and correspondence.

Not only do we pass by these means from one of our moments to an adjacent one; but, by means of abbreviations which collect in one image a long series of moments, we pass from one period to another of our life. In fact, if, in order to recollect one of our somewhat distant events, it were necessary to call up the images of all our intermediate sensations, the operation would be of prodigious length; strictly speaking, it would require as much time as elapsed between that event and the present moment. For the whole detail and duration of the intermediate sensations are reproduced in the images which conduct us backwards to that event; it would thus require twenty-four hours to recall a sensation of yesterday. For this Nature has supplied a remedy in the obliteration which images undergo,* and in the property possessed by certain prominent images of being the abbreviatory substitutes of the group in which they are included.—For instance, this morning I went into such a street, and such a house; at present, if I recall my walk, numbers of details are missing; many of my sensations do not revive. I do not see again the different figures of the houses, carriages, and passers-by, which I then saw; nine out of ten of them are obliterated definitively and for ever; of all these impressions there is but a remnant capable of reviving. Again, it almost always happens that, in ordinary life, I do not give it time to rise; it would be necessary for me to dwell on it, to search in my memory. It is only when I search that I see again certain precise details, some shop, some interesting countenance, some striking part of the street. If I do not dwell on it, if I do not drive away supervening impressions and distractions, if I do not give my recollections time to become precise and complete, they almost all remain in the latent state; that which survives and emerges is one fragment out of ten thousand, the vague representation of my progress at some moment in the street, of my arrival in the house, or of the attitude of the friend I went to see.—But this is enough; the shred which is preserved supplies the place of the rest; I know by experience that by concentrating my attention upon it, I should revive several similar ones of the same series; it is to me in future the summary representation of the whole. —So is it with the breakfast I had previously eaten, with the reading which occupied the first hours of the morning; so that, with three abbreviatory substitutes, I remount in a mo-

* Part i. book ii, chapter ii.

ment to my getting up, that is to say to an incident separated by ten hours from the present moment.

The more distant the event, the greater is the obliteration of the images; and the greater the obliteration, the more things does the abbreviatory substitute comprise.—My doings of yesterday or the previous day subsist in me only through some striking event, some visit I received, some domestic occurrence for which it was necessary to provide. If I recede still further, I perceive only, in the shipwreck an irremediable swallowing up of my innumerable anterior sensations, a few surviving images, my arrival at the country house I am staying in, the first green leaves of spring, a winter's evening at a particular house, the appearance of a strange town I visited a year ago. I may thus go back very far and very fast, and by springing from peak to peak, may reach in an instant things ten or twenty years distant.—Add to this the calendar, calculations, all the different means which we possess, and which children and savages do not possess, of measuring this distance. Thanks to an association of images, we place our events in the series of days and months with which the almanac furnishes us, in the series of years furnished by chronology. When this is effected, we render precise, by these auxiliary charts; the position which our various events occupy in duration with reference to one another, and are able, not only to review in a second our most distant events, but also to estimate the interval separating them from the present.

By this operation, more or less perfected, we embrace very long fragments of our being in an instant, and, so to speak, in a single glance. The distinct events whose succession has, during this interval, constituted our being, cease to be distinct; they are obliterated by the abbreviations and the speed; nothing of the series survives, except a character common to all the elements traversed, the particularity they have of being internal. There remains, then, the idea of an internal something, of a *within*, which is, in this respect, opposed to all the without, which is always met with the same at all moments of the series, which, consequently, lasts and subsists, which, for this reason, appears to us of superior importance, and which attaches to itself, as accessories, the various transient events. This stable within is what each of us calls *I* or *me*.*—Compared to its events, which pass away while it subsists, it is a substance; it is denoted by a substantive or a pronoun, and it incessantly reverts to the most prominent place in oral or mental discourse.—Henceforward, when we reflect on it, we permit ourselves to be duped by language; we forget that its permanence is apparent, that, if it appears fixed, it is because it is incessantly repeated, that it is in itself nothing more than an extract from internal events, that it derives from them all its being, that this borrowed being, detached by fiction, isolated by the oblivion of its connections, is nothing in itself and apart. If we do not undeceive ourselves by a rigid analysis, we fall into metaphysical illusion; we are disposed to conceive it as a distinct thing, stable and independent of its modes of being, and even capable of subsisting after the series from which it is derived has disappeared.

Another metaphysical illusion comes in to complete its being and effect its isolation. We have classed its events and the facts which its events excite according to their resemblances and differences, and we have placed each group in a distinct compartment and under a common name—here sensations, there external perceptions, there, again, recollections, volitions, voluntary movements, and so on. Considering our present state, we know or suppose that the conditions of these events are present—in other words, that these events are possible; we express this by saying that we have the power, capacity, or faculty of feeling, perceiving, recollecting, willing, contracting our muscles. Besides these powers common to all men, each of us discovers in himself,

* According to some, the word I (je, ich, ego, aham) comes from the root *ah*, to breathe, and denotes the inner breath; according to others, it comes from the root *gha*, *ha*, which signifies *this one*, and by which a person speaking denotes him self to his listener.—Max Mueller, "The Science of Language."

by a similar experience, special powers peculiar to himself. Now, when we consider these powers, we find them all more or less permanent. They precede events, and, in general, survive events. They last intact during long years, some during our whole life. They thus form a contrast with transitory events, and seem the essential part of man. In this way their notion is attached to the notion of the persistent Ego; thereupon this Ego ceases to appear to us as a simple *within;* it becomes furnished, is qualified, and determined; we define it by the group of its powers, and, if we allow ourselves to slip into metaphysical error, we set it apart as something complete and independent, invariably the same under the flow of its events.

VI. Such is the notion of the Ego. Illusory in the metaphysical sense, it is not so in the ordinary sense; we cannot pronounce it void; there is something corresponding to it, something very analogous to that which, according to our analysis, constitutes the substance of bodies. This something is the permanent possibility of certain events under certain conditions, and the permanent necessity of the same events under the same conditions, with the addition of a complementary one, all these events having a common and distinctive character, that of appearing as internal. Thus we are entitled to say, while preserving exactly the meanings of our words, that the Ego is a force as bodies are—a force which, with relation to them, is a within, as they, with relation to it, are a without. These three words, force within, without, express relations only; nothing more; at all the moments of my life, I am a within, capable of certain events under certain conditions, and whose events under certain conditions are capable of exciting other events in itself or others. This is what endures in me, and this will be invariably the same at all the instants of my existence.—It is manifest that we have not here a primitive notion. It has precedents, elements, and a history, and we may reckon all the steps of the involuntary operation which results in forming it.

It is necessary, first, that we should have recollections and exact recollections. It is further necessary that, by the fixing of our recollections, our events should appear to us as a continuous thread. It is then necessary that, thanks to the abbreviations of memory, the particularities of our events should be obliterated, that a character common to all the elements of the thread should predominate, be disengaged, be isolated, and erected, by a substantive name, into a substance. It is further necessary that we should acquire the idea of the powers, capacities, or faculties of this substance, therefore, that we should classify our events according to their various kinds, that, by a more or less prolonged experience, we should discover their external and internal conditions, that, stating or presuming the presence of conditions, we should conceive these events as possible, and finally, that isolating this possibility, we should attribute it to ourselves, under the name of power, capacity, or faculty.—The idea, then, of the Ego, is a product; many variously elaborated materials concur in its formation. Like every mental or organic compound, it has its normal form; but, in ordor that it may attain this form, certain materials and a certain elaboration are required; with a very slight change in the elements and derangement of the process, the form is deviated from and the final result is monstrous. Consequently the idea of self may deviate and become monstrous; and, nearly as we are situated to ourselves, we may deceive ourselves in many ways respecting our self.

In the first place, certain foreign elements may introduce themselves into the idea we have of it. There are circumstances in which a series of imaginary events inserts itself in the series of real events; we then attribute to ourselves what we have not experienced and have not done.—In the waking state, this ocurrence is rare; and seldom happens except with men whose imagination is over-excited. I have mentioned the story of Balzac, who described one day, at the house of Madame de Girardin, a white horse he intended to present to his friend Sandeau, and who, a few days afterwards, in the persuasion that he had actually given it, inquired of Sandeau about it. It is plain that the starting-point of an illusion like this is a voluntary fiction; the author of it is at first aware that it is fictitious, but finally forgets it.—With barbarous people, in uncultivated and childish minds, many false recollections thus take root. Men have seen a very simple fact; gradually, when it is distant, in thinking of it, they interpret it, amplify it, provide it with details, and these imaginary details, becoming incorporated with the recollection, end by themselves seeming to be recollections. The majority of legends, and religious legends especially, are formed in this way.—A peasant, whose sister had died abroad, assured me that he had seen her soul the very evening of her death; on inquiry being made, this soul was a phosphorescence produced in a corner on an old chest of drawers, where there was a bottle of spirits of wine standing.—The guide of a friend of mine at Smyrna declared that he had seen a young girl carried through the air in full daylight by enchantment; the whole town had witnessed the miracle; after fifteen hours skilful questioning, it became evident that all the guide recollected was having seen on that day a small cloud in the sky.—In fact, what constitutes recollection is the spontaneous recoil of a representation which becomes precisely fixed between certain links in the series of events which form our life. When this recoil and this fixing have become involuntary, when we no longer remember that they were at first purely voluntary, when finally no other representation is projected to the same spot and rises there to form an obstacle, the false recollection is taken for true.

All these conditions are met with in dreams; this is why we have, when dreaming, not only false external perceptions, but also false recollections.* I have noted many such in my own

* September 28, 1868. M. Maury cites many false recollections which he has had in dreams. "Le Sommeil," etc., p. 211, and p. 70.—See *ante*, p. 65 (part i. book ii. chap. i.), the story of the old man who attributed to himself the travels he had read, as well as those he had actually made.

case; only lately, I imagined myself to be in a drawing-room turning over an album of landscapes. The first of these pictures represented the Polar Sea, a great expanse of blue water, surrounded with icebergs. At this moment, I perceived the artist standing before me, and felt myself compelled to praise aloud the beauty of the work; I turned over the pages, and the pictures seemed to me to grow more and more wretched, and suddenly I recollected that, a year ago, I had had this album in hand, that I had even noticed it in a newspaper that my article, by no means a laudatory one, was of about thirty or forty lines on the third column of the second page. On this recollection, I felt so confused that I woke up. Now, observe that the whole dream was a fiction; but the recoil and fixing took place spontaneously without meeting a contradictory representation, in such a way that the imaginary article found itself affirmed.

So, again, there is nothing more common than false recollections in cases of insanity, and especially with monomaniacs. Such persons form a romance in accordance with their ruling passion, and this romance inserted in their life ends by composing in their eyes all their past life.—A woman whom I have seen at Salpêtrière, told, with perfect precision and conviction, a story according to which she was noble and wealthy. Her real name was Virginie Silly, and she called herself Eugénie de Sully. To believe her, her parents had purposely lost her seven or eight times, and her mother had finally sold her to a mountebank, with whom she remained two years. Before 1848, she had interviews with Louis Philippe and made reports to him on the Casino, the Chaumière, the Ranelagh, and the hospitals. "I was," she said, "commissary-reporter to his Majesty, and the King gave me large sums." Later on, when she was living in the Rue Poissonnière, the Emperor came to listen to her conversation from behind a screen, and caused her to be locked up. One of her uncles, a slave dealer in Chili, left her six millions; she has still a quarter of a million in the Bank. But she has been robbed of her papers and parchments, and in their stead has been left a false register of birth, according to which she is poor and of humble origin.*—Another woman, in the service of M. Métivier, and the daughter of a porter in a public office, being young and pretty, imagined that the minister frequently noticed her, and alleged that he had communicated with her through a procuress. On this, her lover, who was a clerk in the office, broke off the engagement. She married a workman, became pregnant, was confined, and, in the meantime, the minister died; she then announced that he had left her by will two hundred thousand francs. Her false recollections were so clear that her lover abandoned her, and her husband almost believed her.†—In somnambulism and hypnotism, the patient who has become extremely sensible to *suggestion*, is subject to similar illusions of memory; he is told that he has committed such and such a crime, and his figure at once expresses horror and dismay. Ordinary recollections no longer present themselves, or are too feeble to exercise their ordinary power of repression; in the absence of the normal counterpoise, the simple conception becomes an affirmative conception, and the patient recollects murders which he has not committed.

Other cases present the inverse illusion. We then no longer deceive ourselves by addition, but by exclusion; instead of inserting in our series events which do not belong to us, we cast out of our series events which are really ours.—This is the error into which we fall respecting colors and sounds; its mechanism has been described. These, in themselves, are sensations, like those of heat or taste; but as they are repulsed from our nervous surface, they appear detached from us; by this alienation, sound appears as an external event, and color as a quality of a body other than ourselves.—

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* From a note of a Lecture by M. Baillarger, at the Salpêtrière, in 1856. The Professor questioned the patients in the presence of his class.

† See Leuret, "Fragments Psychologiques," for an analogous case of a madman called Benoît (p. 64).

This error is normal, and we have shown in what way it is useful. But there are others which are abnormal, and bring disturbance into all our conduct; these are the hallucinations termed psychical;* in such cases, the patient alienates and refers to others thoughts which are his own; he understands by *thought*, he hears "secret internal voices;" they speak to him "silently;" he sees "invisibly." The wife of an English officer at Charenton spoke of a sixth sense by which she heard voices; it was "the sense of thought."—When we question such patients, they reply that the word voice of which they avail themselves is very inappropriate, and that they use it by way of metaphor, for want of a better word; the voice has no tone, it does not seem to come from the outer world as in ordinary cases; mystics have already made this distinction, and oppose "intellectual speech and voices" which their soul seizes without the intervention of the organs of sense, to bodily voices which they perceive in the same way as in ordinary life. Blake, the poet and engraver, who called up the illustrious dead, conversed with them "soul to soul," and, as he said, "by intuition and magnetism."—It is easy to recognize that the ideas which such persons attribute to others belong to themselves. A person talking with Blake begged him to ask Richard III. if he professed to justify the murders he had committed during his life. "Your question," said Blake, "has already reached him. . . . We have no need of words. This is his answer, only it is somewhat longer than he gave it me, for you would not understand the language of spirits.—He says that what you call murder and carnage is all nothing; that in slaughtering fifteen or twenty thousand men you do no wrong, for what is immortal of them is not only preserved but passes into a better world, and the man who reproaches his assassin is guilty of ingratitude, for it is by his means that he enters into a happier and more perfect state of existence. But do not interrupt me, he is

* Baillarger, "Des Hallucinations," part i.

now in a very good position, and if you say anything more he will go." It is evident that Blake imputed his own theories and dreams to Richard III.; the person he imagined was an echo which sent him back his own thought.—A madwoman played incessantly at even or odd with an absent person whom she believed to be the prefect of police; before playing, she looked at the coins she had in her hand, and thus knew their number; the prefect, therefore, always guessed wrong, and never failed to lose; later on, she neglected her preliminary examination; and then, the prefect sometimes lost, and sometimes won.—It is evident that, at first, she herself fabricated, without suspecting it, the error she attributed to the prefect.

The starting point of these illusions is not hard to distinguish; we find it in the process of mind of the dramatic author, the novelist, of every person of lively imagination; in the midst of a mental monologue, there springs up an address, an answer, a kind of internal person rises and addresses us in the second person: "Rentre en toi-même, Octave, et cesse de te plaindre."—Now suppose that these addresses, these answers, while remaining mental, are wholly unforeseen and involuntary—a thing which often happens. Suppose they comprise strange and sometimes terrible ideas, that the patient cannot excite them at will, that he undergoes them, that he is beset by them.* Suppose, in a word, that these discourses are well connected, indicate an intention, impel the patient in one or another direction, towards devotion or towards vice. He will be tempted to attribute them to an invisible speaker, especially if the religious atmosphere in which he lives, and his own special creed, authorize his fabricating such a speaker. The whole series which constitutes the Ego is thus cut into two parts, because the two partial

* See the whole autobiography of Bunyan, the author of the "Pilgrim's Progress."—Also the eloquent and sublime conversations of Tasso with his familiar genius, recorded by Manso.—So again, the warnings given to Socrates by an internal voice.

series which compose it present distinct or even opposite characters. Sometimes, when the second has nothing extraordinary about it, the patient still attributes it to himself, and believes himself to be double. "I am led to believe," says a sufferer from hallucinations, "that I have always had within me a double thought, one of which controls the actions of the other." "There is," says another patient, "as it were a second myself who inspects all my actions and words, like an echo which repeats everything." A third, recovering from a fever, "believed himself formed of two individuals, one of which was in bed, while the other walked about; although he felt no appetite, he ate largely, having, as he said, two bodies to support."*—At other times, the second series is referred to another person, especially when the ideas it contains are out of proportion to those which make up the first series. Thus were formed the demon of Socrates, and the familiar genius of Tasso.—Usually, after a time, sensorial hallucination comes in to complete psychical hallucination. The internal mental voices become physical and external. "At first, according to patients, it was something ideal and like a spirit speaking in them; now, they actually hear speech;" the voices are clear or indistinct, deep or high, melodious or screeching. I have already mentioned the case of Theophile Gautier, and how, passing once before the Vaudeville, a phrase printed on the notice-board fastened itself upon his recollection, how, in spite of himself, he incessantly repeated it, how after some time it ceased to be simply mental, and seemed to proceed from a bodily throat, with distinct tone and accent; it revisited him thus, at intervals and unexpectedly, and this lasted several weeks. Suppose a mind preoccupied, beset with fears, assume that the voice pronounces, not only a single monotonous phrase, but a series of threatening and appropriate speeches, and we have the case of Luther at the Wartburg, when he disputed

* Griesinger, p. 93, and Baillarger, op. cit. passim.

with the devil. The mental words have excited in the sensory centres of the encephalon corresponding sensations of hearing, and henceforth, detached in this double sense from the Ego, they are imputed to an interlocutor.

These illusions are partial only; there are total illusions, in which the series of our events is replaced by a strange series. Peter imagines himself Paul, and acts on the belief. Here again, the starting point of the error is in a well-known process of the mind, that of the novelist or author who puts himself in the place of his characters, adopts their passion, and experiences their emotions.—This operation is nowhere so clearly seen as in hypnotism; the attention of the patient is then limited and concentrated, and rests only on one series of ideas; this alone is developed; all others are benumbed, and, for the time, incapable of reviving; consequently ordinary recollections are missing and no longer exercise their repression; the illusion which, in the author and novelist, is upset at every moment, is now no longer checked and follows its course.* "A. B. was asked his name, he answered rightly, without hesitation. When hypnotized and in the state of coma (being capable of holding himself upright and in appearance wide awake, though with a strange wandering air as in somnambulism) it was strongly suggested to him that he was Richard Cobden. A few seconds afterwards he was asked his name. He answered at once, and without hesitation, 'Richard Cobden.'—'Are you perfectly sure of it?'—'Yes,' he answered.—Similar experiments tried with different names, on various other occasions, had always the same results.—During the state of normal wakefulness, the subjects experimented on gave their proper names as soon as they were asked. On the contrary, if during the fitting period of hypnotic sleep the name of a king was suggested to them, not only were they impelled to say that it was their name, *but they felt and acted in a way which manifested their conviction that they were kings.*"

* "Annales Médico-psychologiques," 4me Série, vi. 428.—Dr. Hack Tuke, "De la Folie Artificielle."

This state, instead of being transient, may become fixed; this is frequent in the asylums, and is often met with in periods of religious exaltation.—A quartermaster in Cromwell's army, James Naylor, believed himself God the Father, and was worshipped by many enthusiastic women. He was tried by Parliament, and sentenced to the pillory.—We find, in asylums, lunatics who believe themselves Napoleon, the Virgin Mary, the Messiah, or some other person. One of them named Dupré, a patient of Leuret, believed and said that he was at once Napoleon, Delavigne, Picard, Andrieux, Destouches, and Bernardin de Saint-Pierre.—A woman called Catherine, mentioned by Leuret, is no longer herself; she does not call herself Catherine; there is a rupture between her past and present; she only speaks of herself in the third person, saying "the person of myself."—Others are transformed into animals. "There was a man of Padua," says Wier, "in 1541, who believed himself to be changed into a wolf, and ran about the country attacking and killing all he met. After many difficulties, they contrived to seize him. He said boldly to those who arrested him: 'I am really a wolf, and if my skin does not look like a wolf's skin, it is because it is turned and the hair is inside.'—In order to assure themselves of the fact, they wounded the wretched man in different parts of his body, and tore off his arms and legs."—If the patient experiences false sensations, through hypnotism or illness, he may come to form the most eccentric ideas of his body, and therefore of his personality.—"Among a number of hypnotized women," says Dr. Elliotson, "one imagined that she was made of glass, and was afraid that she might become broken; another that she was no bigger than a grain of wheat; another that she was dead." And so, some insane persons are convinced that their body is made of wax, of butter, of wood, and act accordingly. Leuret mentions men who believe themselves changed into women, and women who believe themselves men.—A soldier whose skin had become insensible, believed himself to have been dead since the battle of Austerlitz, where he received a wound. "When he was asked as to his health, he said—'You want to know how Father Lambert is? But there is no Father Lambert; a cannon-ball killed him at Austerlitz; what you see here is not him; it is a wretched machine made to look like him; you ought to ask them to make a better one.'"—In speaking of himself he never said *me*, but always *it*.*

In short, the conception which I have of myself at any given moment is an abbreviatory and substitutive name, sometimes my name, sometimes the word *I* or *me*, both of them mentally pronounced. If I dwell on this name, it will, in the normal state, call up in me, by association, its equivalent, that is to say the series of my actual and interior events, joined with the numerous series of possible events of which I am actually capable. But this principal association, being an acquired one, may be lost; and so it is with the secondary associations which solder together in my mind the various fragments of the whole series. If an extrinsic fragment or an extrinsic series then comes to intercalate itself in the empty place, the patient will be mistaken about himself. We have just seen the principal conditions of this transposition. Sometimes the energy of the normal associations is weakened, as in sleep and hypnotism; the link which binds my name to the word *I* is weakened; consequently, a persistent suggestion is capable of substituting for my name that of another; henceforward this name with the whole series of events of which it is the equivalent is called up in me as soon as the word *I* reverts mentally, and henceforward I am, in my own eyes, some other person—Richard Cobden, or Prince Albert. —Sometimes the energy of the normal associations is conquered by a greater force. The pure conception which,

* Analogous illusions occur in dreams. M. Charma dreamed once that he was aide-de-camp to Henry IV.; another time that he was Voltaire.—Dr. Macnish dreamed that he was a pillar of stone, and saw all that passed around him. —De Quincey, the opium-eater, dreamed that he was the idol in a Brahminical temple, etc.

repressed by the series of recollections, was at first checked in its evolution, now accomplishes its development in accordance with its hallucinatory tendency. Incessantly repeated, with daily increased vividness, maintained by a ruling passion, by vanity, love, or religious scruples, sustained by false sensations ill interpreted, confirmed by a group of suitable explanations, it assumes a definite ascendancy, annuls contradictory recollections; being no longer negatived, it is pronounced affirmative; and the fiction, which was at first declared a fiction, seems a true story.—Thus, our idea of our person is a group of co-ordinated elements whose mutual associations, ceaselessly attacked and ceaselessly victorious, are maintained during our waking hours and reason, as the composition of an organ is maintained during health and life. But madness is always hovering near the mind, as illness is always hovering near the body; for the normal combination is a victory only; it results from and is renewed by the continual defeat of the contrary forces. Now, these last are always present; an accident may give them the preponderance; there is but little required to enable them to assume it; a slight alteration in the proportion of the elementary affinities and in the direction of the constructing process would bring on a degeneracy. Morally or physically, the form we term regular may indeed be the most frequent, but it is through an infinite number of possible deformations that it is produced.—We may compare the silent elaboration of which consciousness is the ordinary result to the progress of the slave, who, after the games of the circus, crossed the length of the arena, among wearied lions and glutted tigers, bearing in his hand an egg; if he arrived safely, he received his freedom. So passes the mind through the confusion of monstrous deliria and yelling madness, almost always with impunity, to settle itself in accurate consciousness and exact recollection.

VII. How does it happen that the slave arrives so frequently at his destination? Whence comes it that our present recollections almost invariably correspond to past sensations; that the place we assign to these sensations is almost invariably that which they actually occupied; that it scarcely ever happens that the chain of our events lets slip one of its own links or receives a link that does not belong to it; that the group of past, present, and possible events, of which we compose our personality is, almost always, really the group of events which have happened to us, are passing within us, and which may occur to us? By what adjustment is the almost invariable accordance of our thought and our being set up?—It must be understood that we do not here undertake to demonstrate the veracity of memory; the thing is impossible. In fact, such a proof would be reasoning in a circle; for, if memory be accurate, it is through certain laws which accommodate the recollection to its object; now these laws can only be obtained by us from the facts we observe and which we *remember* for the purpose of comparing them; so that, in order to prove the fidelity of memory, it would first be necessary to admit the fidelity of memory. We do admit it and without much hesitation, if not upon a direct demonstration, at least after a host of innumerable confirmations, and as an hypothesis justifying the whole of the experience, verifications, and previsions of mankind.—This, when settled, is enough to explain it, and we have but to regard the described mechanism to comprehend the almost infallible accuracy of its working.

In the first place, what constitutes recollection is a present image which appears a past sensation, and which, by the repressive contradiction of present sensations, finds itself constrained to an apparent recoil. Now, we have seen that the sensation, after it has ceased, has the property of reviving by its image; as a general rule, almost every clear and circumstantial image supposes an antecedent sensation; so that, if our judgment is invariably false in itself, it is almost invariably true by correspondence. We invariably deceive ourselves by taking the present image for a distant sensation; but, as a rule, the distant sensation was produced. If the image by its presence excites a constant illusion which forms recollection, on the other hand, it *compensates* this illusion by its origin, which is almost invariably an anterior sensation; if I may venture to say so, it rectifies, on the one hand, the error into which it leads us on the other.

Secondly, what situates the repulsed image before some particular sensation is the presence of that sensation or the recall of that sensation by its image. Now, as we saw in proving the laws which govern the revival of images, my present sensation tends to call up the image of the preceding sensation contiguous to it; and, in general, images of sensations which have been contiguous, tend to call each other up; whence it follows that the image of a past sensation tends to call up the images of the anterior and posterior sensations which were contiguous to it. Consequently, the abbreviatory image of a long series of sensations, operations, and actions, that is to say of a considerable fragment of my life, tends to call up abbreviatory images of the anterior and posterior fragments.—But we have shown that the posterior sensation, whether by itself or by its image, exerts on the image of the preceding sensation a contradiction which comes to an end when its commencement meets with the end of its antagonist, whence it happens that the repulsed image appears fastened by its end to the commencement of the image or sensation repulsing it. Consequently, when the image of a past sensation calls up the image of the posterior sensation and the image of the anterior one, it is repulsed by the first, it repulses the second, it connects itself by its end with the commencement of the first, by its commencement with the end of the second, and thus becomes *fixed* between the two. Whenever the three images come in to override on another, the two repulsions act in the manner indicated, the mechanism which situates them acts so as to arrange them in a line, as soon as the law of mutual evocation arouses them together. They thus contract, with relation to one another, an apparent order which corresponds to the real order of the sensations of which they are the remains. The contiguity of two sensations, one preceding, the other following, the reciprocal calling up of the image of the one by the image of the other, the apparent joining of the two images, a joining such that, while both appear as sensations, the first appears anterior to the second: these are all the steps of the operation; hence we see that the *real date* of a sensation determines the *apparent* date of its image. Here again, the agreement is established by a correspondence.

As a general rule, not only does every precise and detailed image presume an antecedent sensation, but every precise and detailed image, which is joined, in appearance, to another posterior one, presumes that the sensation whence it was derived was joined in the same manner, but in reality, to the sensation which the other repeats. If its attachment, then, invariably excites an illusion by compelling the other to appear anterior, almost invariably does its origin—the sensation posterior to the sensation of which the other is the echo—repair this error.

Thus, the thread of our events is formed in our memory; at every moment we look back on a portion; a day never passes without our having frequently reverted back, and sometimes far back in the chain, sometimes, by means of abbreviatory processes, to events separated from the present moment by many months and many years. Associations so repeated are continually becoming more tenacious; our past is a line which we never weary of tracing over and refreshing with ink.—Classes become established among these events; they group themselves spontaneously according to their resemblances and differences; the most frequent, the acts of walking, grasping with the hand, lifting a weight, feeling, touching, smelling, tasting, seeing, hearing, recollecting, foreseeing, willing, are collected each under a name; we conceive them as possible to us, and these possibilities, incessantly verified and limited by experience, constitute our powers or faculties. There is no one of them whose presence, range, and limits may not at any hour be manifested to us, so that our idea is associated with the idea of self by links which are hourly re-forged and strengthened.—Add to the recollection of my events and to the idea of my powers a last idea similarly renewed and strengthened at every moment by experience, that of the body which I call mine, and which is distinguished by sharply divided characteristics from all others, being the only one which answers to my touch by a sensation of contact, the only one whose changes excite sensations in me without an intermediate, the only one in which my will is capable of exciting changes without an intermediate, the only one in which the sensations I ascribe to myself appear to be situated. All this group of true ideas and exact recollections form a singularly solid network. It requires, then, a great accumulation of forces to tear from it any portion really belonging to it, or to insert in it any portion extrinsic to it.—In fact, these transpositions are rare; they are principally met with when an organic change, like sleep or hypnotism, loosens the meshes of the network, when an inveterate, predominant passion, fortified by psychical or sensorial hallucinations, at last wears away some thread of the tissue, substitutes another thread, and, gaining step by step, sets a fictitious web in the place of the natural web. But, as woven under ordinary conditions, the web is good, and its threads correspond, by their presence, by their diversities, by their apparent dates, by their connections, to the presence, the diversities, the real dates, the connections of the real facts; this is because the real facts themselves have woven it. The mind resembles a loom; every event is an impulse which sets it in action, and the fabric which issues from it, transcribes by its structure the order and kind of the impulses which the machine has received.

VIII. When, by the experiences of touch, of the educated sight, and the other senses, we have acquired a sufficiently precise and complete idea of our body, and there is associated to this idea that of a within or subject, capable of sensations, recollections, perceptions, volitions, and the rest, we make a further step. Among the innumerable bodies surrounding us, there are many which more or less resemble our own. In other words, if we explore them, they excite in us sensations of contact, resistance, temperature, color, and of tactile and visual shape and size, nearly analogous to those which we experience when we take cognizance by the eye and hand of our own body. Thus the group of images by which we picture to ourselves these bodies is very similar to the group of images by which we represent to ourselves our own.—Consequently, in accordance with the law of the association of images, when the first group rises in us, it must, like the other, call up the idea of a *subject or within*, capable of sensations, perceptions, volitions, and other similar operations. This is the spontaneous suggestion or induction; it is gradually confirmed and rendered precise by numerous verifications.—In the first place, we observe that this body moves, not always in the same manner, in correspondence to a mechanical impulse, but variously, without external impulsion, towards an end, seemingly directed by a purpose, just as our own body is moved and directed, which leads us to conjecture that in its case there are intentions, preferences, motive ideas, a will, as with us.*—Secondly, and especially if it be an animal of a higher species, we see it perform a number of actions analogous to what we find in ourselves, such as crying, walking, running, sleeping, drinking, eating, all of which leads us to impute to it perceptions, ideas, recollections, emotions, desires, similar to those of which these actions are in our cases the effects.—Lastly, we put our conjectures to the proof. Having

* The child is angry with a balloon or tuft of down which floats about capriciously, and will not allow him to seize it.—In primitive times, men considered the sun, the rivers, as animated beings.—The savage takes a watch which ticks and whose hands move, for a little round tortoise.—A movement which appears spontaneous, invariably suggests the idea of a will, and especially if it appears to have an object.

recognized in our own cases the antecedents and consequents of fear, pain, joy, and, in general, of some particular internal state, we reproduce for it these antecedents, or prove in it these consequents, and conclude that the internal and intermediate state, which, visible in our cases, is invisible in its case, must have been produced in its case as in our own. We know that, in our cases, a blow with a stick is the antecedent of a pain, and that a cry is the consequent of the pain. We strike a dog, and at once hear it give a cry; between this condition of pain and this sign of pain, both of which we clearly perceive, we insert, by conjecture, a pain similar to what we should ourselves have felt in such a case.—Thanks to these suggestions and these continual verifications, the outer world which so far has been peopled with bodies only, is also peopled with souls, and the solitary Ego conceives and affirms around it a multitude of beings more or less similar to itself.

IX. All these cognitions are composed of the same elements joined together according to the same law. Whether it be a question of a body, of ourselves, of another animated being, whether the operation be termed external perception, act of consciousness, recollection, induction, pure conception, our operation is invariably a mass of which the molecules are sensations and images joined to images agglutinated into partial groups which mutually call each other up.—A couple is formed by the aggregation of two molecules; to this is attached another couple, to these combined, others combined, and so on, till at last the vast compound we term the idea of an individual, the idea of this tree, of myself, of this dog, of Peter, or of Paul, is established.—Take an ivory billiard ball at two paces distance. It excites in us a certain crude sensation of the retina and the muscles of the eye, which calls up the image of the muscular sensations of locomotion which would lead our hand two paces off, according to a certain outline; the compound is a patch of color with a certain shape, and situated in appearance two paces from us.—We reach forward our hand and feel the ball; it produces in us a certain crude sensation of cold, of even contact, of resistance, which calls up the image of the tactile and visual sensations which we should have if we were to look at or touch our right hand; the compound is a sensation of even contact, resistance, and cold, apparently situated in our right hand.—Now, whenever we have repeated the experiment, each one of these two compounds has always accompanied the other. Consequently, in any interval of time, however long and however divided it may be, we cannot imagine a moment in which, where one of the two compounds is given, the other cannot and must not also be given, so that the possibility and necessity of both last without discontinuity, during all the moments of the interval; this is what we express by saying that there is in it something stable which is permanently tangible, resisting, and clothed with color.—To this compound so constructed are added the images of the distinct visual sensations, which the ball would excite in us, according to the differences of light and distance; from all these connected appearances, is formed the internal semblance which now springs up in us in the presence of the ball.—Add two other compounds, the image of the sensations by which we ascertain the changes which on certain conditions the ball undergoes, and the image of the sensations by which we ascertain the changes which the ball on certain conditions excites in any other body.—Such is the vast collection of intellectual atoms joined one by one and group to group, of which all the groups spring up, or are ready to spring up within us, when the crude visual sensation of the white form or the crude tactile sensation of smooth contact, cold, and resistance, is produced in us.

Now let us suppose the sensation to cease, and all that subsists of it to be the image with its appurtenances, that is to say a representation of the ball, and let us assume that a different sensation may rise at the same moment with its special train. By this attachment of a contradictory sensation, the representation of the ball appears something internal, a past event; and, in this manner, it arouses other analogous representations, in the midst of which it fixes itself in such a way as to constitute with them a line of internal events; this line is opposed to other groups, because all its elements present a constant character, which, being continually repeated, seems persistent, that is to say, the particularity of being a *within*, in opposition to the without; and this, later on, will offer to reflection and language the temptation to isolate it under the name of subject and Ego.—In this immense chain, each class of internal events, sensations, perceptions, emotions, each species of perceptions, of sensations, and emotions has its image associated with that of its conditions and of its internal and external effects; and this forms an infinite number of new couples, the two links of which draw one another into the light; so that we cannot imagine any pain without imagining its condition—a particular nervous lesion —and without imagining its effect—a contraction or a complaint.—Now, by a necessary suggestion, when an external body presents the conditions and effects of our own, the group of sensations which represent it calls up in us a group of images analogous to those by which we represent to ourselves our own events; and this forms a last compound, the most extensive of all, since it comprises a body and a soul, with all their mutual connections and all the connections which join their events to the events of others.—Thus, in our mind, every compound is a couple; the couple of a sensation and an image; the couple of a sensation and of a group, or many groups of images; more complex couples, in which a sensation, combined with its train of images, contradicts a representation or group of images; couples, still more vast, in which a sensation, present with its train of images, repulses into the past the abbreviatory images of a considerable fragment of our life; couples, the most comprehensive of all, in which, by still more summary abbreviations, the sensation and images which represent to us all the properties of a body call up the group of images which represent to us all the properties of a soul. Each couple, if properly constructed, corresponds in our mind to a couple among events, and each, when its first term is precisely repeated by the present sensation, has, as its second term, a *prevision.*

What is the mechanism of this final operation, the most closely allied to practice, and the most important of all, since by its means we are enabled to act?—We foresee that the sun will rise to-morrow, that it will describe a certain curve in the sky, that it will set at such a spot, at such an hour, and even, with the aid of science, that in so many years it will undergo, at a particular moment, an eclipse of certain extent. Here, as in recollection, an image appears projected from the present; only, instead of being projected backwards on the line of time, it is projected forwards. When, this evening, I foresee that the sun will rise to-morrow, what I actually have in my mind is the more or less express representation of the sun at daybreak, of a golden disc rising in the eastern sky, of nearly horizontal rays which first illuminate the tops of the hills, all this summed up in a word, in a reviving shred of visual sensation, in other words, in a present image. This image appears as a future sensation, and fixes itself by its anterior extremity on to the posterior extremity of the sensation of obscurity which I have at present, which situates it in a determinate point of the line of the future. Here is the crude fact; to explain it, it is enough to refer to the operations of memory.—There are two sensations which have never failed to succeed one another in us; on the one hand, the sensation of an obscurity of several hours; on the other, that of a luminous globe rising in the eastern boundary of the sky. However far we may reascend into the past, the first has never been present to us without having been followed by the second, nor the second without having been preceded by the first. At whatever point of our past we may consider them, we always find them joined to one another in this same order. The constant repetition has created the tenacious habit which has produced the energetic tendency, and henceforward, when we represent to ourselves the couple, the first term perforce appears to us as anterior to the second, and the second as posterior to the first.—Now, at this moment, the first is a present sensation; the second, then, must appear as posterior to the present sensation, that is to say, as future. In this manner, our prevision is the child of our memory. When given a couple of recollections in which the second term appears as posterior to the first, if the first is found to be repeated by the present sensation, the second cannot fail to appear as posterior to the present sensation, and to situate itself by so much the more in advance and more distant with relation to it, as there is a greater interval between the two terms of the primitive couple.

All our previsions, and consequently all our conjectures, are constructed in this manner. I wish to move my arm, and I foresee that it will move; I shake a bell, and foresee that it will give a ringing sound; I light a fire under the boiler of a locomotive, and foresee that the steam disengaged will move the piston; I read and re-read attentively a piece of poetry, and foresee that I shall presently be able to repeat it by heart; I address a question to my neighbor, and foresee that he will answer me. In all these cases, two successive links, of the past, are, while preserving their reciprocal situation, transported out of their primitive position to be placed, the first in the present, the second at some point of the future, because we have ascertained, or believe that we have ascertained, a perfect resemblance between the first and our present state.

Now, in fact, the majority of these previsions agree with the events which are foreseen, and, in ordinary life, our expectation is scarcely ever mistaken. We do not perform an act without reckoning beforehand on its effect, and this effect scarcely ever fails to be produced. I have foreseen, before performing them, all the movements I perform with my body and limbs, and, a hundred thousand times to one, they are such as I have foreseen. I have foreseen, before experiencing them, the sensations of resistance, form, position, temperature, which will be given me by the somewhat familiar and not too distant objects which I perceive by sight, and, a hundred thousand times to one, they give me the sensation I have foreseen. I foresee, before ascertaining them, the changes which a particular modification of a certain ordinary body will excite in some other ordinary body, and, a hundred thousand times to one, these changes will take place exactly as I have foreseen them. Drinking, eating, sleeping, walking, reading, writing, speaking, singing, the carriage of the body, the exercise of an art, a profession, a trade, no one of these common actions is accomplished without the intervention of an innumerable multitude of necessarily correct expectations. The intelligent being, animal or man, supplies its wants, preserves its life, improves its condition, only by the exact accordance of its present prevision and the near or even distant future.—If this harmony sometimes fails, it is on account of the objects or circumstances in question being such that anterior observation has not furnished sufficient indications respecting them. But, as to common objects, this disagreement is infrequent, and, if the preliminary experience has been sufficiently extensive, it disappears entirely.—There are, then, a prodigious multitude of cases in which the event justifies the prevision, and, in all these cases, the couple formed by our thoughts is the exact counterpart of the couple formed by the facts. Consequently, the mental law which connects our two thoughts is as general as the physical or moral law which connects the two facts.

But it is not from the outset that we recognize it as general; primitively, it acts within us without our distinguishing its character or measuring its range. The child and the animal foresee that this water will quench their thirst, that this fire will burn them; it is enough for this purpose that experience and custom have coupled in their minds a particular sensation and a particular representation; in their present cases, the sight of water invariably excites the image of quenched thirst, and the sight of fire invariably excites the image of burning. There is nothing more than this; what fills their whole mind at the moment is a certain visual perception joined to the image of a certain future sensation. So is it with the majority of our ordinary previsions; the adult and reflecting man is child and animal with respect to all his habitual and mechanical actions, and this is sufficient for his conduct and practice.—But he is capable of outstepping this state, and, in fact, by gradual degrees, he does outstep it. Not only is the mental law within him, but he observes that it is within him. Not only does he obey it, in the present case, but he ascertains that it holds good for all cases, present, past, and future. By means of signs, he extracts, denotes, and connects the two abstract terms of water and of extinguished thirst, the two abstract terms of fire and of burning. When this is effected, he considers, by aid of a formula, their couple in itself, excluding all the particular cases in which they are met with. When subjected to this operation, the couples which make up our animal thought assume a new aspect, and, beneath the flow of transient and complex events, we perceive the world of fixed and simple laws.

BOOK IV.

THE KNOWLEDGE OF GENERAL THINGS.

CHAPTER I.

GENERAL CHARACTERS AND GENERAL IDEAS.

HITHERTO we have only considered particular things, and the knowledge we gain of them; we have now to consider general things, and the ideas we have of them. For there are general things—I mean thereby things common to many instances or individuals; these are characters or groups of characters. Observe, for example, what is meant by the word *water*, or the word *drink;* water denotes a group of characters which is met with alike in a number of liquids, in that of wells, of rivers, of springs, of the sea; drink denotes a group of characters which is met with alike in a number of actions, in all those by which a man or an animal causes a liquid to flow into his mouth and stomach. So is it with the other words of the dictionary; each of them denotes a character or group of characters which is or may be present in many natural cases or individuals. Here we have a new object of knowledge. Just as there are in our minds thoughts corresponding to particular instances and individuals, so are there thoughts corresponding to general characters. These we call general ideas. They form in our minds couples, series, aggregates of various kinds, in short a vast complex edifice. We shall now examine of what elements this mental edifice is composed, how it is constructed, how its equilibrium is maintained, and under what conditions it corresponds to the real and natural edifice of things.

§ I. General Ideas which are Copies.

I. General characters play a great part in nature. In the first place, strange as the paradox may appear, a general character is requisite to constitute an individual, a particular lasting thing. Whether it be a body or a mind, this stone or this man, there is a character connecting its various successive moments, a common character which we find alike in all of them. In the case of the stone it is, at every moment and during the whole duration of its existence, the possibility of exciting in us the same sensations of contact, resistance, and form, and of undergoing the same changes of position or structure under the same circumstances; in short, the incessantly renewed presence of the same sensible and physical characters. In the case of the man, it is the constant possession of the same aptitudes and the same inclinations, or, if the expression is preferred, the continuous action of the same brain.—This we have already seen; what lies at the foundation of the idea of self is the idea of a within in opposition to a without, all our events having this common character of appearing to us as internal, in opposition to others which appear to us as external. So again, what lies at the foundation of the idea of a particular body is the idea of certain invariably identical sensations, which may under certain conditions be obtained at any moment.—In short, without pushing the analysis very far, we perceive that existence is in its nature fragmentary, perpetually repeated, made up of an indefinite number of successive portions, just like the flame of a candle, which is a series of ethereal vibrations, or the course of a stream, which is a flow of continually renewed waters. In this immense flow of events—the world—series which are sharply divided from surrounding series, and whose elements are very similar to each other, form what we term particular and individual beings. Each of these beings is a kind of distinct vortex; its continuous repetition resembles permanence: in fact there is nothing permanent in it except its form, that is to say the group of characters common to all its moments. But, from the vanishing and the incessant diversity of all its constituent events, the group of its fixed characters acquires a capital importance, and we legitimately consider it as the essential portion of the individual.

Let us now compare with one another a great number of individuals. It is a remarkable fact that, in spite of the separations of time and space, we find in an indefinite number of individuals, certain characters which are always the same. Six thousand years ago, the plants and animals of Egypt were similar to those of the present day; there are many kinds of plants and animals which have not varied throughout the enormous intervals of geological periods; from one end of the world to the other, at the present time and in epochs separated from the present by myriads of ages, the little mollusk whose shell forms chalk has had the same structure and same existence.—Nay more, many of our chemical bodies, hydrogen, iron, sodium, and others, are met with in the sun, thirty-five millions of leagues from our earth, and beyond that again in stars so remote that it takes several years for their light to reach us, and that their distance escapes all our measurements.—At this prodigious distance the stars are, like the earth, subject to gravitation: this is proved by the movements of double stars. Their light is subject to the same conditions as that of the bodies we burn; this is proved by studying the rays of the spectrum.—Lastly, no scientific man has any doubt that, in accordance with the laws of the conservation of force, movement must have always existed and must exist for ever.—And so, just as there are common characters whose continuous presence connects together the various moments of the individual, so are there common characters whose multiplied and repeated presence connects together the various individuals of the class. These characters are the uniform and fixed portion of dispersed and successive existence, and this alone would suffice to show us the interest we have in separating and seizing them.

But their importance appears still more clearly from another characteristic. We do not arrange them merely for the convenience of thought; they are not simple means of classification, instruments of technical memory. Not only do they exist in fact, without us, and often far beyond the short range of our senses and our conjectures, but more than this, they are effective. Each of them, by itself and by itself alone, draws on with it another which is its companion, its antecedent or its consequent, and so forms a couple which we term a Law. Thus, in any animal whatever, the presence of mammæ implies that of vertebræ. In every plant with two cotyledons, the arborescent bark is formed of concentric layers. In all the layers of the atmosphere which become chilled below a certain point, the included vapor is precipitated as dew. Whenever two heavy bodies are in the presence of one another, they attract each other in the direct ratio of their mass and the inverse ratio of the square of their distance. If the vapor of sodium be burnt, its luminous spectrum presents a yellow ray at a determined point.—All these examples show us that general characters are not only the most widely distributed inmates, but also the most important agents of nature; not only have they the largest place, but the principal part and most decisive activity in the field of being.

We must now observe that they are not all equally general. Some are more so, others less; each of them is by so much the more general as it is less complex, and so much the less complex as it is the more general.—In fact, let us begin by considering the group of characters which persists in a particular being, in some man, through the successive moments of his life. This group is a very extensive one; we see this by the multitude of details we are compelled to give when we attempt to describe a human person or soul. But on the other hand, this group only corresponds with this man, and lasts, like him, for a short interval of time only.—Pass now from the individual to the race; the inverse happens; here, no doubt, common characters are much more extended in space, and last much longer in time, since they are met with in an indefinite number of contemporary individuals, and are repeated through an indefinite number of successive generations. But, on the other hand, they are themselves less in number, since necessarily the whole of the characteristics which distinguish each individual from the rest have been left on one side, and since the general type obtained by this retrenchment is a remnant only.—The same observation is made on passing from the race or variety, that is to say from the Negro or the Indo-European, to the species, that is to say to Man.—Continue and follow out the classifications of Natural History, from the species to the genus, then to the family, to the order, to the sub-kingdom, and to the kingdom. At each step of the ladder, the type, impoverished on the one hand, enriched on the other, loses some of its preceding characters, and acquires new representatives; its elements are more restrained, but its province is more extensive; its contents decrease, while its extension increases.—For instance, the species is less durable than the genus. A particular species of animal, that of the megalosaurians, has perished, after having existed during a geological period, and the genus to which it belonged still subsists in other species which have since arisen, or which have survived; but the characters of the genus are but a fragment of those of the species, and the genus which survives in the modern saurians presents a portion only of the characters of the species which has disappeared.—The rule is everywhere the same. If we pass from organized and living matter to mineral and dead matter, then to mechanical matter, we see the group of characters common to various bodies reduce themselves, on the one hand, till they consist of one or two qualities almost absolutely simple, and become applicable, on the other, till they include all bodies real or imaginable.—Thus general characters arrange themselves in stages, one above the other, and in proportion as their presence becomes more universal, their contents decrease. At the lowest point is the momentary fact, absolutely singular and distinct, which forms the element of the rest; every moment, action, state, or fact, is thus a prodigiously complex datum, differing from every other, and having its special shade of character. This shade of character subtracted, there remains a cluster of characters common to a whole series of facts, and whose persistence forms the individual. If from this cluster we omit all personal characteristics, the remainder forms the race, that is to say a character present in the individual and in many others. An extract from this remainder is the genus, that is to say a character present in many species; and so on.—By this series of suppressions we pass, from a curtailed remainder, to a remainder still more curtailed, and, at the same time, from a general datum to a still more general datum. At all these stages, the general character is an abstract character, and the more abstract as it becomes more general, and the more general as it becomes more abstract.

II. To these extracts or remnants, present at several points of time and space, correspond within us thoughts of a distinct kind which we term general and abstract ideas.—We have already shown in what these ideas consist.* A general and abstract idea is a name, nothing but a name, *the significant and comprehended* name of a series of similar facts, or of a class of similar individuals, usually *accompanied* by the sensible, though vague, representation of some one of these facts or individuals. The analysis is one of great delicacy, and we have already performed it; but in such a matter we cannot accumulate too many examples, and I beg the reader will re-

* Part i. book i. ch. ii.

peat the examination in his own case, choosing some very striking idea which he has recently acquired.—Here is one of my own, whose commencement I clearly recall. Some years ago I saw in England, in Kew Gardens, for the first time, araucarias, and I walked along the beds looking at these strange plants, with their rigid bark, and compact, short, scaly leaves, of a sombre green, whose abrupt, rough, bristling form cut in upon the fine softly lighted turf of the fresh grass-plat. If I now inquire what this experience has left in me, I find, first, the sensible representation of an araucaria; in fact, I have been able to describe almost exactly the form and color of the plant. But there is a difference between this representation and the former sensations, of which it is the present echo. The internal semblance, from which I have just made my description, is vague, and my past sensations were precise. For, assuredly, each of the araucarias I saw, then excited in me a distinct visual sensation; there are no two absolutely similar plants in nature; I observed perhaps twenty or thirty araucarias; without a doubt each one of them differed from the others in size, in girth, by the more or less obtuse angles of its branches, by the more or less abrupt jutting out of its scales, by the style of its texture; consequently, my twenty or thirty visual sensations were different. But no one of these sensations has completely survived in its echo; the twenty or thirty revivals have blunted one another; thus upset and agglutinated by their resemblance they are confounded together, and my present representation is their residue only. This is the product, or rather the fragment, which is deposited in us, when we have gone through a series of similar facts or individuals. Of our numerous experiences there remain on the following day four or five more or less distinct recollections, which, obliterated themselves, leave behind in us a simple colorless, vague representation, into which enter as components various reviving sensations, in an utterly feeble, incomplete, and abortive state.—But this representation is not the general and abstract idea. It is but its accompaniment, and, if I may say so, the ore from which it is extracted. For the representation, though badly sketched, is a sketch, the sensible sketch of a distinct individual; in fact, if I make it persist and dwell upon it, it repeats some special visual sensation; I see mentally some outline which corresponds only to some particular araucaria, and therefore cannot correspond to the whole class; now my abstract idea corresponds to the whole class; it differs, then, from the representation of an individual.—Moreover, my abstract idea is perfectly clear and determinate; now that I possess it, I never fail to recognize an araucaria among the various plants I may be shown; it differs, then, from the confused and floating representation I have of some particular araucaria.

What is there, then, within me so clear and determinate corresponding to the abstract character common to all araucarias, and corresponding to it alone?—A class-name, the name araucaria, pronounced or mentally understood, that is to say a *significant* sound, which is *comprehended*, and is, in this way, possessed of two properties. On the one hand, as soon as it is perceived or imagined, it awakes in me the sensible representation, more or less express, of an individual of the class; this attachment is exclusive; it does not arouse in me the representation of an individual of another class. On the other hand, as soon as I perceive or imagine an individual of the class, I imagine this sound itself, and am tempted to pronounce it; this attachment again is exclusive; the real or mental presence of an individual of another class does not rouse it in my mind, and does not call it to my lips.—By this double attachment it becomes incorporated with all the perceptions and sensible representations I have of the individuals of the class, and is incorporated with them alone. But it is not specially attached to any one of them; it calls up all indifferently; it is called up indifferently by all. Therefore, if they call it up, it is owing to what all have in common, and not owing to what each has specially; therefore, again, it is attached to what all have in common and to that alone.—Now this something is precisely the abstract character, the same for all the individuals of the class. It is, then, to this character, and to this character alone, that the name, mentally heard or pronounced, corresponds; which we express by saying that the name signifies and denotes the character. In this way the name is equivalent to the sight, experience, or sensible representation which we do not and cannot possess of the abstract character present in all the similar individuals. It replaces this character, and performs the same functions. —Thus we conceive the abstract characters of things by means of abstract names which are our abstract ideas, and the formation of our ideas is nothing more than the formation of names, which are *substitutes.*

How does a general and abstract name arise, and by what mechanism does it contract this double exclusive attachment to our sensible representations and special perceptions which gives it its signification and value?—There is here, as we have shown above, a single association of a certain class. We point out a dog to a very little child, and tell him, in the language of the nursery, imitating more or less happily the barking of the animal, "That is a *bow-wow.*" His eye follows the indicating gesture; he sees the dog, hears the sound, and, after the apprenticeship of some repetitions, the two images, that of the dog and that of the sound, are, in accordance with the law of the association of images, permanently associated in his mind. In other words, when he next sees the dog, he imagines the sound, and even, by imitative instinct, makes the sound, after some attempts. If the dog barks, he laughs and is delighted, he has a double inducement to utter the new and very striking animal noise of which he has as yet heard a human imitation only.—So far there is nothing original or superior; the brain of every mammal is capable of similar associations; a fox, when he seizes a rabbit certainly imagines beforehand the sharp quick cry of the rabbit; a sporting dog, who hears the cry of a partridge, certainly imagines the visual form of the partridge in the air, and, as to the instinctive reproduction of a sound when heard, there are the well-known cases of parrots and other kinds of imitative animals.

But there is this peculiar to man, the sound which has become associated in his case with the perception of some particular individual is called up again, not only at the sight of absolutely similar individuals, but also by the presence of individuals strikingly different, though in some respects comprised in the same class. In other words, analogies which do not strike animals, strike men.—The child says *bow-wow*, first to the house-dog, then, after a little, he says *bow-wow* to the terriers, mastiffs, and Newfoundlands he sees in the street.—A little later, and he does what an animal never does, says *bow-wow* to a pasteboard dog which barks when squeezed then to a pasteboard dog which does not bark, but which runs on wheels, then to the silent and motionless bronze dog which ornaments the drawing-room, then to his little cousin who runs about the room on all fours, then, at last, to a picture representing a dog.—Under these last circumstances, I saw a little boy two years old repeat the word *bow-wow*, some forty or fifty consecutive times, with extraordinary wonder, animation, and delight. He was held up to look at a shade placed over a light, and ornamented with black figures of dogs which were strongly illuminated. As the shade was turned round, and each new figure appeared, he cried *bow-wow* with an air of triumph; it was the enthusiasm of discovery; and every day it was necessary to repeat it. I determined to count his exclamations; one evening, in less than three-quarters of an hour, he cried *bow-wow* fifty-three times in succession, and his curiosity was never wearied.—If with the aid of philologists we observe the primitive meanings of words in Latin, Greek, and German, and especially, in Hebrew and Sanscrit, we find at their origin a wholly similar operation:* a very loose analogy, that is to say a very

* Renan, "De l'Origine du Langage," pp. 125, 136. Max Müller, "The Science of Language."

trifling resemblance between two facts, is sufficient for the name given to the first to be applied to the second.—At the present day, too, our most important discoveries are made in a similar manner. When Oken, coming across the skeleton of a sheep, conceived the skull to be a compound of flattened and consolidated vertebræ; when Goethe, observing petalloid stamens, conceived all the organs of a plant to be transformed leaves; when Newton, seeing an apple fall, conceived the moon to be a heavy body also tending to fall to the earth, they repeated the mental operation and experienced the delight of the little boy who saw the dogs on the lamp-shade and cried out *bow-wow*.—Between a vertebra and the skull, between the green leaf and a pistil or stamen, between the falling apple and the moon travelling through the sky, between the living barking dog and the little figure on the lamp-shade, the difference of appearance is enormous; it seems that the two representations differ all in all. And yet they have a common characteristic; thanks to this common possession, the name called up by the first has also been called up by the second, and henceforward corresponds to a very general and very abstract character.—All that distinguishes man from the animal, intelligent races from those of limited capacity, comprehensive and delicate from ordinary minds, is reduced to this faculty of seizing more delicate analogies, to this contagion, by which the name of an individual attaches to a more different individual, to the property of more dissimilar representations or perceptions to excite the same name. For, the more rare are the points of resemblance, the more individuals does the class contain; the more individuals does it contain, the more general and abstract is the character to which the idea, that is to say the name, corresponds; the more general and abstract is this character, the more place does it occupy in nature and the more individuals does it connect.—The discovery of relations between very remote objects, the detection of very delicate analogies, the extraction of common characteristics from very dissimilar objects, the formation of very general ideas, the isolation of very abstract qualities—these expressions are all equivalent, and all these operations are reduced to the calling up the same name by perceptions or representations whose resemblances are very slight, to the excitement of the sign by an almost imperceptible stimulus, to the mental appearance of the word *upon a summons of the slightest nature.*

By means of this aptitude, the child of fifteen months old learns, in two or three years, the principal words of ordinary familiar language.—Observe the profound difference separating this acquisition and the parallel acquisition which a parrot might make. The infant invents and discovers incessantly, and of its own accord; there is no period of life in which his intelligence is so creative. The names suggested to him by his parents and the persons about him, are but starting points for his innumerable efforts; hence his joy and trouble.—When once a name he receives is associated in his mind with the perception of an individual object, his mind acts as in the previous example; he applies the name to the more or less similar objects which he recognizes as alike. This wholly spontaneous recognition appertains entirely to the child; a parrot does not apply the name which is taught him; in a bird's brain, it remains isolated; in a child's brain, it becomes associated to the presence of a general character, which henceforth has only to appear in order to call it up. This is what the child does with words transmitted from *significant words.* There is not even need on all occasions for the words to be transmitted, with deliberate intention and by a human mouth; sometimes the child seizes them in the involuntary sounds he utters, or in the accidental sounds he catches. "A member of my own family," says Mr. Lieber,* "showed, in early infancy, a peculiar tendency to form new words, partly from sounds which the child caught, as *to woh* for *to stop,* from the interjection *woh,* used by waggoners when they wish to stop

* "Smithsonian Contributions to Knowledge," vol. ii. p. 15.

their horses; partly from symphenomenal emissions of sounds. Thus, when the boy was a little above a year old he had made and established in the nursery the word *nim* for everything fit to eat. I had watched the growth of this word. First, he expressed his satisfaction at seeing his meal, when hungry, by the natural humming sound, which we might express thus, *hm*. Gradually, as his organs of speech became more skilful, and repetition made the sound more familiar and clearer, it changed into the more articulate *um* and *im*. Finally, an *n* was placed before it, *nim* being much easier to pronounce than *im*, when the mouth has been closed. But soon the growing mind began to generalize, and *nim* came to signify everything edible; so that the boy would add the words *good* or *bad*, which he had learned in the meantime. He now would say *good nim*, *bad nim*, his nurse adopting the word with him. On one occasion he said, *fie nim*, for *bad, repulsive to eat*.—There is no doubt but that a verb *to nim*, for to eat, would have developed itself, had not the ripening mind adopted the vernacular language, which was offered to it ready made."—The initiative of the infant is further shown by the incorrect use it makes of our words by giving them a meaning which they have not for us, and which it invents. The same child had learned the words *Good Boy*, which he always pronounced together, and which formed one word for him. "One day, wishing to express the idea *Good Cow*, he said *Goodboy Cow* . . . . . Similarly a little girl said to a man, *Doctor naughty girl*, because he had teased her."—We may sum up the whole apprenticeship of a child by saying that it receives words, but creates their meanings, and that a series of continuous rectifications are required in order that the meaning it attributes to them may coincide with the meaning we attribute to them.

III. Suppose this process accomplished, and the infant arrived at the threshold of adult life. Here begins a new series of re-arrangements, additions and corrections, an indefinite series, carried on from generation to generation, and from people to people—I mean scientific research.—It is here a question of making our general ideas correspond, no longer with the general ideas of other people, but with the general characters of things. As soon as we are seized with this desire, a primary need declares itself; there are blanks in our ideas; it is necessary to fill these blanks.—For instance, the notion an ordinary person has of the human body is very meagre and incomplete; he only knows it in the rough; to him it is a head, a trunk, a neck, four limbs, of certain color and certain form—that suffices him for practical purposes. But it is clear that the characters special to the human body are infinitely more numerous; such a notion represents some five or six only of the most obvious ones; we must add to it all those which prolonged and varied observation can discover.—The anatomist comes with the desire to see the details and the interior; he dissects, notes, describes, and draws. The text-book for beginners contains a thousand pages, and I cannot tell how many charts and volumes would be required to hold the figures and enumeration of all the parts which the naked eye discovers.—When the eye is aided by the microscope, this number is multiplied a hundredfold. Lyonnet did not find twenty years too much to describe the caterpillar found in willow trees.—Beyond our microscope, more powerful instruments would further increase our knowledge; it is evident that in this direction there is no limit to the research.—So, again, take an inorganic body, water; my idea of it is that of an inodorous, colorless, transparent liquid, fit to drink, which may become ice or steam; nothing more; this is all I know of the enormous group of physical and chemical characters or properties which accompany and constitute water. Physicists and chemists come with their balances, their thermometers, their electrical machines, their optical instruments, their retorts, their reagents, and, in their hands the five or six meshes which make up my idea become multiplied till they form a vast net. But this net, however we may imagine it enlarged, will never have as many meshes as there are characters in the object to which it corresponds; for the discovery of a new body will always be sufficient to add a new character to the object. At the beginning of the century, the discovery of potassium and sodium showed that, in contact with certain metals, water was decomposed at the ordinary temperature; here was a new character. If we had here the unknown simple bodies which the rays of the spectrum now indicate to us among the stars, and if we could submit water to their action, it would most undoubtedly exhibit unknown properties, which would have to be added to the list.—Meanwhile, with every object, this list, fruitlessly lengthened, remains still open; and the idea we have of a species, a genus, in short, of any list of general characters, never comprises, and can never comprise, more than a limited fragment of their unlimited chain.

Nevertheless, this addition of new links is enough to introduce considerable changes into our ideas. As furnished by common experience, they were most frequently too wide or too narrow; scientific experience comes in to contract or extend them, to adjust their corrected dimensions to the real dimensions of objects.—Whilst the examination is made roughly and only bears on the outer aspects of things, we unite, under a single name and idea, fishes strictly so called and the unicorn fish, the dolphin, the cachalot, the whale. After a more minute and penetrating examination, we find that this idea is too wide; there is no type corresponding to it in nature; the organs of circulation and respiration, the skeleton and limbs, are not the same in fishes strictly so called and in the unicorn fish, cachalot, dolphin, and whale; these last are mammals; they must be taken from the class and set apart; when this operation is accomplished, my idea, reduced to proper limits, agrees with a natural group of characters actually connected and always met with in conjunction, those of the fish.—My idea of the mammal is correspondingly enlarged; it was too narrow as it only comprised terrestrial animals with four legs, and giving suck; I have added to it the cetacea, which swim, and the cheiroptera, which fly; henceforward, being enlarged and proportioned to the extension of the type, it is applicable to all the species which present the same group of characters, whatever be their difference of external appearance and habitation.

So it is in all the provinces of nature. As soon as profound and prolonged analysis ascertains an ignored and important character in a species of objects, this species tends to leave its compartment and to enter another. It was necessary to burn the diamond to know that it was composed of carbon: and it is merely within the last hundred years that the formation of chemistry has enabled the classification of inanimate bodies.—Thanks to these processes, we have been enabled, in each department of nature, to place beings in more and more nearly natural classes, to arrange as in an army, under companies, battalions, regiments, and divisions, the enormous multitude of individuals, all animal forms, all vegetable forms, the hundred and twenty thousand species of plants, two hundred and sixty thousand species of animals, and, in the majority of cases, to determine the real and constant type which constitutes each species, each genus, each family, each order, each sub-kingdom.—We have not invariably succeeded in this; many of our divisions remain artificial, and are convenient only; others, provisional ones, await further researches to become definitive.* In mineralogy, especially, there is as yet no real classification.—But for the majority of the species and genera of animals and plants, for the vegetable families of Jussieu, for the orders and three higher sub-kingdoms of Cuvier, the acquired general idea corresponds with an actually general thing, that is to say with a group of characters which involve or tend to involve one other, whatever be the individuals and circumstances under which one of them is given.

* For instance, the sub-kingdom of zoophytes, the class of infusoria and that of entozoa.

IV. At present, in addition to these general characters, there are others still more general, which appertain to the *elements* of the classified individuals, and which, spread universally under various disguisements, are, through their ascendancy, the regulators of the rest.—Hence it follows that of all general ideas, those corresponding to such characters are by far the most valuable.—We attain these characters, like the rest, by taking a general type already known, and by gradually removing from it a number of accessory characters so as to preserve only the most stable and most universal.—The idea of the leaf in botany is of this kind.* It is now known that the various organs of a plant are nothing more than transformed leaves. Developed in spirals on the stem, they are drawn together at the summit in superposed horizontal verticils, whose various stages are the various parts of the flower. The impoverishment of the final vegetation has drawn them together, and other circumstances have consolidated and deformed them. Sometimes, one among them has become abortive; sometimes, two or more of them have become monstrous. But the original type is manifested by fixed relations, by sudden reversions, by a thousand incontestible characteristics; and the idea of the leaf, disengaged from all sensible impressions, purified, drawn by energetic abstraction far away from common experience, is nothing more than the almost geometrical idea of a cycle of vegetable elements, which preserve their primordial order under all imaginable forms and in all imaginable functions.—And so, in animals, through all the diversities of structure and function, we find throughout the whole class of mammalia the same type of skeleton, throughout the whole class of crustacea, as throughout the whole class of insects, the same type of segments, of mouth, and limbs; and this type is so tenacious that, in many species, we find, to evidence its presence, the subsistence or appearance of useless parts or dispositions; a suture,

* Auguste Saint-Hilaire, "Morphologie végétale," pp. 10, et seq.

a set of teeth, a nail, a bony excrescence, transient or rudimentary organs render it visible by presenting its transitory memorial or surviving remnant.

Other still more general characters or groups of characters are met with under the name of chemical and physical properties of bodies, not only in the living, but also in the inorganic world. Here again, the process which forms the corresponding idea is the same.—Vulgar experience has discovered some property of a body—for instance, the power of amber to attract to it small and very light objects. Multiplied and precise experience multiplies and renders precise the circumstances and instances of this attraction. By degrees, we let slip these variable characters to seize only on its fixed characters. We thus isolate a universal mode of action, that is, electric action, one determinate, purified, extended idea coincides with a force which operates or may operate in all bodies.—And so again, before the researches of the scientific men of the Renaissance, our idea of a heavy body was that of a body tending downwards, and impressing on us, when lifted, a sensation of muscular effort. In proportion to our discoveries this idea becomes more abstract.—In the first place, it is not necessary that such bodies should afford a sensation of resistance to the hand lifting them; for the air which sustains the mercury in the barometer is heavy. Further, it is not only in a downward direction that bodies fall; for, the earth being round, they fall at the antipodes in a different direction from what they do with us. Thus, all within our atmosphere falls, and falls toward the centre of our planet.—But, for a body to fall, it is not necessary that it should be comprised in our atmosphere; of the two movements which make up the whole movement of the moon, one is a fall towards us.—With two further steps, the purification of our idea is accomplished. It is not only bodies disposed about the earth which tend to fall to it: all the bodies of our solar system tend to fall towards one another. It is not only the huge heavenly masses which attract each other mutually; all their molecules, the most distant and the most nearly approaching, attract each other mutually according to the same law, in the direct ratio of their mass and the inverse ratio of the square of their distance.—Gravity, thus defined, is a character so persistent as to appear indestructible; each body preserves its own, always equal and intact, through all the changes of state we can make it undergo, and in all the chemical combinations into which it can possibly enter.

Such is the progress by which our general ideas are formed and adjusted to general things. These ideas pass through two states. First the idea rises with the sign; then it is gradually rectified. In fact, as we find it in current language, and as vulgar experience furnishes it, it corresponds imperfectly to its object.—On the one hand, it is incomplete and vague; in other words, the general characters which it denotes are neither precise enough nor numerous enough. By more attentive observation and more varied experience, we determine the ascertained characters, and add on to them a row of new characters.—On the other hand it is not sufficiently purified and abstract; in other words, among the characters it denotes, there are accessory and accidental ones amalgamated with those which are important and fixed. By extended experience and multiplied comparison, we expel the parasitical and transient characters, so as to preserve those only which are intrinsic and stable.—Our idea has become adapted to its object, first by *addition*, then by *subtraction*.

§ II.—GENERAL IDEAS WHICH ARE MODELS.

I. Another class of general ideas presents other characteristics and is formed by another process. These are the ideas which compose arithmetic, geometry, mechanics, and in general, all sciences treating, like mathematics, of the possible and not of the real. We form these ideas without examining whether there are in nature objects which correspond to them, and for this we *construct* them.

Let us follow the detail of this construction, and see with what elements we fabricate these new ideas.—The most simple of all are those of arithmetic, which have numbers for their objects. Now we all know that every number is formed by unity added to itself; it is the notion of unity, then, which we shall first examine.—It comprises nothing mysterious, and its origin has nothing strange in it. We are not dealing here with the absolute and metaphysical unity which consists in the property of being indivisible, or rather, without parts, and which would be possessed, for example, by one of Leibnitz's monads. We deal simply with an office which any object whatever may fulfil, with the function it performs, with the part it plays, in contributing with others like it to form a collection. It is in this aspect alone that we consider it; therefore, twenty heaps of stones by a roadside are, in this sense, twenty units as much as twenty monads. The unity of each heap is nothing more than its aptitude for entering as a factor into the total of twenty heaps, and into any other analogous total, greater or smaller. Consequently it is, like every aptitude, property, and capacity, nothing more than a general character of the object, and this character may be disengaged, extracted, and set apart by ordinary processes, that is to say by means of a name, and, in general, by means of a sign.—Moreover, there is no character more easy to set apart; for all objects and all events present it, since every object and every event contributes with other similar ones to form a collection which is its class. The materials, then, from which the notion of unity may be extracted exists in superabundance, and the first step of arithmetic may be made in all regions.

Let us, then, observe a series of objects or events, taking care to consider in each of them its capacity only to enter as a component in a collection. For this, let us purposely omit all its other characters; after this retrenchment, a row of poplars, a series of sounds, any other series or row, ceases to be a row of poplars, a series of sounds, a series or row of determinate objects or events; it is nothing more than a sequence, row or series of *ones* or *units*. Now in this point of view, all ones are the same one, and all series of ones are the same series ; for the characters which distinguish individuals from one another, and series from one another, having been excluded, the individuals can no longer be distinguished from one another, and the series can no longer be distinguished from one another. Here, then, we have an abstract series composed of abstract units.—To observe this series more conveniently, men have substituted for it a sensible series of very manageable objects, sometimes of little pebbles, sometimes the ten fingers of the two hands.* Nothing is easier than to raise, successively, one by one, the fingers of the closed hand, or to lower, successively, one by one, the fingers of the open hand.—Nothing is easier than to add pebbles, one by one, in such a way as to make a heap, or to take away pebbles, one by one, in such a way as to unmake the heap. And as, by taking away or adding one or more pebbles, by raising or lowering one or more fingers, we can *visibly* alter the total of the collected pebbles or of the lifted fingers, it is easy, not only to fabricate in this way various *visible* totals, but also to observe *with our eyes* how these totals are made and unmade.† We make them progressively, as to pebbles, by adding a pebble to the first pebble and so on, as to the fingers by raising a finger in addition to the first finger, and so on. We unmake them progressively, as to pebbles, by removing a first pebble and so on, as to the fingers by lowering a first finger and so on.---These are the primitive substitutes; each finger or pebble visibly replaces an abstract unit: the different groups

* Calculation is derived from *calculus*, a little pebble. The Roman numerals I, II, III, V, X, are rude drawings representing one or many fingers, one or both hands.—Our system of numeration by tens was originated by the fact of our having ten fingers.

† See the very elegant and very delicate analysis of this mental process in Condillac's "Langue des Calculs."

of visible fingers or pebbles replace the different groups of abstract units, and, in proportion as a visible finger or pebble is added to the group of visible fingers or pebbles, a pure unit is added to the group of pure units.

At present, in the place of these already convenient substitutes, we substitute other still more manageable ones, the various sounds which constitute our names of number. For a lifted finger, we say one, for two fingers lifted, two, for three fingers lifted, three, and so on up to ten. In this way, the name *one* replaces a lifted finger, and therefore an abstract unit. So, again, each one of the following names replaces a group of lifted fingers, and therefore a group of abstract units. So, finally, when we pass from a name of number to the following name, a finger is lifted to add to the preceding group of lifted fingers, an abstract unit is added to the preceding group of abstract units, and the name of number expressed replaces the group of units which replaced the preceding one, together with an additional unit. In other words, each name of number is equivalent to the group denoted by the preceding one, with the addition of one.*—So as not to encumber our memory, we reduce these names to what is strictly necessary. When we get beyond ten, we say eleven, twelve,† thirteen,‡ and so on, till we get to nineteen.—After nineteen, as the following number is equivalent to twice ten, well-constructed languages revert to the word two, modifying it suitably, and similarly modifying the names of the following numbers, so as to make them express three times ten, four times ten, and the sequence of decades up to ten times ten.§ The

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* As to the primitive meaning of our nouns of number see Bopp, "Comparative Grammar" (tr. Breal) ii. 221. *Tri* (three) means "exceeding"—*i. e.*, the two inferior numbers.—Four probably means, three *plus* one; five, four *plus* one; ten, twice five.—A hundred certainly means, ten times ten.—A thousand probably means, many, a great number.

† In Latin, undecim, duodecim.

‡ In Latin, tredecim. In German, zwölf, dreizehn, derived from zwei, drei.

§ In German, Zwanzig. In Latin, triginta, quadraginta, quinquaginta, etc. In old French, septante, octante, nonante.

decades thus form units of a second order, capable, like simple units, of being counted up to ten.—Arrived here, we give their total the name of hundred, and this new total forms a unit of the third order, capable in its turn of being repeated up to ten hundred, or a thousand, a unit of the fourth order —The previous operation, repeated on this new unit, leads us up to ten thousand, thence to a hundred thousand, thence to a million, and so on, so that with eleven names, arranged in a certain order, we can represent precisely an enormous group, such for instance as the collection of two million, three hundred and twenty-seven thousand, six hundred and forty-eight units.

An expression like this is a very abbreviatory substitute; for it may be pronounced in less than a second; nothing shorter has been found in the matter of sounds. But, when written for the eyes, it occupies a line and a half, and requires sixty-seven characters; this is a great deal, and, in this respect, it may be improved.—For written names, we substitute more simple characters, which, instead of replacing nouns of number directly, and numbers themselves indirectly, replace numbers directly. These characters are called ciphers; it is arranged that a cipher placed to the left of another denotes units of an immediately higher order, that is to say, ten times as great; we compose a list of nine distinct ciphers to represent the nine first numbers; we add to this list a zero to represent the absence of unity or number, and then, instead of sixty-seven characters, we need employ seven only to represent a collection of 2,327,648 units.

Thanks to these abbreviatory notations, we construct a prodigious quantity of compounds which are numbers. For this, it is enough to arrange the ciphers or to utter the names, recollecting the meanings which our convention has imposed on them.—Let us now observe the characters of the idea so constructed. When we read and understand one of these groups of signs, for instance, 2,327,648, we do not consider whether nature furnishes an object corresponding to our idea. Is there anywhere a group of real units to which this collection of mental units is, feature for feature, adapted? This is a question we set aside; we pay no heed to it; our idea has been constructed for its own sake.—And yet there is a possibility of this mental construction coinciding with some real construction. For to the elements of which my idea is constructed, there correspond elements included in things. In fact, what I call unity, is the aptitude to enter into a collection. Now there is no natural individual or actual event which may not so enter; whether it be a body or a mind, an external or internal modification, as soon as we perceive a fact or thing, we put it in its class, that is to say with others similar to it; moreover, as soon as the object is conceived by us, it spontaneously calls up in us, without our desiring it, and solely by the law of association of ideas, other more or less similar objects. Together they form a group of more or less similar data, each of them having the character of being a distinct datum among many other analogous ones. In this manner, and in this narrow sense, it is a unit among many other units.—There are, then, collections of units in nature, as there are collections of units in the mind. In fact, there are a certain number of planets about the sun. There are, at this moment, a certain number of men, animals, and plants, living on the earth. During this year, the earth or any other planet, has advanced a certain number of kilometres in its orbit. During this year, a certain number of persons have died in France. Whilst my mind performs its additions and subtractions, nature performs hers. I fabricate in advance a long series of distinct moulds, arranged according to their increasing dimensions; nature fabricates, or has fabricated with her various clays all that is required to fill them; and the thing contained is adjusted to what contains it, first, because the mental elements of the one were fashioned upon the real elements of the other, next, because the artificial structure of the containing thing happens to correspond with the natural structure of the thing contained.

II. This is the character common to all the ideas we construct; they are *preliminary outlines;* when we form one of them, we have no real thing in view to which we attempt to make our thought conform; and nevertheless, our thought is found to conform to one or more real things as yet unknown, which, when known, will manifest this conformity.

Not that the adaptation is always exact; there are cases in which it is approximate only. Of this kind are geometrical ideas. Let us first search for the elements with which we construct them; we all know that they are few in number, and we readily see from what experiences we extract them.—Take any body observed by the senses, this stone, this piece of wood. It has, as limit, one or more outer parts enclosing its inner part; and these outer parts by which it terminates are its surfaces. But each of these surfaces is itself terminated by one or more limits which are called lines, and each of these lines is itself terminated by two limits which are called points.—So far there is no difficulty; each of these limits, surface, line, or point is a character of the body, a character isolated by abstraction, considered apart, and, moreover, general, that is to say common to many bodies, or rather, universal, that is to say common to all bodies. We detach this character and denote it by means of symbols, which are sometimes the names of surface, line, and point, sometimes a class of sensible objects, very manageable, and selected to take the place of all the rest, the real surface of a black board or white paper, the slender trace left on the paper or board by a stroke of ink or chalk, the little dot left by the momentary touch of the pen or chalk.—The dot being very small we are disposed to pay no attention to its length and breadth, though real; by this omission we involuntarily make abstraction of them, and have no difficulty in treating the dot as a point.—The trace being very thin, we are not disposed to trouble ourselves about its breadth, though real; by this omission we cut it away, and come, without difficulty, to consider the stroke as a line.—The board and the paper being very flat, and level to the eye and hand, we experience no sensation to remind us of their thickness; by this omission we suppress it, and are led to consider the board and paper as true surfaces.—In this way the board, the narrow stroke, the little spot of chalk, become convenient substitutes. They are sensible and special things, but they replace wholly abstract and general limits, in the same way as, just now, in arithmetic, pebbles and fingers replaced pure units.

To these elements so represented, add another movement; it is also met with in the majority of bodies we perceive; we are, then, capable of detaching it from them. When once these data are extracted, it is sufficient to combine them in different ways to obtain all geometrical compounds. In addition to this, by a still further reduction, we find that the point and movement are sufficient elements for the reconstruction of the two other kinds of limits which we have termed the line and surface, and further, of the solid body, from which we have drawn, with the ideas of surface and line, those of point and movement.—In fact, imagine a point, that is to say the limit of a line, and assume that it moves; the continuous series of positions it occupies forms a line. Assume this line to move; the continuous series of the positions it occupies forms a surface. Assume this surface to move; the continuous series of the positions it occupies forms a solid body, *at least, in a geometrical point of view.* And the substitutes we have adopted for the point, line, and surface, render this construction sensible to us. By prolonging this little dot of chalk, we see a slender trace produced. By causing this whole trace to move in a mass, we see a greater or less surface produced. By mentally causing the surface of the board to recede, we see the whole solid board produced.—From this general construction, let us pass to special ones. Let there be two points; if the first moves towards the second, and towards the second only, the line it describes is straight.—If, during an appreciable fragment of its movement, it moves towards the second point, and then, during other equally appreciable fractions, towards a third, a fourth, etc., the line it describes is broken, or composed of distinct straight lines.—If at each instant of its movement it moves towards a different point, the line it describes is curved. Such are the different species of lines.—Next, if two straight lines start from the same point, and move, each towards a different point, they diverge from one another, and this greater or less divergence is called an angle. If the two angles which the second line makes to left and right with the first are equal, they are called right angles, and we say that the second line is perpendicular to the first. Such are angles.—With straight lines cutting each other in pairs, and forming certain angles, we construct all triangles, all quadrilaterals, and generally, all polygons.—If we submit a curve to the condition of having all its points at an equal distance from some other anterior point, we have circumference.—"The plane surface, or plane, is generated by a straight line perpendicular to another, and turning about it while always passing through some one point in it."* With planes terminated by certain polygons and forming certain angles by their mutual inclination, we construct all polyhedra.—By the revolution of the semicircle about its diameter, of the rectangle about one of its sides, of the right angled triangle about one of the sides containing the right angle, we form the sphere, the cylinder, the cone; by sections of the cone, we form the ellipse, parabola, and hyperbola; by various combinations of the primitive elements, and of these first compounds, we form all possible species of lines, surfaces, and solids, sometimes so complex that imagination cannot form them, and that, if nature or art were to furnish instances of them, the most attentive eye could not contrive precisely to distinguish all their characters.

Are there in nature physical constructions conforming to these mental constructions?—And first, are there in nature surfaces, lines and points? Yes, certainly, at least as far as our senses are concerned; for, to our senses, a body has sur-

* Duhamel, "De la Méthode dans les sciences de raisonnement," 2me partie, 12.

faces which are the limits in which it appears to be contained, a surface has its lines which are the limits by which it seems circumscribed, a line has its points which are the limits by which it seems to be terminated, or by which we may interrupt it.—Are there in nature surfaces, lines, and points which move? Yes, since bodies move and their limits accompany them in their movement.—Next, are there in nature points, lines, and surfaces, which, in their motions and combinations, rigorously conform to the conditions enunciated in our constructions? In other words, are there perfect straight lines, right angles, squares, circles, planes, polyhedra, round bodies?—As far as we can judge, nature does not furnish us with such. When we arm our eye with a powerful microscope, we find inflections in what seem the straightest lines, roughness in the smoothest planes, irregularities in the most regular forms. A cannon-ball appears to advance in a straight line; theory shows us that it begins to fall the moment it leaves the cannon. The planets seem to describe an ellipse; observation and the calculations of their perturbations prove that this ellipse is not exact.—In short, when we compare the work of nature and the work of the mind, we prove that their conformity is not entire; the first approximates to the second; that is all. Usually, this coincidence is remote enough, but, even in the most favorable instances, it fails in some point; we might say that the real substance attempts to mould itself on the mental form, but that the imperfection of its material hinders it from copying rigorously the prescribed shape.

There is a reason for this impotence; and, if we take cases whose theory is constructed, we are able to explain it. The cannon-ball would advance continuously in a straight line, if gravity did not cause it to descend towards the ground. The planet would describe a perfect ellipse, if the variable proximity of the other planetary bodies did not intervene to alter the regularity of its curve. If the ball deviates from its straight line and the planet from its ellipse, it is through other perturbing directions being added to the simple direction followed by the ball, to the two simple directions according to which the planet travels. Consequently, if the real construction is but approximately adjusted to the mental construction, it is owing to the first being more complex and the second simpler. Disencumbered of its accessory elements, and reduced to its principal elements, the first would precisely copy the second ; and in fact, it does approximate to it in proportion as its ulterior or accessory elements become feeble, and leave greater ascendancy to its primitive or principal element.—Thus, in geometry, as just now in arithmetic, our preliminary outlines have a function and a value. Though constructed on their own accounts, they have a relation with things. In a certain sense they are exact, and, with a complementary operation, they may become so. The divergence we observe between them and the facts may disappear, and does in fact disappear in two ways.—We have seen it disappear by an abstraction, that is to say by the mental omission of certain elements of the facts ; in this way, the *reduced* facts are adjusted to the outlines.—It may also disappear by an inverse process, that is to say by the introduction into the outlines of the elements omitted in their preliminary construction ; to the consideration of the principal or primitive directions, we add those of the perturbing directions, whether ulterior or accessory, and, in this way, the *completed* outlines will be adjusted to the facts.

III. Other elements, fashioned like the preceding ones on the general characters of natural objects, combine with the preceding ones to form new outlines. We may consider movement, not only as having the effect of describing a line, but in itself. Daily, beneath our eyes, a prodigious quantity of bodies are at rest or in motion, so that in this point of view experience furnishes us with all the materials necessary to enable us to isolate the two elementary ideas of *rest* and *motion*.

Take a body in motion ; it passes from one point to another while describing a line ; we have many occasions of observing that, according to circumstances, this same line is described in more or less time, and we thence draw a new elementary idea, that of *velocity.*—Take a body passing from rest to motion; in the majority of cases, we discover that something has been altered in it or in its surroundings, and after a certain number of experiences we ascertain, or believe that we ascertain, that this internal or external alteration is always followed by the movement of the body. Whatever be this condition of motion, the import of another body, the attraction of a magnet, electric repulsion, whether it appear to reside in the moved body or in another, is of no importance; we call it *force*, without forming any previous conclusion as to its nature, and we mean nothing more by this name than a condition whose presence is sufficient to excite the motion, a condition which is met with in an infinite number of various circumstances, and which, when detached and isolated by a mental fiction, thus becomes wholly general and abstract. In this state of purity, it is defined only by its relation with the movement it excites. Therefore, if in the movement it excites we find a character susceptible of magnitude, the force will be susceptible of magnitude; now, we have just seen that this character is velocity. In this manner, we speak of a force as double or triple another; and we thereby mean nothing more than a condition whose presence is enough to excite in the same body, surrounded by the same circumstances, a movement, twice, thrice, four, etc., times as rapid as the first.

When this is settled, we can take a step in advance. Among the bodies we examine, there are some which appear to us homogeneous, that is to say composed of particles all of which are perfectly similar, except in the difference of their position in the body; such, for instance, is a measure of pure water, a piece of refined gold. From this indication of experience, we have no difficulty in conceiving an absolutely homogeneous movable body, analogous to a pure geometrical solid, divisible therefore into two halves, each composed of the same number of exactly similar particles. Now, take a force which impresses a certain velocity on the block formed by the half of these particles; as, by definition, these two halves are absolutely similar and may be substituted without inconvenience for one another, it will require a force absolutely similar and capable of being substituted without inconvenience for the other, that is to say, in short, an equal force, to impress the same velocity on the block formed by the other half, consequently two forces, each equal to the first, that is to say a double force, to impress the same velocity on the block formed by the two halves. Thus arises our last elementary notion, that of *mass*, which is found to be a quantity like velocity, and henceforward, we measure force in two ways, either by the magnitude of the mass on which it impresses a certain velocity, or by the velocity which it impresses on a certain mass. With these elements, denoted by means of lines, ciphers, and words, we are able to construct an infinite number of different mental compounds, to conceive, first, a movable body at rest, or to which no force is applied, then, a movable body at rest to which a force is applied, then, by a further complication, to imagine a movable body to which are applied two or more equal or unequal forces, which impel it in the same line, in the same or in contrary directions, or which impel it in different lines, etc. By this operation, the science of mechanics acquires similar outlines to those of geometry, and the facts conform to the outlines in the first case in the same manner and in the same degree as in the second.

One of the most simple of these intellectual combinations is that of a movable body at rest and remaining at rest for an indefinite period; for, in this case, there is no idea of a new state introduced.—Another, which is fellow to it, and almost equally simple, is that of a body in motion which moves on in a straight line with uniform velocity, and that indefinitely; for, to form this conception, requires a minimum of mental elements. In the first place, there is no simpler line than the straight line, since, when the starting point is given, all required to determine it is a single second point, whilst for every other line, broken or curved, many or an infinite number of such points are required. Secondly, it is more simple for velocity once given to subsist invariably with the same magnitude; for in this way, no new magnitude is introduced. Lastly, it is more simple for the movement, once given, to subsist indefinitely; for in this way, no new state is introduced.

Now it is an admirable thing that the bodies of nature, however different they may be, however different may be the real forces by which they are set in motion, or the real circumstances in which they happen to be at rest, all tend to conform to this double conception. We assure ourselves of this by experience; real matter is inert, and indifferent to rest or motion. In order for a body at rest to move, the intervention of a force is required; if this intervention is wanting, it remains indefinitely at rest, and its tendency to persist in its state is so thoroughly inherent to all its particles, that, according to the magnitude of its mass, it requires a force of corresponding magnitude to impress on it the same velocity.—On the other hand, in order that a body in motion may stop, or change its velocity, or deviate from a straight line, there is also required the intervention of another force. This stone which I cast in the air, this ball driven from the cannon by the explosion of powder, would continue their route indefinitely, the one towards the stars, the other along a tangent to the earth, in a straight line, with the initial velocity, if gravity and the resistance of the air did not intervene to bend the straight line, to diminish the velocity, and finally, to arrest the movement. As far as we can judge by observation, there is no particle of matter, at rest or in motion, which, taken by itself and with the abstraction of all perturbing solicitations, does not conform itself to this conception.

Let us now introduce a new condition, the simplest we can, into our mental compound; let us suppose the initial force, instead of acting at the first instant only, to continue to act during the whole duration of the movement, and consequently the velocity of the movement to increase uniformly. By a coincidence almost as beautiful as the preceding one, we find that this kind of motion is that of all falling bodies.*—Lastly, let us imagine a body, subject to this kind of motion, and to uniform rectilinear motion besides. The coincidence is no less surprising; to our intellectual construction corresponds a real movement, similarly composed in all respects, with respect to the curve traced, with respect to the alternately increasing and decreasing velocities, that of the planets about the sun. Thus it is that the mathematician prepares beforehand moulds which the physicist will subsequently proceed to fill.—There are three conditions requisite for these moulds to have a chance of agreeing with things. It is first necessary for the mental elements with which they are fabricated to be traced in exact accordance with the elements of real things; for then the elements of our mould will be found in nature.—It is then necessary for them to be very general, and, if possible, universal, for the more general they are, the more considerable will be the number of individuals or instances in which they will be found, and if universal, they will be found in all.—Lastly, it is necessary for the combinations we give them to be as simple as possible; for there is the more chance of our finding them in nature, since a minimum of elements and conditions is then sufficient for their production.

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* "'When a stone falls,' says Galileo, 'if we consider the matter attentively, we shall find that there is no addition, no increase, of the velocity more simple than that which is always added in the same manner,' that is, when equal additions take place in equal times. From this law, thus assumed, he deduced that the spaces described from the beginning of the motion must be as the squares of the times; and again, assuming that the laws of descent for balls rolling down inclined planes, must be the same as for bodies falling freely, he verified this conclusion by experiment."—Whewell's "History of the Inductive Sciences," ii. 30, citing Galileo. 'Dial. Sc.' iv. p. 91.

IV. It will be understood that this process may be applied to all classes of objects, since, in all classes of objects, we meet and isolate general characters capable of being combined with one another. In fact, we suppose perfect solids, that is to say bodies absolutely rigid, and such that, all their parts being indissolubly connected, one particle cannot be displaced without displacing all the rest, in such a way that the reciprocal position of their particles is never altered in any way. And so, we assume the existence of perfect or absolutely fluid liquids, such that no one of their particles has the least adherence to the adjacent ones, and that all can move with perfect freedom about one another. So finally, we conceive water or oxygen as absolutely pure, platina or lead as free from all alloy, without being sure that nature ever furnishes, or art has ever obtained, objects such as we conceive.—Among mental types so constructed, there are some which are more particularly interesting to us; they are those to which we *desire* that things should conform, and in this case the need of conformity becomes for us a spring of action We construct the Useful, the Beautiful, and the Good, and we so act as to approximate things, as far as possible, to these constructions.—For instance, when we find rough unhewn scattered stones, we imagine them hewn, transported, and piled up, in the spot in which we wish to live, and, in conformity with the idea of the wall so constructed, we actually construct the real wall which is to shelter us from the weather.—We survey the men who live around us, we are struck with a certain general form appropriate to them; we observe, sometimes in one, and sometimes in another, higher degrees of the external signs of some quality or disposition beneficial to the individual or the race, agility, vigor, health, sagacity, or energy;* we gradually collect these different signs; we take pleasure in contemplating a human form in which the characters we consider most important and

* I have worked out this analysis in detail in "La Philosophie de l'Art," and in "L'Idéal dans l'Art."

most valuable are manifested by a deeper and more universal print, and if an artist be found in whom this group of conceived conditions results in an express image, a sensible representation, an internal half-sight, he takes a block of marble and hews out the ideal form which Nature has not been able to display to us.—Finally, when we survey the different motives which impel men to will, we observe that the individual acts most frequently with a view to his personal benefit, that is to say through interest, often with a view to the benefit of another person whom he loves, that is to say, through sympathy, very rarely with a view to the general good, with complete abstraction of his interests or of his sympathies, with no more regard to himself or his friends than for any other individual, without any other intention than that of being useful to the community present or future, of all sentient and intelligent beings. We separate this last motive, we desire that it should have an ascendancy in all human deliberation, we praise it loudly, we inculcate it on others, we sometimes strive to give it the empire over ourselves. We have thus constructed the idea of a certain moral character, and, in fact, on occasion, at a considerable distance, we adapt our actual character to this model.—Thus arise works of industry, art, and virtue, with the object of filling or diminishing the interval which separates our conceptions from things.

CHAPTER II.

THE COUPLES OF GENERAL CHARACTERS AND GENERAL PROPOSITIONS.

I. HITHERTO, in general ideas, we have studied only the general ideas themselves and the manner in which they are formed, sometimes by extraction, sometimes by construction, sometimes when, after detecting a common character in many similar facts or individuals, we have conceived it apart by means of a sign, and have, by a series of additions and rectifications, caused the comprehension and extension of our idea to coincide with the comprehension and extension of the character it denotes; sometimes when, after distinguishing and conceiving apart certain very simple general characters, we have combined ideas thus acquired so as to form of them mental compounds, which are preliminary moulds to which the real compounds have a possibility of being found to conform, or preliminary models to which we desire to make the real compounds conform.—A second investigation remains to be effected. In nature, general characters are not detached from one another; whatever be the character we have noted, we never fail to find it connected with some other. In fact, the one involves the other, or at least tends to involve it. Sometimes it is the first which involves the second, sometimes the second which involves the first, sometimes each of them involves the other. In all these cases, the two characters form a *couple*, and this couple is termed a law. To conceive a law, is to connect together two general ideas, in other words, to form a general judgment, in other words again, to mentally enounce a general proposition. We shall now examine how it is we arrive at connecting these ideas, at forming these judgments, at mentally enouncing these propositions.

II. Let us first consider these couples or laws in themselves. Every piece of iron exposed to damp becomes rusted. Every crystal capable of scratching any other body whatever is a diamond, that is to say a crystal of pure carbon. All bodies immersed in a liquid lose a portion of their weight equal to the weight of the liquid they displace. In every polygon, the sum of the internal angles together with four right angles is equal to twice as many right angles as the figure has sides.—Here are laws; each of them consists in a couple of general and abstract characters which are connected. On the one hand, the property of being iron and of being exposed to damp, on the other, the formation of the chemical compound termed rust; on the one hand, extreme hardness, and on the other, the property of being a crystal of pure carbon; on the one hand, the amount of weight lost by the immersed body, and on the other, the equal quantity of the weight of the displaced liquid; on the one hand, the sum of the internal angles of the polygon together with four right angles, on the other hand, the equal sum of twice as many right angles as the figure has sides: it is evident that all these data are general characters, that is to say characters common to an indefinite number of individuals or cases; that all these data are abstract characters, that is to say extracts considered apart; that all these data are connected characters, that is to say such that, the first being given, the second is also given.—There is nothing more advantageous to the human mind than this structure of things; we discern at once that our chief attempt must be to discover connections similar to the foregoing ones; for there is no better means of extending and increasing our knowledge. When once the law is discovered, the first character becomes the indication of the second; in future it will be sufficient for us to ascertain the presence of the first; we may then, blindfold and without inquiry, assert the presence of the second. In fact, at present, it is sufficient for us to know that this piece of metal is iron, and exposed to damp from water, steam, or fog, to foresee that, in some hours or days, it will be covered with rust. It is sufficient for us to collect the water which has run from the full vessel and to weigh it, to know beforehand the weight lost by the immersed body. It is sufficient for us to count the sides of the polygon, to take two from their number, and multiply the remainder by two, to know beforehand the number of right angles contained by the polygon. It is sufficient for us to observe that a given crystal scratches the hardest bodies, to enable us to declare that when burnt it will furnish carbonic acid.—Owing to these established connections, an anatomist who opens a human body, is able to describe beforehand the color, form, structure, and disposition of the nervous cells and arterial network which his microscope will show in a particular part of a particular organ. Owing to these established connections, an astronomer is able to predict the duration, time, and magnitude of the eclipse, which, a century hence, will hide the sun from the inhabitants of some particular country.

These very valuable connections are of many kinds.—Sometimes the two connected characters are *simultaneous*. Two cases then present themselves.—Either the first character may involve by its presence the presence of the second without the presence of the second involving that of the first. Thus, when the sum of the digits of a number is divisible by nine, the number itself is divisible by three, but the converse is not true; when an animal has mammæ, it has vertebræ, but the converse is not true. In this case, the link joining the two characters is unilateral or simple.—Or again, the first character may involve by its presence the presence of the second, and the presence of the second may involve in its turn the presence of the first. Thus, in every polygon, three sides are always accompanied by a number of angles equal to two right angles, and conversely; in every mammal, incisor teeth invariably accompany a short digestive tube and carnivorous instincts, and conversely. In this case, the link joining the two characters is bilateral and double.—Sometimes, of the two connected characters, one termed the antecedent *precedes*, and one termed the consequent *follows;* the first is then termed the cause of the second, and the second the effect of the first. Then again two cases present themselves.—Either the first character may excite by its presence the existence of the second, and the second, in its turn, may require, for its production, the preliminary presence of the first. Thus, every movable body to which are applied two divergent forces of which one is continuous will describe a curve; and a movable body in order to describe a curve requires the previous application of two divergent forces of which one is continuous. In this case, the link joining the two characters is bilateral or double.—Or again, the first may excite by its presence the existence of the second, without the second requiring for its production the previous presence of the first. Thus, every series of vibrations of certain velocity transmitted to the auditory nerve by the surrounding medium excites in us the sensation of sound; but this sensation may arise spontaneously in our sensory centres, without the previous vibration of an external body or a surrounding medium. In this, which is the most usual case, the link of the two characters is unilateral or simple; it is the most important case and the one which we shall examine with most attention; we can reduce the others to it, and we usually express it by saying that the cause produces the effect.

III. It now remains to be seen in what the connection of the two characters consists. Is there any virtue or secret reason which is resident in the one and involves or evokes the other? This question we reserve; we shall discuss it later on. At present, the words connection, link, implication, excitement, requirement are nothing more than abbreviatory metaphors. When we say that the antecedent gives rise to the consequent, we are not thinking of the mysterious link by which metaphysicians connect cause and effect, nor of the intimate and incorporal force which certain philosophers insert between the thing producing and the product. "The only notion," says Mill, "of which induction has need, may be attained by experience. We learn by experience that there is in nature an invariable order of succession, and that each fact is always preceded by another fact. We call the invariable antecedent, cause, and the invariable consequent, effect." No other foundation underlies these two words. We wish simply to say that, at every time and place, the application of heat will be followed by the dilatation of bodies, that at every time and place, the vibration of the external body transmitted by the surrounding medium to the healthy auditory nerve will be followed by the sensation of sound. "The real cause is the series of conditions—the whole of the antecedents without which the effect would not arrive. . . . . There is no scientific foundation for distinguishing between the cause of a phenomenon and the conditions of its happening . . . . The distinction drawn between the patient and the agent is purely verbal . . . . The cause is the sum of negative and positive conditions taken together; the whole of the circumstances and contingencies of every kind, which, once given, are invariably followed by the consequence." Philosophers are mistaken when they think that they discover in our will a different type of causation, and assert that we there see efficient force in act and exercise. Nothing of the sort is to be found there; but there as elsewhere, we find constant successions only. We do not find fact invariably engendering fact, but fact invariably accompanying fact. To quote Mill again: "Our will produces our bodily actions, as cold produces ice, or as a spark produces an explosion of gunpowder." There, as elsewhere, we find an antecedent—the resolution which is a momentary character of our mind, and, there as elsewhere, a consequent—the muscular contraction which is a momentary character of one or more of our organs; experience connects them and enables us to foresee that the contraction will follow the resolution, just as it enables us to foresee that the explosion of gunpowder will follow the contact of the spark. —More precisely still and whatever be the two characters, simultaneous or successive, momentary or permanent, the link by which the first involves, excites, or supposes the second as its contemporary, consequent, or antecedent, is nothing more than a peculiarity of the first considered alone and apart. This means that the one possesses, in itself, the property of being accompanied, followed, or preceded by the other; that is all. In other words, it is sufficient for the one to exist for the other to be its companion, precursor, or successor. As soon as the one is given, no other condition is required; the circumstances may be of any kind; it does not matter. Whether it be given in a particular individual with a particular group of other characters, at a particular time or place, is a matter of indifference; the property it possesses does not depend on circumstances, nor on the individual, nor on the surrounding group of other characters, nor on the place, nor on the time; taken apart and in itself, isolated by abstraction, extracted from the various media in which we meet with it, it possesses this property. This is why, into whatever medium we transfer it, it preserves this property. If it possesses this property at every time and place, this is because it possesses the property of itself and by itself alone; if it possesses this property without exception, this is because it possesses the property without condition. If all triangles enclose angles together equal to two right angles, it is because the abstract triangle has the property of enclosing angles together equal to two right angles. If every piece of iron exposed to damp becomes rusted, it is because iron taken apart, in itself, and submitted to damp taken apart, and in itself, possesses the property of becoming rusted. If the law is universal, it is from its being abstract.—There is nothing surprising in this constitution of things. It is no more strange to find companions, precursors, and successors in the case of a general character than in that of a particular individual or a momentary event. No doubt in the infinite dispersion and remediless flow of being, these sorts of characters are the only elements which are everywhere the same and which always arise the same: but they do not exist outside individuals and events, as Plato taught, nor in a world other than our own; for they are the characters of the events and individuals which compose our world. They are, like individuals and events, forms of existence, and differ only from individuals and events by being more stable and more widely spread forms. For this reason, we must expect to discover that they too have accompaniments, precedents, sequences, peculiarities, personal properties, and, to succeed in this, we have only to observe them apart.

It is precisely in this that the difficulty lies. For how are we to observe apart a character which, being an extract, is only met with and can only be met with in a particular case or individual, that is to say in company with other characters? How can we contrive to study in nature iron in itself exposed to damp in general, and to ascertain that, in this state of abstraction, it has rust in general as a consequence? How can we contrive to detect the abstract triangle which is neither scalene, nor isosceles, nor right angled, to measure its abstract angles which are neither equal nor unequal, and to prove that, in this strange state, their sum is equal to two right angles?—From the question thus presented, an answer follows. When once the obstacle is clearly determined, we are usually able, if not to suppress it, at least to evade it. Two artifices of method lead us to our end. We have distinguished two kinds of general characters. The first are real, and the general ideas which correspond to them, for instance, those of iron, of damp, and of rust, being formed by extraction, become by degrees adjusted to them; they are the object of the experimental sciences; and their connections are discovered by the *inductive road*. The second are possible only, and the general ideas which correspond to them, for instance, those of the triangle, the angle, parallel lines, being formed by combination, are outlines only, to which certain real things have a possibility of being adjusted; they are the object of the constructive sciences, and their connections are discovered by the *deductive road*.—Let us follow these roads in turn, and attempt to observe the successive stages of the mind in traversing them.

§ I. LAWS CONCERNING REAL THINGS.

I. Here, in the first road, our starting point is the already explained acquisition of general ideas. In fact, the child of fifteen months old, who already repeats and applies certain general names, has but to associate two of them in order to form a general proposition, and this is what happens when an object which calls up in him a name also arouses in him another name. He then attempts his first lisping, verbless sentences:—nice soup, naughty cat, etc. The mechanism of this junction is very simple, and here animal thought leads naturally to human thought.—When a dog sees in a trench or pit a flowing inodorous, uncolored, clear liquid, this perception, by virtue of anterior experience, excites in him by association the image of a sensation of cold, and the perception joined to the image form in him a couple. In the case of the child, owing to the names he learns and understands, the same perception further calls up the word *water;* the same image further calls up the word *cold*, and the two words *water*, *cold*, associated by contiguity, form a second superadded couple.

Now later on, when the child reverts to and dwells on these two words, he finds that the first excites in him an indefinite series of anterior experiences, that of the water-bottle, the well, the spring, the rain, the river, and that in each of these representations the word *cold* is called up as well as the word *water*. He then observes that they form a couple through all the procession and all the review; this he expresses by saying that all waters are cold. Somewhat later on, he omits the differences of the various representations and preserves the couple itself alone; this he expresses by saying that water is cold. In this manner, he enounces, mentally or aloud, his first general propositions and his first abstract propositions.—By degrees, as he grows older, he learns new words; he applies them to the old couples of representations which former experience has already established in him, and to the new couples of representations which incessant experience daily establishes in him; thus, arise new couples of understood words, that is to say, of ideas.—It is between eighteen months and five or six years old that the greater part of this process is accomplished; it is continued, later on and up to adult life, but with fewer acquisitions. The child thus forms a number of judgments on the objects and facts familiar to him. "Sugar is nice. Fire burns. A blow hurts. Cats scratch. Cows eat grass. A person who speaks harshly is angry."—At first, when given an individual or event of a certain class, he formed only one of these general judgments respecting it; soon he forms two, three, four, then ten, twenty, a hundred, and so on. Seeing a bounding form, with which the name cat is associated in his mind, he says, first, that the cat scratches; later on, he will say that it mews, that it climbs on the roofs, that it catches mice, and so on.—It is the same with all other class names; each of them ends by calling up a considerable number of general judgments, and each is capable of calling up an indefinite number of them. Each of them thus, by its more or less ample escort, sums up our more or less ample experience, and being the product of our experience, affords its measure.

General judgments of this kind and of this origin are sufficient for practice. Children, savages, and uneducated persons form few others, and few others are made use of in ordinary conversation. Many men and many nations never go beyond this. But we are capable of going beyond it, and of passing from ordinary propositions to scientific propositions. Experience at its commencement led us to the first; prolonged experience leads us to the second. For on applying our primitive judgment to new instances, we find it inexact. The child at first concluded that all waters are cold; if he puts his hand into a kettle just taken from the fire, he changes his opinion and no longer attributes cold to water, except of a certain temperature. A gardener who has never left his province, considers that all swans are white; if he is taken to the Zoological Gardens and shown the black Australian swans, he will no longer attribute whiteness except to a certain variety of swans. A student of botany thinks that all plants with an arborescent bark arranged in concentric layers have two cotyledons; when shown the dodder and two or three other kinds, he sees that the preceding law is almost universal, but not universal.—By degrees, owing to such corrections, our general judgments become adjusted to things. To the couple of abstract ideas associated in our minds, there corresponds, line for line, a couple of abstract characters associated in nature; henceforward, in every new instance we observe, our proposition receives a new justification, and the law enounced no longer meets with exceptions.—At the expiration of a very long time, after numbers of correspondences thus verified, men of certain races and of certain civilizations—for instance, modern Europeans—have ended by believing that this is so in every case, that such is the constitution of things, that the whole of nature is governed by laws, that all its course is uniform, that in every time and every place, in the moral as well as in the physical world, when any character is given, there is necessarily another which is connected with it. Is this supposition true? Have we here a wholly universal law? We shall inquire into this later on.—Meanwhile, we are able, from the vast number of ascertained laws within us and about us, to admit that it is so for our little universe, or at all events to avail ourselves of it on occasion as an instrument of research, to discover the unknown character which we suppose to be attached to the known character, remembering that we have in every case to verify our success or failure by the conformity or divergence of the supposition we have admitted and the subsequent facts. Thus it is we inquire, and our different modes of inquiry in this route are the different processes of scientific *Induction.*

II. We begin then with an hypothesis, but with a very probable hypothesis, warranted by a multitude of precedents, and capable, moreover, of being invalidated or confirmed after we have availed ourselves of it, therefore as well selected as possible to put us in the right road, and to warn us off the wrong road if we happen to be led into it; this hypothesis being that a character, taken apart, has an influence; by itself and by itself alone, it involves something else, either contemporary, antecedent, or consequent; it is sufficient for it to be given for one or more other characters to be also given.

Observe this word it is *sufficient.* It is the key of the door; for it puts in our hand a property of the unknown character, a kind of distinctive mark, by means of which we shall recognize it; since the fact of the presence of the other is sufficient to give us this, we shall recognize by this characteristic that it is present in all the cases in which the other is present; in none of these cases can it fail. This is its special sign, and, so to speak, the ticket which denotes it from all other things. Hence a first method, termed by Mill *The Method of Agreement.* We collect many cases in which the known character is given; according to what has just been said, the unknown character is met with in them all; in other words, it is common to them all, and is, therefore, found comprised in the portion which is common to them.—Here, we choose cases as dissimilar as possible, and take away their differences. The greater and more numerous their differences, the smaller will be the common remnant left by the elimination; as this remnant is the only common part, it necessarily comprises the character we are in search of, and if after this elimination there remains a single character only, this single character is necessarily the character we are in search of.

Thus, take all animals with mammæ, and especially the most widely different ones, the whale, the bat, the monkey, the horse, the rat, the ornithorynchus, and exclude their differences. After this enormous elimination, there will only remain a small number of common characters, double circulation, the circumscription of the lungs by a pleura, the property of bringing forth the young alive; either this entire group or some element of it, among others the last, is evidently the character we are in search of; in fact, the last invariably accompanies the possession of mammæ.—Let us collect a number of oils as different as possible, of alkaline substances as different as possible, and combine them; here is the known antecedent. Now let us seek for the known consequent, and, for this, let us compare together their different products. If we set aside their differences, we shall find one common character only, that of being a soap; this, then, is the character which is connected as consequent to the presence of the given antecedent.—Let us now take a known and well-defined consequent, the sensation of sound.* To find its antecedent, we collect many cases in which a healthy ear perceives a sound, the sound produced by a bell, by a string which is pinched or rubbed by a bow, the sound of a beaten drum, of a horn which is blown, the sound of the human voice, the sound heard when the head is under water, or on putting the ear to a beam which is slightly struck, etc. After a long examination, we discover that all these cases agree, as far as we can judge, in one single point, which is the presence of a reciprocating movement, in other words, of a vibration of the sonorous body, comprised between certain limits of slowness and rapidity, and propagated through a medium to the auditory organ. This transmitted vibration, then, is the antecedent we are in search of.

Such is the first method; by it we exclude the differences

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* Ordinary Sound, that is to say, excited by an external antecedent, and not the subjective sound excited by a spontaneous state of the auditory organ.

of the cases in question, which sets apart their resemblances. It requires as preliminary, the collection of many cases in which the known character is given. It adopts as a guide, the necessary presence of the unknown character in all cases in which the known character is found. It has for its auxiliary, the greatest possible difference of appearance between the cases. It has for its object, the severance of their agreements. It has, as its effect, the isolation of a remnant, which is, in whole or part, the character we are in search of.

We have only to invert this method to possess another, termed by Mill *The Method of Difference.* Let there be a known character, and take two cases; the first in which it is given, the second in which it is not given. Since, by its presence alone, it introduces an unknown character, when absent it will not introduce this; this character which it would have introduced, will be wanting, and, therefore, will not be found in the second case. Here is a new property of the unknown character, a second distinctive characteristic, by means of which we shall be able to discover it; we shall recognize it by the mark, that, being present in the first case, it is absent in the second.—Here we choose two cases as similar as possible. Since it is present in the one and absent in the other, it cannot be one of the characters in which they are alike, and must necessarily be one of the characters in which they differ. Let us exclude, then, all the characters in which they are alike; the remainder is the sum of their differences; and it is in this remainder that the character we are in search of is necessarily comprised. But this remainder is very small, since we have chosen the two cases as much alike us possible; if, therefore, this remainder consists in one single character, this character is necessarily the one we are in search of.

Thus, take a known character, extreme hardness, or the capacity of scratching all other bodies. We take two bodies as much alike as possible, one in which the character is present, the other in which it is absent; one of these bodies is a diamond which is pure carbon; the other is purified carbon;

or, better still, let one body be a particular diamond, the other the same diamond burnt and reduced to the state of cinder. Chemical properties, weight, component molecules, many characters, and those the most important of all, are exactly alike in the two cases. We eliminate them, and have as residue a group of characters which are present in the diamond and absent in the piece of coke, brilliancy, transparency, octohedric form, crystalline structure. It is this whole group, then, or an element of this group, and especially the last, which is the character we are in search of; in fact, the other elements of the group are nothing more than various aspects of the last, and in carbon, crystalline structure invariably accompanies extreme hardness.—Again, when given the sensation of sound, let us select two cases, one in which it is produced, the other in which it is not produced, and let us select them so very similar as to differ in a very small number of characters only, and, if possible, in one character alone. For this purpose, let us repeat the same case twice, and introduce or suppress on the second occasion a single well-defined circumstance; this added or excluded circumstance, being the only difference separating the two cases, will be the character we are in search of. For instance, in the case of the continuous sound produced by a vibrating tuning-fork, we touch lightly the little blades, this stops their vibration, and the sound at once ceases. In the case of a bell struck by its clapper, we put it under the receiver of an air-pump and exhaust the air, and the sound at once ceases. In the case of the silent tuning-fork, we press it and suddenly let go the blades, which restores their vibration, the sound at once recommences. In the case of the clapper silently striking the bell, we let the air into the receiver, the sound at once recommences. Here the only circumstance in turn introduced or suppressed among the antecedents of the sound is the rapid reciprocating movement in the case of the tuning-fork, and the presence of the elastic medium in the case of the bell. This double circumstance, then, is the only character by which the case in which the sound is present, differs from the case in which the sound is wanting, hence it follows that it is the antecedent we are in search of.

Such is the second method; by it we exclude the resem blances of the cases considered, and so set apart their differences. It requires as preliminary the selection of two cases distinguished, one by the presence, the other by the absence, of the known character. It adopts as a guide the necessary absence of the unknown character in all the cases in which the known character is absent. It has, for its auxiliary, the greatest possible resemblance between the two cases. It has, for its object, the severance of differences. It has as its effect the isolation of a remnant, which is, in whole or part, the character we are in search of.

These two methods suggest a third, termed by Mill, *The Method of Concomitant Variations.* To the two marks by which we make discovery of the unknown character, it adds a a new one. We have recognized it by the characteristic of its presence whenever the known character is present, and by the characteristic of its absence whenever the known character is absent; we can also recognize it by the characteristic that, whenever the known character varies, the unknown character also varies in a corresponding manner. In fact, in one aspect or another,* the known character may be considered as a sum of degrees, each of which taken apart has its influence; for if each taken apart had no influence whatever, we might successively suppress them all up to the last, and,

* For instance, in the corresponding variations which the form of the teeth, the structure of the condyle, the length of the intestines, and the arrangement of the limbs, undergo in different species, the observed organ becomes more or less fitted or unfitted for carnivorous or herbivorous life; the degree of fitness for carnivorous life being lowered in proportion as the degree of fitness for herbivorous life increases. In this double sense, an organ may be considered in the aspect of its quantity, and may present a sum of greater or less degrees. Hence, the methods of Cuvier for determining unknown organs from their dependence with relation to known organs.

therefore, suppress the character itself, without suppressing its influence; we might also add them all, one after another, up to a certain limit, and, therefore, reconstitute the character itself as fully as we pleased, without re-constituting its influence. Now these two suppositions are contrary to the notion of the character as we have assumed it. Thus, from this very notion, we may conclude that every variation of the known character involves a variation of the unknown character, and on this indication, may seek for the unknown character.

For instance, take a known character, the progressive retardation, and consequent final extinction, of the movement of the pendulum. We cannot construct a pendulum to oscillate for ever, and consequently cannot find a second case in which the known character is absent. For this impracticable case of absence of retardation, we substitute a number of practical cases of diminished retardation. We diminish more and more the obstacles the pendulum meets with, and find that its retardation is proportionately diminished. When the friction at the point of suspension is reduced as much as possible, and when the surrounding air is exhausted as much as possible, it takes thirty hours, instead of some minutes, for the movement to stop. In proportion as the obstacles approach the degree at which they would vanish, the retardation approaches the degree at which it would vanish. As far as we are able to judge, there is, between the first case in which the pendulum ceases to oscillate after a few minutes, and the other cases in which it continues its oscillation for a longer and longer time, one difference only, which is that, in the first case, the obstacles are greater, and that, in the others, they are less; the presence, then, of an increase in the obstacles is the antecedent of an increase in the retardation.—But this does not as yet prove that, were there no obstacles, there would be no retardation. For it might happen that the diminution of the antecedent and the diminution of the consequent did not proceed at the same rate;

perhaps, in proportion as the resistance is diminished by one half, the retardation is diminished only by a fourth or other smaller fraction; this would be the case, if the retardation had two causes, one of which was a property inherent to the motion itself, that is to say a tendency to cease after the lapse of a certain time, the other appertaining to the circumstances, that is to say to the resistance of the surrounding bodies. In this case, the complete suppression of the obstacles would only diminish the retardation, without wholly suppressing it; the pendulum would oscillate sixty hours and more, but would finally stop.—We must prove, then, that the retardation diminishes at the same rate as the resistance, and that every degree added to or taken from the resistance corresponds to an equal degree added to or taken from the retardation. This is effected by the two methods already described, though seeking, no longer the antecedent of the retardation, but the antecedents of two of its diminutions or augmentations measured beforehand, and through discovering, by the extraction of agreements or differences, that these antecedents are two precisely equal diminutions or augmentations introduced into the sum of the resistances presented by the surrounding obstacles. When this is established it becomes proved that, when the resistance ceases, the retardation ceases.—This is a proposition which we were just now unable to establish by experience: but now we have no need to establish it by experience; the gap is filled up; we may dispense with observation; we have its equivalent. Thanks to this equivalent, we know now that the case in which the motion is retarded, and that in which it is not retarded, differ only in one character, namely, the resistance opposed, in the first case, by obstacles; hence it follows that this resistance is the antecedent we are in search of.—Such is the third method which, compounded of the first and second, is a substitute for the second, and which is often of higher value than they are, from its determining, not only the quality, but also the quantity, of the unknown character.*

All these methods employ the same artifice, that is to say the elimination or exclusion of characters other than the character we are in search of. Let us take a known character; it is accompanied, followed, or preceded by ten others. Which one or more of these ten are so connected with its presence, that its presence is sufficient to give them as its companions, antecedents, or consequents? All the difficulty, and the only possible solution, lie here. To resolve the difficulty and effect the solution, elimination is required, that is to say the exclusion, amongst the ten characters, of those which are not thus connected with the presence of the known character. But, as we are not able actually to exclude them, and as, in nature, the character we are in search of is always hidden in a crowd of others, we collect cases which by their diversity entitle the mind to clear away this crowd. We look for indications which may enable us to distinguish between the character we are in search of and superfluous characters. We find three of these indications, and apply them; for greater security, we apply all three of them successively in order that they may correct one another. When the expulsion is accomplished, what remains is the character we are in search of.

In some cases these eliminating processes are ineffectual, namely, in those in which the consequent, though produced by a concurrence of antecedents, cannot be reduced into its elements. Methods of isolation are then impracticable; and, as we can no longer eliminate, we can no longer perform induction.—Now, this grave difficulty presents itself in nearly all cases of motion; for nearly every motion is the effect of a concurrence of forces, and the respective effects of the

* Mill, after describing this method, indicates a fourth, which he terms *the Method of Residues.* It is but another case of the Method of Differences, and is but rarely employed. The three which we have explained had their first origin in Bacon's "Tables of Presence, Absence, and Degrees."

different forces are found so mixea up in it that we cannot separate them without destroying it, and it seems impossible to know what part each force has in the production of the movement. Take a body acted on by two forces whose directions form an angle; it moves along the diagonal; every part, every moment, every position, every element of its movement is the combined effect of the two impelling forces. The two effects are so intimately combined that we cannot isolate either of them to refer it to its origin.—To perceive each effect separately, we should have to consider the motions turned in another direction, that is to say to suppress the given movement and replace it by others. It is the double consequent of a double antecedent, and, as we cannot isolate one or other of its two parts, we cannot isolate one or other of the two parts of its antecedent. Neither the usual method of Agreement or of Difference, nor the subsidiary methods of Residues or of Concomitant Variations, all of which are decomposing and eliminative, can serve us in a case which by its nature excludes all elimination and all decomposition.—We must therefore evade the obstacle, and here it is that *the Method of Deduction*—the last key to Nature—comes in. We commence by borrowing a process from the sciences of construction; we leave the effect, we set to work beside it, we study other simpler cases; we examine various analogous effects or consequents, we connect each to its cause or antecedent by the processes of ordinary induction; then, we form a *construction.* We mentally collect many of these antecedents or causes, and we conclude, from their known consequents or effects, what must be their total consequent or effect. We then verify if the total effect given is exactly similar to the total effect predicted, and, if so, we attribute it to the combination of causes we have fabricated.—Thus, to discover the causes of the motion of the planets, we establish, by simple inductions, first, the law connecting the motion in direction of the tangent with a force of initial impulsion, then, the law connecting the fall of a body towards another with the accelerating force of gravity. From these two laws obtained by induction, we deduce, by calculation, the various positions and velocities which a body would assume, under the combined influences of an initial impulsion and accelerating gravity, and, after verifying that the observed planetary motions coincide exactly with the foreseen motions, we conclude that the two forces in question are actually the causes of the planetary motions. "To the Deductive Method," says Mill, "the human mind is indebted for its most conspicuous triumphs in the investigation of Nature. To it, we owe all the theories by which vast and complicated phenomena are embraced under a few simple laws."—It is only a derivation of the preceding methods; for it starts from a property of the antecedent obtained by those methods. This property is that of being sufficient, that is to say of exciting, by its presence alone, a certain consequent. Therefore, if it be present, the consequent will arise; and, if another antecedent obtained in the same way is also present, its consequent will similarly arise; so that the whole consequent will be mixed and double.—If now the whole consequent observed coincides in all its parts with the whole consequent predicted, we shall say with certainty that the double antecedent supposed is sufficient to cause it to arise, and we shall be able to assume that, in the case in question, this double antecedent in fact exists.—In truth, this will only be a supposition or hypothesis; but it will be the more probable in proportion as the total consequent, being more complex and more multiplex, further limits the number of hypothesis capable of accounting for it; and it will be wholly certain when, as is the case with the motion of the planets, we can demonstrate that no other combination of forces could produce it, that is to say that the double antecedent assumed is not only possible, but alone possible, and therefore, real.

These are the rules: an example will make them clearer; there is one in which we shall see all the methods in exercise

—Dr. Well's theory of Dew. I shall cite the exact words of Mill and Herschel.* They are so clear that we must give ourselves the pleasure of considering them. We must begin by separating dew from rain, and the moisture of fogs, and by defining it as "the spontaneous appearance of moisture on substances exposed in the open air, when no rain or *visible* wet is falling." What is the cause of the phenomenon we have thus defined, and how was that cause discovered?

In the first place, "'we have analogous phenomena in the moisture which bedews a cold metal or stone when we breathe upon it; that which appears on a glass of water fresh from the well in hot weather; that which appears on the inside of windows when sudden rain or hail chills the external air; that which runs down our walls when, after a long frost, a warm moist thaw comes on.' Comparing these cases, we find that they all contain the phenomenon which was proposed as the subject of investigation. Now, 'all these instances agree on one point—the coldness of the object dewed, in comparison with the air in contact with it.' But there still remains the most important case of all, that of nocturnal dew: does the same circumstance exist in this case? 'Is it a fact that the object dewed *is* colder than the air? Certainly not, one would at first be inclined to say; for what is to *make* it so? But . . . the experiment is easy: we have only to lay a thermometer in contact with the dewed substance, and to hang one at a little distance above it, out of reach of its influence. The experiment has therefore been made; the question has been asked, and the answer has been invariably in the affirmative. Whenever an object contracts dew, it *is* colder than the air.'

"Here then is a complete application of the *Method of Agreement*, establishing the fact of an invariable connection between the deposition of dew on a surface, and the coldness

* Mill, "Logic," 4th edition, i. 451–8, citing from Sir J. Herschel, "Discourse on the Study of Natural Philosophy."

of that surface compared with the external air. But which of these is cause, and which effect?—or are they both effects of something else? On this subject, the Method of Agreement can afford us no light: we must call in a more potent method. 'We must collect more facts, or, which comes to the same thing, vary the circumstances; since every instance in which the circumstances differ is a fresh fact: and especially we must note the contrary or negative cases, *i. e.*, where no dew is produced:' a comparison between instances of dew, and instances of no dew, being the condition necessary to bring the *Method of Difference* into play.

"'Now, first, no dew is produced on the surface of polished metals, but it *is* very copiously on glass.' Here is an instance in which the effect is produced, and another instance in which it is not produced. . . . But, as the differences between glass and polished metal are manifold, the only thing we can as yet be sure of is, that the cause of dew will be found among the circumstances by which the former substance is distinguished from the latter. . . . To detect this particular circumstance of difference we have but one practicable method—that of *Concomitant Variations.* 'In the cases of polished metal and polished glass, the contrast shows evidently that the *substance* has much to do with the phenomenon, therefore let the substance *alone* be diversified as much as possible, by exposing polished surfaces of various kinds. This done, a *scale* of *intensity* becomes obvious. Those polished substances are found to be most strongly dewed which conduct heat worst; while those which conduct well, resist dew most effectually.' Hence we conclude that the deposition of dew is in some way connected with the power which the body possesses of resisting the passage of heat.

"'But, if we expose rough surfaces instead of polished, we sometimes find this law interfered with. Thus, roughened iron, especially if painted over or blackened, becomes dewed sooner than varnished paper; the *kind of surface*, therefore, has a great influence. Expose, then, the *same* material in very diversified states as to surface,' (that is, employ the Method of Difference to ascertain concomitance of variations,) 'and another scale of intensity becomes at once apparent; those *surfaces* which *part with their heat* most readily by radiation, are found to contract dew most copiously.' Hence we conclude that the deposition of dew is also in some way connected with the power of radiating heat.

"'Again, the influence ascertained to exist of *substance* and *surface* leads us to consider that of *texture*: and here, again, we are presented on trial with remarkable differences, and with a third scale of intensity, pointing out substances of a close firm texture, such as stones, metals, etc., as unfavorable, but those of a loose one, as cloth, velvet, wool, eider-down, cotton, etc., as eminently favorable to the contraction of dew.' Looseness of texture, therefore, or something which is the cause of that quality, is another circumstance which promotes the deposition of dew; but this third cause resolves itself into the first, viz., the quality of resisting the passage of heat; for substances of loose texture 'are precisely those which are best adapted for clothing, or for impeding the free passage of heat from the skin into the air, so as to allow their outer surfaces to be very cold, while they remain warm within.'

"It thus appears that the instances in which much dew is deposited, which are very various, agree in this, and, so far as we are able to observe, in this only, that they either radiate heat rapidly or conduct it slowly: qualities between which there is no other circumstance of agreement, than that by virtue of either, the body tends to lose heat from the surface more rapidly than it can be restored from within. The instances on the contrary, in which no dew, or but a small quantity of it, is formed, and which are also extremely various, agree (as far as we can observe) in nothing except in *not* having this same property." We can now revert to our previous inquiry, as to whether the coldness was the cause of dew, or its effect. "This doubt we are now able to resolve. We have found that, in every such instance, the substance on which dew is deposited is one which, by its own properties or laws, would, if exposed in the night, become colder than the surrounding air. The coldness, therefore, being accounted for independently of the dew, while it is proved that there is a connection between the two, it must be the dew that depends on the coldness; or, in other words, the coldness is the cause of the dew.

"This law of causation, already so amply established, admits, however, of efficient additional corroboration in no less than three ways. First, by deduction from the known laws of aqueous vapor when diffused through air, or any other gas. . . . It is known by direct experiment that only a limited quantity of water can remain suspended in the state of vapor at each degree of temperature, and that this maximum grows less and less as the temperature diminishes. From this it follows, deductively, that if there is already as much vapor suspended as the air will contain at its existing temperature, any lowering of that temperature will cause a portion of the vapor to be condensed, and become water. But, again, we know deductively, from the laws of heat, that the contact of the air with a body colder than itself, will necessarily lower the temperature of the stratum of air immediately applied to its surface; and will therefore cause it to part with a portion of its water, which accordingly will, by the ordinary laws of gravitation or cohesion, attach itself to the surface of the body, thereby constituting dew. This deductive proof has the advantage that it accounts for the *exceptions* to the occurrence of the phenomenon, the cases in which, although the body is colder than the air, yet no dew is deposited; by showing that this will necessarily be the case when the air is so under-supplied with aqueous vapor, comparatively to its temperature, that even when somewhat cooled by the contact of the colder body, it can still continue to hold in suspension all the vapor which was previously suspended in it: thus in a very dry summer there are no dews, in a very dry winter no hoar-frost.

"The second corroboration of the theory is by direct experiment, according to the canon of the Method of Difference. We can, by cooling the surface of any body, find in all cases some temperature at which dew will begin to be deposited. We can, it is true, accomplish this only on a small scale; but we have ample reason to conclude that the same operation, if conducted in Nature's great laboratory, would equally produce the effect.

"And finally, even on that great scale we are able to verify the result. The case is one of those rare cases, as we have shown them to be, in which Nature works the experiment for us in the same manner in which we ourselves perform it; introducing into the previous state of things a single and perfectly definite new circumstance, and manifesting the effect so rapidly that there is not time for any other material change in the pre-existing circumstances. 'It is observed that dew is never copiously deposited in situations much screened from the open sky, and not at all in a cloudy night; but *if the clouds withdraw even for a few minutes, and leave a clear opening, a deposition of dew presently begins*, and goes on increasing.' . . . The proof, therefore, is complete, that the presence or absence of an uninterrupted communication with the sky causes the deposition or non-deposition of dew. Now, since a clear sky is nothing but the absence of clouds, and it is a known property of clouds, as of all other bodies between which and any given object nothing intervenes but an elastic fluid, that they tend to raise or keep up the superficial temperature of the object by radiating heat to it, we see at once that the disappearance of clouds will cause the surface to cool; so that Nature, in this case, produces a change in the antecedent by definite and known means, and the consequent follows accordingly: a natural experiment which satisfies the requisitions of the Method of Difference."

§ II. LAWS CONCERNING POSSIBLE THINGS.

I. We see that this process is of considerable length; for it requires the collection, selection, and comparison of many instances. Further than this, it usually happens that the more general the law, the more time is required to obtain it; for it requires the preliminary discovery of many partial laws; Newton, Geoffroy, Saint-Hilaire, Dalton, Faraday are but the successors of many others, and the most extensive inductive law we are acquainted with, that which states the Conservation of Force, is of yesterday's discovery.* Again, however well-established and verified one of these laws may be, if we wish to apply it outside of the little circle of space and short fragment of duration to which our observations are limited, it becomes probable only. It is not absolutely certain that the Law of Gravitation continues to hold good, beyond the furthest nebulæ of Herschel. It is not at all certain that, in the sun, hydrogen and oxygen preserve the chemical affinity which we find they have here with us. It is possible that the intense temperature in the sun, that some unknown circumstance beyond the furthest nebulæ, may intervene to alter or annul these laws. Consequently, on considering the proposition enouncing it, we find, on the one hand, that its acquisition is tardy, on the other, that its application is limited.

II. Such are the distinctive characteristics of the general proposition whose component ideas, being formed by extraction and gradually adjusted to the general characters of real things, are bound to correspond with their object.—Very different are the distinctive characteristics of the general propositions whose component ideas, being formed by construction, are not subject to a similar obligation. Such are the ideas of arithmetic, of geometry, of pure mechanics, of all

* See, as to the order of these discoveries, the valuable work of Dr. Whewell, on the "History of the Inductive Sciences."

the mathematical sciences, and, more generally, of all the deductive sciences. The propositions of these sciences are not merely probable, but certain beyond our little world; at all events, we believe it to be so, and, moreover, are unable to believe or conceive that it is otherwise. Even beyond the furthest nebulæ, two facts or objects added to three facts or objects of the same class make five facts or objects of the same class; if a triangle be found there, its angles are, as with us, together equal to two right angles; if a body be impelled by two forces whose directions form an angle, it will move, as with us, along their diagonal. At all events, whatever effort we may make to conceive the contrary, we cannot do so; the two component ideas of the proposition, once well understood, form in our mind an indissoluble couple whose terms, in themselves, refuse separation.—Besides, the most general of these propositions are the ones which are first discovered; for it is by their means that we prove the less general ones. Looked at geometrically, the idea of a solid is less general than that of a surface, and that of a surface less general than that of a line, since the solid is constructed with surfaces, and the surface with lines, whence it follows that we find, mentally at least, if not in nature, the surface without the solid, and the line without the surface, but never the solid without the surface, or the surface without the line; so that the surface occurs more frequently than the solid, and the line more frequently than the surface. Now we all know that, to establish propositions relating to solids, we must first establish those relating to surfaces, and that, to establish propositions relating to surfaces, we must first establish those relating to lines.—Finally, among the most general of these propositions, there are certain ones, called axioms, which we do not demonstrate, and by which we demonstrate the rest. We fix them at the head of every science, like hooks from which the other propositions may depend. These others are so many links, forming one or more chains; each link in them is hung from the one preceding it, and sustains the one succeeding it; but the supports which bear the whole are two, three, or four expressed or implied propositions, placed at the summit. If we do not demonstrate them, it is because we pronounce them evident in themselves; at least, it seems to the attentive reader that he requires no proof to admit them, but that it is enough for him to understand them. As soon as the two component ideas of the proposition are clear to his mind, they become mutually attached there, and form a couple; this reciprocal consolidation is instantaneous; every one sees at first sight that, among all the lines drawn from one point to another, the straight line is the shortest. So, too, in every other deductive science, there are certain primitive ideas which, once present in the mind, become fitted to one another as speedily, with as invincible a link, with as uncontested authority. Here, indeed, are propositions fashioned in a strange way, and these are what we are now about to examine.

III. For propositions of this kind, there are two kinds of proof: the one, experimental, inductive, approximative, and slow; the other analytical, deductive, precise, and short; it is this last of which we avail ourselves in all the sciences of construction.—The better to mark out the characters and contrasts of these two kinds of proofs, the reader must allow me to make a supposition. Take a proposition closely bordering on an axiom, that truth of elementary geometry that, in every triangle, the sum of the angles is equal to two right angles. Let us imagine a man not a geometrician, and incapable, by the structure of his brain, of becoming one, but very patient, very precise, and very skilful at induction. I put in his hand a semicircle divided into minutes and degrees so as to measure angles; I trace before him a number of triangles; I teach him to trace others, and I ask him to investigate whether, in all these triangles, the sum of the angles is not equal to a certain number of right angles.—For several days, he applies his semicircle to the angles of three or four hundred triangles; in each case, he observes by his semicircle the magnitudes of the three angles, and, by adding their values, invariably finds that their sum amounts to 180°, that is, to two right angles. This interests him, and he attempts to discover the partial laws of which this law, obtained by the collection of agreements, is the total.—He first takes triangles having one right angle; the sum of the other two angles is then equal to one right angle, and it will be easier to find the circumstance which causes this equality. He goes to work again with his semicircle, and proves that, as the first of these two angles approaches a right angle in magnitude, the second of them differs from a right angle in magnitude, so that the diminution of the one is compensated by the augmentation of the other, and that, by means of this perpetual compensation, the sum of the two angles is always equal to a right angle.—He then takes other triangles having an angle of the same magnitude; then, measuring this angle, he calculates by subtraction the value which the two other angles must together have to form with it a magnitude equal to two right angles. Then applying once more his semicircle, he proves that, whenever the first of these two angles approaches the required amount, the second proportionately differs from it, in such a way that, the loss being equal to the gain, the sum of the two angles is always equal to the required magnitude.—Thus, in all triangles, when one angle is given, the diminutions or augmentations which one of the two remaining angles may undergo are compensated by equal augmentations or diminutions of the other remaining angle; and compensated in such a way that the total magnitude of the two remaining angles is the magnitude requisite to form with the given angle a number of angles equal to two right angles.—When this is effected, our inquirer has found a fixed connection between the values of the second and third angle, another fixed connection between the sum of these values and the value of the first angle, and, by these two connections, he explains the whole value of the three angles. But he has reached his limit, he can go no further. Besides this, after all these measurements, additions, subtractions, and recapitulations, he has grounds of doubt; he must ask himself whether the triangles he has drawn are absolutely perfect, if the divisions of his semicircle are strictly equal, whether, in applying his semicircle to the angles, he has made the lines of division coincide exactly with the sides of the angles. Let him use a powerful microscope; he will find that in very few cases are these conditions fulfilled, and he must suppose that, if the microscope were more powerful, he would not find them fulfilled in any case. Therefore, all he can affirm is that, in triangles apparently perfect, the sum of the three angles is apparently equal to two right angles.—Now, let the geometrician come in; he draws one triangle only; in fact, he does not busy himself with this or any other figured triangle; his object is any triangle whatever; he expressly tells us this; to him, the apparent figure is but a means of more readily effecting a mental construction; his eyes follow on the board or paper ideal lines, to which the physical marks do but approximately correspond. He completes his mental construction and his apparent figure, by drawing through the vertex of the triangle and parallel to the base, on the one hand, an ideal line, on the other, a physical mark, so that between this mark and line there is a rough correspondence. Having completed his mental construction, he resumes his definitions of the triangle and of parallel lines, he observes their elements, he follows with his finger these elements in the approximating mark, he finds in one or more of them the property he is in search of, and thus proves the theorem by the analysis of his definitions.

Axioms are analogous theorems, but we dispense with their proof, either because it is very easy or because it is very difficult. In other words, they are *analytical* propositions, the subject of which contains the attribute, either, in a very evident manner, which renders the analysis useless, or, in a very hidden manner, which renders the analysis almost impracticable. Hence there are two kinds of axioms, which border on one another by transitions.

At the foot of the scale are some which seem insignificant; this arises from the required analysis being completely effected; the terms of the attribute are found before-hand in the terms of the subject; the reader does not find the proposition instructive; he says that he has been told the same thing twice over. Such are the celebrated metaphysical axioms of *identity* and *contradiction*.—The first may be thus expressed: if, in an object, there be a certain datum present, that datum is present.—The second may be formulated thus: if, in an object, there is a certain datum present, that datum is not absent; if, in an object, there is a certain datum absent, that datum is not present.—As the words, *present* and *not absent*, *absent* and *not present* are synonymous, it is plain that in the axiom of contradiction as well as in the axiom of identity, the second half of the phrase repeats a portion of the first; it is a repetition; we have manœuvred without gaining ground.—Thence we get a third metaphysical axiom, that of the *alternative*, less empty than the preceding ones; for a short analysis is required to prove it; we may enounce it in these terms: in every object, a particular datum is either present or absent.—In fact, suppose the contrary, that is to say, that the datum may be neither absent nor present in the object. Not absent, means that it is present; not present, means that it is absent; the two together mean, then, that the datum is at once present and absent in the object, which is contrary to the two branches of the axiom of contradiction, to the one which says that, if a particular datum is present in an object, that datum is not absent, and to the other which says that if a particular datum is absent from an object, that datum is not present.—Let us now resume the axiom of the alternative, and observe the attitude of the mind which comes across it for the first time. It is implied in a heap of propositions, which we explicitly admit, because we impliedly admit the axiom. For instance, some one tells us that every triangle is equilateral or not; every vertebrate animal is a quadruped or not. Without examining any triangle or any animal, we necessarily recognize that these propositions are true ; the alternative is inevitable and cannot be evaded. And yet, in most cases, we have not the proof at hand. We have not made the foregoing analysis; we could not show, as has been shown above, the series of links by which the proposition is reduced to the axiom of contradiction. We have not disengaged and followed, as just now, the very abstract ideas which, by their delicate and continuous network, fasten together the two elements of the proposition. What does this mean, except that, in the absence of a clear view of this consolidation you have a confused sentiment of it, and that the connection exists between the two elements of your thought without your being able to fix precisely on the points of connection?—We see daily this effectiveness of latent ideas; we feel that a certain person could not have acted in a particular way, that certain conduct would be inopportune, that a certain action is right or blamable, and most frequently we cannot say why; nevertheless, there is a why, a secret reason; this reason is an idea, an idea included in the total conception which we have formed of this person, this conduct, this action; it exists in the total conception like a segment not marked out in a circle, like a grain of lead in a pound of lead; it is active in the conception just as its associated elements; together they form a mass which, coming in contact with another mass, shows sometimes an affinity resulting in union, sometimes a repugnance resulting in separation. Later on, by reflection, we disintegrate this mass; by means of abstract words, we isolate its component ideas; we find one among them which explains to us the involuntary junction or insurmountable incompatibility of our two conceptions.—That there are some demonstrating ideas included in the terms of the preceding axiom, we cannot doubt, since we have just detected them and arranged them in proof. That undetected ideas may and must act in the latent state to unite or sever two conceptions in which they are included, is certain, since we are daily witnesses of the fact. We may conclude, then, that the mental consolidations and repulsions proved respecting the preceding axiom, have as their cause the concealed presence of the latent ideas which we just now detected, and we may conjecture that, in all similar axioms, it is the same cause which produces the same effect.

IV. It would be too long, and moreover useless, to analyse them all. Let us apply ourselves to those which are the most fruitful, and which serve for the construction of whole sciences.—At the head of arithmetic, algebra, and geometry, are inscribed the two following axioms: if equal magnitudes be added to equal magnitudes, the wholes are equal; if equal magnitudes be taken from equal magnitudes, the remainders are equal.—No doubt we may form these two propositions by ordinary induction, and, most probably, it was in this manner that they were first established in our mind. Take two flocks, each of twenty sheep, in separate inclosures; they may be increased or diminished in number; they are, then, magnitudes. I drive fifteen sheep into the first inclosure, and fifteen other sheep into the second; I then count the two flocks so increased, and find that, in each field, there are thirty-five sheep. I then take seventeen sheep from the first inclosure, and seventeen others from the second; I then count the two flocks so diminished, and find that, in each field, there are eighteen sheep.—As often as I have performed similar operations, under similar conditions, upon any number of any kind of animals, or, more generally, upon any collection of any distinct objects or facts, I have verified that the result was similar. The same observation is made when the collection is no longer composed of natural individuals, like a sheep, a pebble, or of facts naturally distinct, like a sound, a blow, a sensation, but of artificial individuals, like a metre, a litre, a gramme, or of facts artificially divided, like the successive parts of a continuous movement. For instance, here are two vessels in each of which are six litres of water; I pour three litres of water into the first, and three litres of water into the second; I then measure the two quantities of water so increased, and find, in each vessel, nine litres of water. I then draw five litres of water from the first vessel, and five litres from the second, and find there is left, in each vessel, four litres of water.—Each of these cases is an experiment. A child does the same with marbles; if he has counted two large equal heaps, and adds to them two little heaps which he has also counted and found equal, and finds, on counting, that the whole heaps are equal, this will be a discovery for him, and I imagine that he will be as much delighted at it as a physicist who has observed for the first time some unknown phenomenon.—After many similar experiments, we are able inductively to conclude, by the method of Agreement, that equal magnitudes added to equal magnitudes give equal sums, and that equal magnitudes taken from equal magnitudes give equal remainders. For if sometimes, as in the experiment made with vessels of water, the sums or remainders are not rigorously equal, we may legitimately attribute this inequality to the inaccuracy of our preliminary measures or the awkwardness of our subsequent manipulation, since the more accurate our measures and the more skilful our manipulation, the smaller does the inequality become.—Besides, to strengthen our conclusion, we have at hand another inductive method, that of Difference. As soon as we suppress the equality of the primitive magnitudes or of the added magnitudes, the equality of the obtained *wholes* disappears. As soon as we suppress the equality of the primitive magnitudes, or of the magnitudes taken away, the equality of the subsisting *remainders* disappears. These two first equalities, then, are the antecedent of the third, as the third is the consequent of the two first; and we have a couple in which the two terms, obtained like cooling and dew, are connected, like cooling and dew, without exception and without condition.

But the two axioms thus formed may also be formed in another manner. In fact, let us lay aside experience, let us close our eyes, and shut ourselves up in the confines of our own mind; let us examine the terms which make up our propositions; let us attempt to find out what it is we mean by the words magnitude and equality, and let us see what mental constructions we form, when we fabricate the idea of a magnitude equal to another.—Here we must distinguish between artificial magnitudes in which the units are natural, and natural magnitudes in which the units are artificial. Let us examine them in turn, and first as to natural magnitudes which we also term collections.

Take a collection of similar individuals, some flock of sheep, or a collection of abstract units, some mental group of pure units, pictured to the eye by the same sign many times repeated. We call these collections magnitudes; and, if we give them this name, it is because, they are capable of becoming greater or smaller, while retaining their nature; we mean to say by this that we may, in fact or by thought, add to the flock one or more sheep, add to the group one or more units, take from the flock one or more sheep, take from the group one or more units. Let us now compare one of these collections with another analogous collection* and make correspond, in thought or otherwise, a first object of the first with a first object of the second. a second with a second, and so on till one of the two be exhausted. Two cases present themselves. Either the two collections are exhausted together; the number of sheep is then the *same* in the first and in the second flock, the number of units is the *same* in the first and in the second group; and in this case we say that the two magnitudes are *equal*. Equality, then, means presence of the same number.—Or one of the two collections is exhausted before the other; the number of sheep is then different in the first and second flock, the number of units is different in the first and second group; and in this case we say that the two magnitudes are unequal. Inequality, then, means presence of two *different* numbers.

* Duhamel, "De la Méthode dans les Sciences de Raisonnement," i. 3.

Now, for these kinds of magnitudes, we are able to prove the axiom. Let there be two equal magnitudes to which we add equal magnitudes. According to the foregoing analysis, this means that the first collection contains a certain number of individuals or of units, that a certain number of them is added to it, that the second contains the *same* number of individuals or of units as the first, that the *same* number of them is added to it as to the first, that, in the two cases, the same number is added to the same number, and that, therefore, the two final collections contain the same number added to the same number, that is to say, the *same total number* of individuals or of units, whence it follows, from the definition, that the two sums or final magnitudes are equal magnitudes.—And so again let there be two equal magnitudes, from which we take two equal magnitudes: according to the same analysis, this means that the first collection contains a certain number of individuals or of units, that a certain number of them are taken from it, that the second contains the *same* number of individuals or of units as the first, that the *same* number of them are taken from it as from the first, so that in the two cases the same number is diminished by the same number, and that, therefore, the two final collections contain the same number diminished by the same number, that is to say, the *same remaining number* of individuals or units; hence it invariably follows, from the definition, that the two remainders or final magnitudes are equal magnitudes.

From artificial magnitudes, let us pass to natural. The most important of these are the geometrical, since they serve as measures for all the rest: times, velocities, forces, masses, etc. These geometrical magnitudes are lines, surfaces, solids; and, if we term them magnitudes, it is because they may become greater or less; we mean to say that, in fact or mentally, we may add a line to a line, a surface to a surface, a solid to a solid. Let us now compare a line with a line, or a surface with a surface, and apply, in thought or otherwise, the second to the first, taking care in doing so not to alter the second in any way. Here, as before, two cases present themselves.—Either the second coincides exactly and completely with the first, so as to become absolutely confounded with it; in this case, the two lines form only one and the *same* line; we then say that the two magnitudes are equal. To say, then, that two magnitudes are equal, is to say that after the application, in other words, when omission and abstraction are made of the two distinct positions, the two lines, surfaces, etc., are the *same*.—Or else, the second line does not exactly and completely coincide with the first; in which case the two lines, not being confounded, remain *different*, we then say that the two magnitudes are unequal. To say, then, that two magnitudes are unequal, is to say that after the application, in other words, when omission and abstraction is made of their two distinct positions, the two lines, surfaces, etc., are different.

Now we can also prove the axiom for these kinds of magnitudes. Let there be two equal magnitudes added to two equal magnitudes. According to the foregoing analysis, this means that a certain primitive line, surface, etc., is given, that a complementary one is added to it, that a second primitive line, when its distinct position is omitted, is the *same* as the first line, that to it is added a complementary line, the *same*, except as to its distinct position, as the other complementary line, that in the two cases, when abstraction is made of the distinct positions, the same line is added to the same line, and that, therefore, the two completed lines are the same line added to the same line, that is to say, the *same total line*, hence it follows, from the definition, that the two sums or total magnitudes are equal.—And so again, let two equal magnitudes be taken from two equal magnitudes. According to the same analysis, this means that a certain primitive line, surface, etc., is given, that a portion of it is cut off, that a second primitive line is, when its position is omitted, the *same* as the first, that from it is cut off a portion, which, except as to its distinct position, is the *same* as the other portion cut off, that, in the two cases, when abstraction is made of the distinct positions, the same line is taken from the same line, and that, therefore, the two diminished lines are the same line diminished by the same line, that is to say, the *same remaining line*, hence, it follows, from the definition, that the two remainders or final magnitudes are equal.—We might demon strate in the same way a third axiom, which is true of nat ural magnitudes as well as of artificial, that is to say, that twc magnitudes each of which is equal to a third magnitude are equal to one another.

Let the reader take the pains to examine the artifice of this proof. By thought, and with the auxiliary confirmation of sensible facts, we make two artificial magnitudes correspond, feature for feature, or we make two natural magnitudes coincide, element for element; if this correspondence or coin cidence are absolute, the idea of equality arises in us. We have watched its birth and distinguish its foundation; it comprises a more simple element and is reduced to the idea of *sameness;* in fact, in a certain aspect, when what it is necessary to omit is omitted, the two magnitudes become *the same.* Consequently, in the inverse aspect, when what it is necessary to add is added, the same magnitude is transformed into two *equal* magnitudes. Cut away from the two magnitudes their distinctive characteristics, from the two equal artificial magnitudes the property of belonging to two distinct collections, from the two equal natural magnitudes the property of having distinct positions; they become *the same magnitude.* Conversely, take the same magnitude twice and attach it successively to two distinct collections or to two distinct positions; it will be transformed into *two equal magnitudes.* Under the word *equal* dwells the word *same;* here we have the essential word; this is the latent idea included in the idea of equality When severed and followed through several intermediate propositions, it reduces the axiom to an analytical proposition. By means of it we connect the attribute to the subject; we see the idea present in both; but, before we saw it there, we had a presentiment that it was there; it was actually there, and evidenced its presence by the constraint it exercised on our affirmation; though not detected, it performed its office; We felt indeed that two magnitudes being equal might, by that alone, be substituted for one another, that, therefore, the aukmentation or diminution undergone by the second might be substituted for the corresponding augmentation or diminution undergone by the first. We divined with certainty, but without the power of stating the matter precisely, that in the two data and in the two operations, there was *something of the same;* the analysis has only isolated this same thing, and has shown us in a distinct state the virtue it possessed in us in the latent state.

V. There are twelve axioms of this kind at the commencement of Euclid's geometry; many of them are reduced to preceding ones; others, comprising the ideas of whole, of part, of greater, of less, are easily demonstrated from the preliminary definition of these terms.* The last and more important ones deserve to be studied apart; they are the ones concerning the straight line and parallel lines. Let us first observe that the usual definition of the straight line is a bad one; we say that it is the shortest which can be drawn from one point to another. This is not a primitive property, but a derived property; we do not, in conceiving it, watch the generation of the line; we do not possess the elements of the mental construction; we do but hold one of its consequences. Besides, "this definition† reduces a notion to others which we do not possess and which are much less simple than the first. What in fact do we understand by a line being less short or greater than another? It is that this line is made up of a part *equal* to the first and of a remainder of some kind. Now, two equal lines are those which may coincide, and con-

* Read as to this, Duhamel, op. cit. ii. 3-6.—Equal angles are defined by the coincidence of their sides; the perpendicular by the equality of the two adjacent angles it makes; the right angle by the perpendiculars, which form its sides.

† Duhamel, op. cit. p. 7.

sequently, equality cannot be conceived between two lines whose figure does not admit of superposition," which is the case with the straight line referred to the other indefinitely numerous broken or curved lines with which it would be necessary to compare it in order to verify that it is shorter than any of them. This is not the way in which the acute and subtle Greek analysts have defined the straight line; Euclid does not admit at the outset that it is the shortest line between two points; he proves it later on, by comparing triangles of which it forms a side, which prove it to be shorter than any broken line, then, by extending the case of the broken line to that of the curve which forms its limit.—We must seek then for another definition, and, according to our custom, watch its construction. Now we constructed it by considering two given points, and by observing the line described by the first point when it moves towards the second and towards the second only, as opposed to the line described, when, before moving towards the second, it moves towards another or several other points, which produces a broken line, or, towards an infinite series of other points, which produces a curved line. We thus see that, in the straight line drawn from a point, the whole line, that is to say the straight line itself, being solely and completely determined by its relation with one second point alone, all its characters, whatever they may be, known or unknown, are solely and completely derived from the relation it has with this second point alone.

Hence, two consequences, one relating to the whole line, the other relating to its various parts.—If we start from the same first point, and trace another line which also moves towards the same second point, and towards this only, this second line does but exactly repeat the first; for all its characters, like all those of the first, are completely and solely derived from the relations which, like the first, it has with this second point alone; hence we see that the characters of the two lines, whatever they may be, known or unknown, are all absolutely *the same*, in other words, that these two lines are confounded together and form but one:* this we express in various ways, by saying that between two points we can only draw one straight line, that two points are sufficient to determine the interposed straight line, that two straight lines having two points in common coincide in all their intermediate extent, and from this, we easily deduce that two straight lines which cut one another cannot enclose a space.†—So much for the whole line; let us now consider its various parts. Since the entire line described is completely and solely determined by its relation to the second point and derives thence all its characters, each of its constituent portions is solely and completely determined by the same relation and also derives thence all its characters, excepting one, namely —the property of being one particular portion and not another, situated at some spot or other of the line, at its commencement, its middle, or its end. Consequently, if we make abstraction of this particularity, all the portions of the line have exactly the same characters, in other words, they are the *same*. Let us effect this abstraction, and, for this, suppress the particular position of a fragment of the line, by taking it from the spot at which it is, for instance the end, by transferring it elsewhere, for instance to the beginning, and there applying it to the whole line. It will be confounded with the portion on which it is applied, and the two fragments will make one only. Hence it follows that any portion of the straight line, taken from its position and applied to any other portion of the whole line, will rigorously coincide with the portion to which it is applied.‡

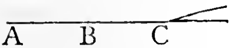
When this is settled, we know the relation of *any* portion *whatever* of the straight line to *any* other portion *whatever*

* An entirely analogous demonstration shows that two circumferences whose radii are equal become confounded into one single one.

† This last proposition is the 12th axiom of Euclid.

‡ An analogous demonstration shows that, in the same circle or in equal circles, any arc transferred from its place, will exactly coincide with the portion of circumference on which it may be placed. This arises from the circumference being, like the straight line, a uniform line.

of this same line, and are consequently able to follow it, beyond the two points through which we have drawn it, up to an infinite distance. In fact, take a straight line A B, prolong it to any distance beyond the point B, put in such a way that it remains straight, that is to say in accordance



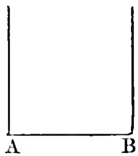
with the preceding condition, in such a way that any one of its portions may coincide with any other of its portions, therefore with all those which are comprised in its prolongation. Now, suppose a second straight line traced from A to B, and also prolonged to any distance; we have already proved that between A and B it will coincide with the first, but we must further prove that, beyond B, however far we may prolong it, it will coincide with the prolongation of the first line. For, let us assume that at some point or other it ceases so to coincide, and that, on leaving the point C, for instance, it diverges above or below the first; then let us take a portion of the line drawn common to the two lines, A B for instance, and apply it to the first line, at the point C, so that it may extend beyond that point in both directions. Since the first line is straight, this portion will coincide on both sides of C with a fragment of the first line to which it has been applied. Since the second line is assumed to be straight, this same portion must also coincide on both sides of C with the fragment of the second line to which it has been applied. But this is contradictory, since beyond C, the second fragment diverges from and ceases to coincide with the first. There is, then, a contradiction in the second line being straight and ceasing to coincide with the first. Its divergence excludes its straightness, and its straightness its divergence. If it has ceased to coincide with the first, it is from its having ceased to be straight; in order for it to remain straight, it must continue to coincide with the first; in order for it always to remain straight, it must always continue to coincide with the first. Consequently, two straight lines which have two points in common coincide throughout all their extent, to whatever distance they may be prolonged; or again, two points are sufficient completely to determine in a straight line, not merely the portion joining them, but also the whole entire line prolonged to any distance in both directions.

"The definition and properties of the straight line," said D'Alembert,* "are the stumbling-block, and, so to speak, the scandal of elementary geometry." If I am not mistaken, we have now seen that this scandal may disappear, and that the assumed axioms are theorems capable of proof. According to D'Alembert, parallel lines present an analogous difficulty. It is rash, no doubt, to approach an obstacle which great minds and specialists have pronounced unsurmountable or unsurmounted; but here, happily, it is less a question of discovering a demonstration than of analyzing a construction; we are doing the work of psychologists rather than of geometricians; we are simply searching for the inner secret process by which, beneath the accessory and insufficient testimony of the eyes, we base the unshakable conviction of the mind.—How do we form the notion of two parallel lines? The usual method is, to erect a perpendicular at any point of a straight line lying in a plane, and another perpendicular at another point; these two perpendiculars are said to be parallel to one another.†—Now, what is there primitive in this construction? Nothing, except that we suppose two straight lines, each of them perpendicular to a third line, denoting by the name perpendicular the straight line which, standing on another straight line, makes the adjacent angles equal to one another; it is from this construction that all the properties of parallels must be deduced.—Now, what are these properties? We perceive that, in these two perpendiculars compared to one another, there is something the *same*; in fact, each of them forms with the base the two same right angles; and, in consequence, one of the two with its angles, applied to the other, will coincide

* Mélanges.—Eclaircissements sur les Eléments de Philosophie, v. 207.

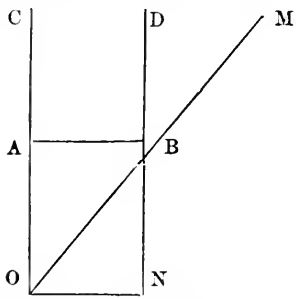
† D'Alembert proposes another construction, very analogous, but somewhat less simple.—Op. cit., p. 202.

completely with the other and its angles. They are, then, except in one circumstance alone—their position at two different points of the base—*the same;* and this partial identity, provided we know how to follow it, must be manifested by precise consequences.—Let us conceive the whole portion of the base intercepted by their feet to mount, with uniform motion, remaining rigid and in such a way that one of its elements traces, in rising, a perpendicular to the base. Since it is a straight line, all its elements are similar; except in their distinct position, they are, as we have seen, the *same* element: hence, it follows that, in their common ascent, they will all of them trace similar straight lines—that is to say, the *same* with the exception of their distinct position; hence, it finally follows that, as one of these lines is perpendicular, all the rest will be. This is why, if the extremity A traces a perpendicular in its ascent, the extremity B will trace another, and the line A B will, in its ascent, have traced two perpendiculars at A and B. But since it is always the same line A B which ascends, it will be everywhere the *same* at all points of its course, and as it is this line which measures the distance of the two perpendiculars, this distance will always be the same at all points of the course. Hence it follows that the distance of the two perpendiculars invariably remains the same, and has as its measure the portion of the base intercepted by their feet; hence it follows, *à fortiori,* that the two perpendiculars, having a distance invariably between them, will never meet.



This is, in my opinion, the secret mental operation which sustains and clears up the evidence of our senses, when we prove, or imagine that we prove, by the eye that the two perpendiculars will always maintain the same distance from one another. We have better reason for admitting this, than the approximately equal durations of the sensations experienced through our ocular muscles. We have no need to apply repeatedly the same measure to one of the perpendiculars, to note with a pencil the distance indicated by the first measurement, to compare it with those indicated by subsequent measurements, and to verify, by recapitulation, that all the measurements agree in indicating equal distances. The mind admits this equality on the spot, but because it has itself created the equality, it creates the equality by causing *the same* intact line to ascend, and also to descend; it is vaguely conscious that, at the commencement and conclusion of its construction, this line is the *same;* this is the silent reminiscence which is added to the suggestion of the eye and anticipates the verifications of the measure, to render useless the employment of the measure, and to confirm, by stronger evidence, the insufficient testimony of the eye.

Such is not the case with the second principal proposition relating to parallel lines, and which is termed Euclid's postulate. It is in fact a postulate, and not an axiom. It



consists in saying that, if a line M B cuts obliquely the first parallel D N, it will also meet the second parallel O C.—We have no difficulty in seeing the necessary and sufficient condition of this meeting. It is necessary and sufficient for the cutting line when prolonged beyond B to become sufficiently distant from the first parallel for a perpendicular N O, erected from its meeting to a point N, to be equal to A B the distances of the two parallels. Will the line cutting the first parallel become sufficiently distant from it for this?—We have no difficulty in showing that its distance increases in proportion as it is prolonged; for if, at any moment, this distance were to diminish or to cease to increase, any two subsequent points taken upon the line would be at an equal distance from the first parallel line, and, as two points are sufficient to determine a straight line, the cutting line would be confounded with a third parallel passing through these two points, which is impossible, since, by the previous proposition, two parallels cannot meet, and since, by hypothesis, our oblique line meets the first parallel. In proportion, then, as the cutting line is prolonged, it becomes more distant from the first parallel, and the perpendicular which measures this distance is a continually increasing magnitude.—But our question still subsists. Will this increasing magnitude ever, in fact, increase sufficiently to equal a very great magnitude, and especially, any magnitude of any extent we please, as the distance of the two chosen parallels may be? Reduced to these precise terms, the proposition leaves us in a certain hesitation; no doubt, at first sight, seeing an oblique line sensibly inclined, and two parallels moderately distant, we decided that the oblique line, having met the first, would meet the second; the point of junction was at no great distance; we could perceive it with our eyes, or note it beforehand by imagination; on these indications, we have inductively concluded with a show of truth that, however small may be the degree of inclination, and however great the distance, the proposition will invariably be true. But, if we suppose the distance equal to the line which joins a fixed star to the earth, and the inclination simultaneously reduced to the hundred millionth part of a second, our eyes no longer avail us, our imagination fails, and we are disturbed. We become still more so, if we recollect that we may further increase the distance and diminish the inclination beyond these enormous figures, and so on indefinitely. We become still more unsettled when we observe that certain magnitudes increase indefinitely, without ever being able to attain a certain limit, that however enlarged and swollen, they invariably remain below a given magnitude, that the series $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}$ etc., always remains less than 2, and that perhaps our perpendicular is in the same position.—We must employ a more delicate analysis. Let us attempt it. We have here no difficulty in observing that the point N becomes distant from the point B in proportion to the diminution of the angle made the oblique line with the first parallel. We further observe that, the angle remaining the same, the point N becomes distant from the point B in proportion to the increase in the distance of the parallels; then, combining these observations, we conclude that B N is a magnitude whose variations depend on the variations of two other magnitudes. It would be necessary to give precision to this double dependence, and for this purpose to seek a fixed relation, not between the three magnitudes, but between their parts, elements, or fractions. In other words, it would be necessary to find in what proportion B N would be increased by halving the angle, and then, in what proportion B N would be increased by doubling the distance of the parallels, and consequently, in what compound proportion the halving the angle and simultaneous doubling the distance would together increase B N. If we could determine exactly this relation, not only should we be able to affirm that, the angle being diminished as much as we please, and the distance increased as much as we please, the oblique line would always meet the second parallel; but more than this, when given the angle and the distance, we should be able to say what would be the length of B N, and consequently, to mark on the second parallel the precise point at which the oblique line would meet it.—Unfortunately, the trigonometrical formulæ which lead us to this are themselves founded on the supposition that the oblique line meets the second parallel. We are unable, then, to avail ourselves of them, and Euclid's postulate remains a postulate, that is to say a proposition which we are willing to admit by tolerance, but which we are not forcibly compelled to give our adhesion to, and it is the opinion of the greatest authorities among geometricians, that the various demonstrations which have been attempted, though sufficient to induce our assent, have not the analytical rigor appertaining to theorems and to axioms strictly so called.

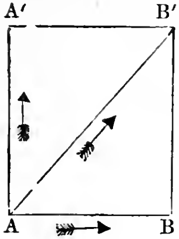
VI. The reader now sees how axioms are formed. Not only is the experience of the eyes or imagination an indication only, but moreover, this indication may, in certain cases, fail; just now we were unable, either with the external or internal eye, to follow the prolongation of the two parallel lines beyond a certain distance; so again, we may cite a figure such as the regular myriagon, which we have never seen drawn, which we cannot draw in imagination, and as to which we can, nevertheless, form certain definite judgments. Beneath the process of the external or internal eye, there is a silent mental process, the repeated or continuous recognition of a circumstance which, supposed in the primitive construction, persists or reappears, always *the same*, at the various successive moments of our operation. When, after having erected my two perpendiculars on a base, I follow them indefinitely in imagination without being able to admit that at some point or other of their course they approach one another, it is because, involuntary and unawares, I carry with them the portion of base intercepted by their feet, and because, at every moment of the transit, this base, which is always the same in my mind, makes itself vaguely recognized by my mind as being always the same.—But though reason may be the real fabricator of the final conviction, the indication furnished by the senses is of great value. For the testimonies of the eye and the imagination anticipate and confirm the conclusions of the analysis; we are led to the axiom by a preliminary suggestion, and we are maintained in it by a subsequent verification. The sensible evidence serves as introduction and complement to the logical evidence, and it is by means of this agreement that arithmetic, geometry, and even algebra, having immediately found their axioms, were of such early growth.—This was not the case with mechanics. In this science, the axioms do not concur with the inductions of experience; at least, they do not concur with the inductions of ordinary experience. For instance, axioms tell us that matter is inert, incapable of spontaneously modifying its state, of passing from rest to motion when it is at rest, and from motion to rest when it is in motion. Now, we are daily seeing bodies passing from motion to rest or from rest to motion, and as it seems, spontaneously, and without the appreciable intervention of a new condition. A projected stone, an oscillating pendulum, finally stop, and we are tempted to believe that they stop of themselves; a mixture explodes, an apple falls from the tree, without our senses detecting the new circumstance which has been added to the former state and has thus produced the new. Throughout the whole of antiquity and of the middle ages, philosophers recognized tendencies to rest or motion, various in various bodies, the tendency downwards in the falling stone, the tendency upwards in air and fire which rise, the tendency to perfect circular movement in the revolving stars, the abhorrence of a vacuum, etc. It was at the Renaissance only, with Stevinus and Galileo, that mechanics commenced; and, most probably, the cause of this long delay was the disagreement of ordinary induction and of pure reason. In place of leading us to the axiom, experience turned us from it; instead of confirming it, experience denied it. We had no assistance in forming it, and if we could have formed it, observation, as then practised, would have been sufficient to upset it. We have ended by forming it, and experience, better directed, is now found to be in accordance with it. Further than this, it has been so well directed, and, in certain cases, as that of Borda's pendulum, is found so conclusive that, according to many authors, induction is the only real proof of the axiom; they look on the principles of mechanics as propositions analogous to the principle of attraction, established like it by pure induction, limited like it by the small circle and small duration of the world our observation can attain, incapable like it of being applied beyond this except by conjecture, and, like it, simply probable, when our rashness wishes to extend their empire over all portions of space, or to all moments of time.

For ourselves, we are inclined to think, with Leibnitz and D'Alembert, that among the principles of mechanics, are many which are not merely truths of experience, but also *analytical* propositions. In order to show this, let us closely examine our constructions.—Take a movable body moving uniformly in a straight line for as short a time as we please, and traversing as short a space as we please; this is what we may term its initial, or primitive movement; will it continue to move, and, if so, what will be its movement?—However short may be the time first elapsed, for instance, the millionth part of a second, and however small may be the space first traversed, for instance, the thousandth part of a millimetre, we can consider successively two halves in this time and two halves in this space. As, according to our supposition, the movement has been rectilinear, the second two-thousandth of a millimetre described will be in a straight line with the first. As, according to our supposition, the movement has been uniform, the space traversed in the second two-millionth part of a second is the same in magnitude with that traversed in the first. Hence two consequences follow. Neither the direction nor the velocity of the body have been changed. The direction it had during the first fraction of space has remained *the same* during the second. The velocity it had during the first fraction of time has remained *the same* during the second. Whether the fraction be the second or first, matters not; the character which forms their difference has had no influence on the movement; as regards the movement, this character has been *indifferent* and, if I may venture to say so, *null.*—But, among the similar fractions of ulterior space and consecutive duration, we may conceive one immediately following our second fraction, after the second two-thousandth of a millimetre of traversed space, a third one, after the second two-millionth of a second of time employed, a third one. This third, taken in itself and compared with the second, differs from it only as the second differs from the first; it comes after the second as the second comes after the first; nothing more. Hence it follows that, since the character by which the second differs from the first, that is to say the property of coming after it, has had no influence on the movement, the character by which the third differs from the second, that is to say the property of coming after it, will have no influence on the movement; as regards the movement, this character will also be *indifferent and null*, and, as during the second moment the body continued its uniform and rectilinear movement, so during the third moment, without the introduction of a new influential character, it will continue its uniform and rectilinear movement. The same reasoning will apply to the fourth, the fifth, and succeeding moments, and so on to infinity.

Reduced to these terms, the proof is rigorous. It is wholly founded on two observations: one being that two equal and contiguous portions of space, like two equal and successive portions of time, are exactly the same, excepting this difference, that the second is after the first; the other being that, if this difference has not, in one instance, had any effect upon the movement, this same difference will not, in a second instance, have any effect upon the movement, on condition that, in the second instance, it is absolutely *the same*, and that no other new and influential difference has intervened. For this we provide, by assuming that the third fraction of time and space repeats the second absolutely and in all respects; that, no disturbing character being met with in the second, no disturbing character will be met with in the third; that in the third space and third instant, as in the second space and second instant, no foreign and influential character has been added to arrest, alter, hasten, or retard the movement; that, the little space first traversed being empty, the infinite space remaining to be traversed is also empty; that, the short duration first elapsed having presented no modifying event, the infinite duration which remains to elapse will not present one. In short, we conclude from a place to a different place, and from an instant to a different instant, with authority and certainty, when this difference, having manifested its absolute want of influence, may be considered as null with reference to the movement, and when, every other influential difference being excluded by hypothesis, the two places and two instants become rigorously *the same* with reference to the movement.

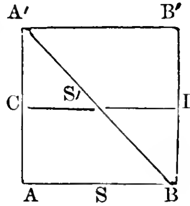
The reader sees without difficulty that an analogous and still more simple reasoning applies to the case of a body at rest; for we have not then to take account of space, but simply of time.—Let a body be at rest during a time as short as we please; as this time is divisible into two halves, we shall demonstrate as before that, the body having remained during the second half in the same state as during the first, the character by which the second half differs from the first, that is to say the property it has of coming after it, has had no influence on this state; hence it follows that a third equal fragment, cut off from consecutive duration, will not have any influence, unless there be made to intervene some new influential circumstance, some foreign effective event. This is why the primitive rest will be maintained, so long as this exclusion is maintained, and however short may be the initial state, the body at rest, as well as the body impressed with a uniform rectilinear motion, will tend to persevere indefinitely in that state.

Observe the restricted range of the axiom, when thus demonstrated and understood. It does not in any way establish that a body impinged on by another will assume a uniform rectilinear movement, nor that a body impressed with a uniform rectilinear movement may lose it under the force of an impact, and will then remain indefinitely at rest; these truths are matters of induction and experience. We are elsewhere, in the pure region of abstract truths; we no longer know whether, in fact, there be any movable bodies at rest or in motion; we do but extract and follow out the consequences included in an initial supposition or construction.—This is why simple analysis has been so far sufficient and will also be sufficient to demonstrate two other capital propositions of mechan-



ics. Take an inflexible straight line A B; suppose it to move altogether and in such a way as always to remain parallel to its first position; after a certain time it becomes A′ B′ parallel to A B, and we assume this time to be a second. Now suppose that, during this movement of the whole line, a movable point, situated at A, is itself directed in a straight line towards the point B, in such a way as to traverse, also in a second, that is to say in the *same* lapse of time, the straight line A B. We thus assume for A two simultaneous and different movements, the one common to it with the other points of the line A B, the other special to itself.—Observe that we do not know if things happen thus in nature. There is nothing to prove that our mental combination has, or even can have, its counterpart in real combinations. We might imagine a state of things in which, from the very fact of a body moving in one direction, it would be impossible for a portion of that body to move at the same time in another direction. But we have not here to trouble ourselves with what the laws of real things permit or deny; we suppose, in our movable body, the independence of two simultaneous movements taking place in opposite directions, reserving a verification later on by experience as to whether the facts do or do not adjust themselves to this conception.—From our two hypotheses, what follows? By the first it is admitted that the straight line A B, mounting towards A′ B′, becomes, at the end of a second, A′ B′, and that thus, at the end of a second, the point B arrives at the point B′. By the second, it is admitted that the movable point situated at A is transferred from A to B, also in a second, without the ascent of A B interfering in any way with this movement of translation. This ascension, then, is *indifferent and null* with respect to the translation, and the movable point travels along A B in motion, as it would along A B at rest. Hence it follows that, at the end of a second, it has arrived at the extremity of A B in motion, just as it would have arrived, at the end of a second, at the extremity of A B at rest. But, at the end of a second, the extremity of A B in motion is B′; therefore, at the end of a second, the movable point is at B′. Hence we see that having started from the angle of the parallelogram it has reached the opposite angle.

We have now to enquire what line it has described in this transit. Two cases may present themselves, that of uniform motion, and that of motion which is not uniform. We shall only examine the first, the simplest of all: in this case, the velocity of A B has remained the same throughout all its ascent, as also the velocity of the movable point A throughout all its translation. Consequently, at the end of half a second, A B is found to be exactly in the middle of its whole transit, that is to say at C D, and at the end of the same half second, the movable point A is found to be exactly in the middle of its whole transit, that is to say at S. But as A B has mounted in the meantime to C D, the point S belonging to it has mounted with it, and is to be found at S′, the middle point of C D, as S is the middle point of A B. Very simple geometrical considerations show that this point S′ is on the diagonal, that is to say on the straight line joining A and B′. By subdividing the divisions of the second, we should prove in the same way that all the other successive positions of the movable point are likewise on the diagonal, hence it follows that the line it describes in its whole double movement of ascension and translation is the diagonal.—Hence, a very important consequence: our movable body which would have described the line A B in a second, and the line A A′ also in a second, likewise describes in a second the diagonal A B′. Since, then, the times employed are the same, and the spaces traversed are different, the velocity of the compound movement will not be the same as the velocities of the component movements, it will be represented by the diagonal, and



they will be represented by the two sides of the angle, these three lines being the measure of the spaces traversed in the unit of time. Now, we have measured force by the greater or less velocity it impresses on the same movable body. Suppose now two forces applied to the preceding movable body, one which, if acting alone, would make it traverse the line A B in a second, the other which, if acting alone, would make it traverse the line A A′, also in a second; apply them both together to the movable body; we have just seen that it will traverse the diagonal in a second. Hence it follows that the resulting force, estimated by the impressed velocity, is to the component forces, estimated also by the impressed velocity, as the diagonal is to the two sides of the angle. Therefore the diagonal measures the resulting force with reference to the component forces, just as it measures the compound velocity with reference to the component velocities.—It is now sufficient to insert, in the measurement of forces, the second element of force, mass, and we have already shown how this idea is connected with the idea of velocity.* When we have done this, we possess all the essential axioms of mechanics, and we have formed them, as all other analytical propositions are formed, by the simple analysis of the mental combination in which they were included in a latent state.

VII. Other less fruitful axioms are also worthy of demonstration by reason of their immense range, and the prodigious power they seem suddenly to confer on the human mind. These are the ones relating, not to particular times compared with other times, nor to particular spaces compared with other spaces, but to the whole of time and the whole of space. With reference to a given moment, duration is infinite in the future and the past, and we may picture it by a straight line which starting from a given point is infinite in both directions. With reference to a given point, space is infinite, in three dimensions; first, in length, which we picture

* Part ii., Book iv., Ch. i., p. 186 *ante*.

by supposing a point which moving in a straight line generates in two directions an infinite straight line; then in breadth, which we picture by supposing this infinite straight line by moving in a direction perpendicular to its own to generate on both sides an infinite surface; lastly, in depth, which we picture by supposing this infinite surface by moving in a direction perpendicular to itself to generate on both sides an infinite geometrical solid.—These are propositions which we cannot prevent ourselves from holding to be true, and thereupon our imagination gives itself scope; we represent to ourselves time and space as two infinite, uniform, indestructible receptacles. In the one are included all real events, in the other, all real bodies. However long may be a series of real events, for instance, the sequence of changes which have occurred since the origin of our solar system, however vast may be a group of real bodies, for instance, the collection of all the stellar systems to which our telescopes can reach, the receptacle extends still further; however we might increase the series or the group, it would always extend beyond them, and the reason is that the receptacle has no limits. We remain startled, and ask ourselves by what marvellous operation of the mind we have been able to discover so marvellous a property.—But our astonishment is diminished when we observe that the same property is met with in all magnitudes, and is at an end when we find that it is comprised in the definition of magnitude.—Take the simplest of all magnitudes, a collection of individuals or units, as small as we please, that is to say containing two units. To construct it, I have supposed two precisely similar units, that is to say the same unit repeated; I have then added the second to the first, 1 to 1, supposing the second unit to be the same before as after the adjunction, in other words, that the second 1, when added, remains intact and absolutely such as before. Since the second 1 is the same as the first, I may, when it is alone, perform on it the operation which I have just performed on the first, and therefore add to it 1. Since the second 1, after its adjunction to the first, remains absolutely such as it was before, I may add 1 to it when it is added to the first, just as I added 1 to it when it was alone. I may then add 1 to 1 + 1, that is to say to 2, just as I have already added 1 to 1. An analogous reasoning shows that we may similarly add 1 to 3, then to 4, to 5, to 6, and in general, to any number whatever. Thus every adjunction we effect generates the possibility of another similar adjunction; hence it follows that the series of numbers is absolutely infinite. There is no number, however enormous, which may not be comprised in this series; it is, as regards imaginable numbers, what duration is with regard to real or imaginable events, what space is with regard to real or imaginable bodies, a boundless receptacle in which every determined or determinable number comes necessarily to find a place, sometimes above, sometimes below, but always in a precise spot, without ever the number, swollen as enormously as we please, ceasing to be contained by the series like a thing enclosed by things *beyond* it.

So much for collections which are artificial and discontinuous magnitudes; the same reasonings applies to times, lines, surfaces, solids, which are natural and continuous magnitudes. Take any portion whatever of the straight line A C; the first notions of geometry show us that it may be divided into two equal straight lines, A B, B C, the second of which, if applied to the first, intact and without alteration, will coincide with it exactly; therefore, except as to its position following the first, it is the *same* as the first, and moreover, by hypothesis, it is the *same* as before its translation. Since the second line is the same as the first, I may, when it coincides with the first, perform on it the same operation as upon the first, and therefore prolong it, like the first, by a line equal to itself. Since the second line is the same, now as before its translation, I may before translating it, that is to say when it still prolongs the first, prolong it, like the first, by a line equal to itself. I may, then, prolong A B C by C D just as

A B C D E

I prolonged A B by B C. An analogous demonstration shows that we can similarly prolong A B C D by D E and so on, however great may be the line so constituted. Every prolongation we effect, then, generates the possibility of another equal prolongation, whence it follows that the series of prolongations is absolutely infinite.—The reader readily perceives that, with the necessary changes of words, this analysis becomes equally applicable to surfaces, solids, times, and rigorously demonstrates the infinity of time and space.—All the artifice of the proof consists in observing two elements of a given magnitude, and remarking that they are the *same* except as to their difference of position in the magnitude, that this difference is itself *indifferent*, that is to say of no effect and without any influence on their nature, that, therefore, the increase given to the first element by the second may be given to the whole by a subsequent third element, and in general, to every other analogous whole by a subsequent element. What creates the infinity of the series, are the properties of its elements. So again, it is by comparing together the elements of infinite series that we compare together such series themselves. This is the process by which I know that the infinite series of even numbers is equal to the infinite series of odd numbers, and that each of them is half of the infinite series of numbers. This is the process by which I know that the infinite surface comprised above a straight line between two perpendiculars a metre apart, is equal to the infinite surface comprised by the same perpendiculars when prolonged below the line, and that these two infinite surfaces taken together are two-thirds of the infinite surface comprised above the line by two perpendiculars three metres apart. Thus, when we study the axioms which removes all limit from the possible increase of any magnitude, and which sets out this magnitude when infinitely increased, as a permanent receptacle in which every limited magnitude of the same kind must necessarily find its place and something *beyond* it, we find only, as in the other axioms, an analytical proposition. It has been sufficient in every case for us to examine attentively our mental construction, to detect in it conditions which are understood, the *latent identity* of one datum and another, the *latent indifference* of a character which seemed to separate the two data, identities and indifferences which we did not perceive at first, since our supposition had not expressly enunciated them, but which were nevertheless tacitly included in our hypothesis, and which, before they were brought to light, revealed their secret presence by the invincible inclination they impressed on our belief, and by the complete evidence with which they enlightened our judgment.

VIII. We now see how it is that the contraries of axioms and their consequences are not only incredible but inconceivable; it arises from their being contradictory; in this sense, axioms and their consequences are necessary truths. There is no question of greater importance in psychology, for no question has more important consequences in philosophy. In fact, these kinds of propositions are the only ones which are applicable, not only to all observed cases, but to all cases, without possible exception; hence it follows that, on their value, depends the reach of human knowledge. But their value depends on their origin; it is essential, then, to know whence they spring, and how they are formed. To this, two original and still existing schools give two opposite answers. Let me be understood to speak only of doctrines which hold a place on the world's stage, and of philosophers who have constructed their doctrines without other care than that for truth.—Of the two principal answers, the first is that of Kant. According to him, these propositions are the work of an internal force, and the effect of our mental structure. It is this structure which effects the connection between the two ideas of the proposition; if the idea of straight line, that is to say of a certain direction, is joined in my mind to the idea of the least distance, that is to say of a certain magnitude, it is not because this direction and this distance are in themselves connected, it is because my intelligence is fashioned in a certain way, and, being so fashioned, cannot avoid establishing a connection between the two ideas which it has of this distance and of this direction. In fact, the two data taken in themselves are of different kinds; there is no point of real connection between them. Consequently, the invincible mutual attachment which I observe to exist between them in my mind finds its explanation, not in their intrinsic nature, but in the mental medium into which they have been introduced. My mind has not ascertained their connection, it has constructed it. We must admit, then, that these propositions reveal to us a necessity of our mind, and not a connection of things. In the narrow circle to which our experience is confined, we may, indeed, establish by induction, that the corresponding sensible data are approximately connected; but to affirm that in every place and at every time these abstract data are connected and necessarily connected, is what is not allowed us; we have no right to impose on facts a connection which belongs only to our ideas, nor to set up an infirmity of the subject as a law of objects.

Starting from the opposite view, Stuart Mill arrives at a similiar conclusion. According to him, these propositions have as their cause an external force, and are, like other truths of experience, the summed-up impression left on our mind by things. Considering two sensible lines sensibly perpendicular to a straight line, we verify by an infinity of readily effected measurements that they remain equally distant from one another. Further, we observe that, the more exactly they are perpendicular, the more exactly equal are their distances. Hence it follows that, if they were rigorously perpendicular, their distances would be rigorously equal. From the equality of these distances on our paper, we conclude by induction that, far beyond our paper and at an infinite distance, they would still remain equal. If the contrary supposition is inconceivable, it is owing to our imagination exactly repeating our vision while giving it greater range; the internal eye does but add a telescope to the external eye; therefore, we cannot imagine the two perpendiculars other than as we see them; we cannot, then, prolong them mentally, without representing them to ourselves as still equally distant.—Hence it follows that the truths termed necessary, having the same origin as the truths of experience, are subject to the same restrictions and the same doubts. By the axiom as to parallel lines just as by the law of the movement of the planets, we prove the constant association of two data, which are, in fact, constantly associated in nature; but this association is not a connection, it is merely a concurrence. Taken in themselves the two data are nothing more than incidents which coincide; there is no internal necessity in them which assembles them in a necessary couple. Perhaps, beyond our little world, they are found disconnected; at all events, we have no right to affirm that beyond it they are in all places and in themselves, connected. A mind constructed upon another model than ours might perhaps readily conceive varying distances between our two perpendiculars. It may be that, beyond the nebulæ of Herschel, none of our laws are true, and there may even be no law which holds good.—We are, then, inevitably driven back from the infinite; our faculties and our assertions can in no way attain to it; we remain confined in a very small circle; our mind cannot carry itself beyond the range of its experience; we cannot establish any universal and necessary connection between facts; perhaps, indeed, no such universal and necessary connection exists.—By following out this idea to its full extent, we should arrive at the conception of the universe of events and beings as a simple collection or heap. There would be no internal necessity for their connections or existence. They would be pure data, that is to say, things accidentally existing. Sometimes, as in our system, they would be found assembled in such a way as to bring about regular recurrences; sometimes, they would be so assembled that nothing of the sort would occur. Chance would be, as Democritus taught, at the foundation of all things. Laws themselves would be derived from it, and would only be derived from it, in certain places. It would be with beings as with recurring decimals, which, according to the hazard of what may be their two primitive factors, sometimes expand in regular periods, and sometimes not, and which generate their successive ciphers, sometimes according to a law, sometimes without following any law.

Here are two high conceptions, and the powerful minds which formed them are worthy of all admiration and respect; but we must examine the foundation on which they are built, and, in my opinion, this foundation is not solid.—According to Kant, there is no necessary connection between the two data; if there is an invincible connection between the two corresponding ideas, its cause lies, not in the structure of the data, but in the structure of our mind. We recognize, with Kant, an invincible connection between the two ideas. But between the two data, which are the objects of these ideas, and to which he refuses any intrinsic connection, we have discovered an intrinsic connection; for the first, in a latent manner, contains the second, from which it follows that the contents being inseparable from what contains them, the unsurmountable connection between our ideas is indestructible between their objects.—According to Stuart Mill, whether there be a connection between the two data or not, we are incapable of knowing it; for the two data are connected by induction alone; and all induction can prove between them is that they are constantly found together, that is to say, an association of fact. We admit, with Mill, that at the outset and in many minds they are only connected by induction; but we have proved that they may also be otherwise connected. We can represent two perpendiculars upon a straight line by imagination, but we can also conceive them by reason. We can consider their sensible image, and also, in addition to their sensible image, their abstract definition. We can study them ready constructed and generated, but we can also study them during their construction and generation, in their factors and their elements. We can watch their formation and detect the ascension of the base which generates them, just as we can watch the formation of the cylinder and detect the rectangle by whose revolution it is described. From this construction we extract the included properties, and thus form by analysis the proposition we at first formed by induction.—Thanks to this second process, the range of our mind is extended infinitely. We are no longer capable only of relative and limited knowledge; we are also capable of absolute and unlimited knowledge; in axioms and their consequences we hold data, not only accompanying one another, but such that one includes the other. If, as Mill teaches, they only accompanied one another, we should be driven to conclude with him that this might not always be the case; we should see no internal necessity for their junction; we should simply state it as a fact; we should say that the two data being isolated in their nature, circumstances might be found in which they would be separate; we should only affirm the truth of axioms and their consequences relatively to our world and our mind. But since, on the contrary, the two data are such that the first includes the second, we establish by that alone the necessity of their junction; the first, wherever it may be, will involve the second, since the second is a part of itself, and since a datum cannot be separated from itself. There is no place between the two for a circumstance to intervene to disjoin them; for they are but one thing in two aspects. Their connection, then, is absolute and universal, and the propositions which concern them do not permit of doubts, limits, conditions, or restrictions.—In truth, these propositions are hypothetical; all they affirm is that, if the first datum be anywhere met with, and especially in nature, the second datum cannot fail to be also met with there, by consequence and correspondence. It remains, then, for us to prove that there are, in fact, equal magnitudes, artificial and natural straight lines, lines perpendicular to a straight line, bodies motionless or moving for a very short time at least uniformly in a straight line, movable bodies possessed of constant velocities in different directions, homogeneous substances exactly divisible into equal portions, in short, real data conforming to our mental constructions. To show this, it is necessary and sufficient for experience to intervene; in fact, in many cases, in astronomy, optics, acoustics, it ascertains that certain existing things present the required characters, or at least tend to present them, and would present them, if we could effect upon them the proper eliminations. In all these cases the necessary propositions are *applicable*, and the real data have the intrinsic connection which Kant and Mill deny them.—Thence follow vast consequences, and a view of the foundation of nature, the essence of laws, and the structure of things opposed to those of Kant and Mill.

CHAPTER III.

THE CONNECTION OF GENERAL CHARACTERS, OR THE EXPLANATORY REASON OF THINGS.

§ I. NATURE OF THE EXPLANATORY INTERMEDIATE.

I. WHEN we have ascertained a connection between two data, possible or real, it often happens that this connection is explainable, and we are then able, not only to affirm that the two data are connected, but also to say *why* they are connected. Between the two data which form a couple, there is found another, an intermediate one, which, being connected on the one side with the first, and on the other side with the second, produces by its presence the connection of the second and first, in such a way that this last connection is derived and presupposes, as conditions, the two preliminary connections whose effect it is. In this case we conceive the two preliminary connections by two preliminary propositions which we term *premises*, and we conceive the derived connection by a derived proposition which we term *conclusion*.—Nothing can be more important than this intermediate datum, since it is the one which, by its insertion between the two data, consolidates them into a couple. We must attempt to find out in what it consists, how we discover it, where we ought to search for it. When this is done, we shall have no difficulty in comprehending the formation of the two premises into which it enters, and of the conclusion which results from them.

II. There is a case in which we know all this, that of individual objects subject to known laws. For instance, Peter is mortal; the two lines drawn on this slate perpendicularly to a third line are parallel: here are couples of data in which the first member is not general, but an individual, particular, determined object.—Moreover, these objects are subject to known laws; we know that all men, among whom is Peter, are mortal, that all straight lines perpendicular to another straight line, among which are the lines on our slate, are parallel.—Now, in this case, the explanatory intermediate which connects the enounced property to the individual object is the first term of a general law: if Peter is mortal, it is because he is a man, and because every man is mortal; if our two lines are parallel, it is because they are perpendicular to a third, and because all straight lines perpendicular to a third straight line are parallel. But *man* is a character included in Peter, an extract from him, more general than he is; so *perpendicular to a third* is a character included in our two lines, an extract from them, more general than they are.—Hence we see that, in the case of individual objects subject to known laws, the intermediate which connects the enounced property with each object is a character included in it, more abstract and more general than it is, common to it and to other analogous objects, and which, involving by its presence the property enounced, draws this property with it in each of the individuals to which it appertains.

Let us now inquire in what this intermediate consists, when it is a question, not of connecting a property to an individual object, but of connecting a property to a general thing. In other words, from the explanation of facts, let us pass to the explanation of laws, and, for this purpose, let us examine some of the laws of which the *reason* and the *why* are now discovered.—In the seventeenth century, after the experiments of Galileo and Pascal, it was known that all terrestrial bodies tend to fall towards the earth, and, after Copernicus and Kepler, it was understood that the earth and all the other planets tend to fall towards the sun. Newton came and proved that the two tendencies are the same; gravitation is common to celestial, as well as to terrestrial, bodies, and, more generally, to all bodies. From that time it was known *why* terrestrial bodies tend to fall towards the earth, and *why* the planets tend to fall towards the sun. The weight of the first, and the centripetal tendency of the others, had as *reason* a property common to both; the two laws were cases only of a third and more extensive law. From the group of characters which constitute a terrestrial body, Newton retained one only, the property of being a mass with reference to another mass; he eliminated the rest. From the group of characters which constitute a planet, he retained one only, the property of being a mass with reference to another mass; here again he eliminated the rest. He had, then, derived from the two groups a general and abstract property, more general and more abstract than either of them, contained in each of them like a part in a total, like a fragment in a whole, like an element in a sum. Instead of connecting, like his predecessors, weight to the first whole group, and centripetal tendency to the second whole group, he connected the weight and the centripetal tendency to an element found alike in both of them.—By this brillaint example, we see in what the intermediate datum furnishing the *reason* of a law consists. Given the object subject to the law, this datum is one of its characters, a character comprised in the group of characters which constitute it, a character included in it, more abstract and more general than it, in short, an extract to be extracted.—Let us follow out the series of *whys*, and we shall see that such is indeed the nature and position of the *becauses*, or alleged reasons.—Why does this stone tend to fall? Because at the surface of the earth all stones, and more generally still all solids, or liquids opposing any resistance to our muscles, tend to fall.—Why do all these solids or liquids tend to fall? Because all masses at the surface of the earth, whatever they may be, solid, liquid, or gaseous, tend to fall.—Why do they tend to fall? Because not only at the surface of the earth, but still further distant, as we have proved in the case of the moon, in all our solar system, as is the case with the planets and their satellites, with comets and the sun, far beyond again, as happens with the double stars, every mass, as soon as it is in relation with another mass, tends to approach it.—Why this strange tendency? Physicists* are at present inquiring if it cannot be reduced to a continuous impulsion, to the pressure exercised by an ether. If we could succeed in proving that this ether in fact exists, and that the density of its successive layers about a heavy body goes on increasing as the square of the line which represents their distance from the body, the supposition presented would become a demonstrated truth, we should have an additional *because;* we should detect in a gravitating body a character still more general and more abstract than gravitation, a property wholly mechanical, that by which a body follows an impulsion, and receives a new velocity at each new impulsion. Now this last explanatory character would have the same characteristics and the same position as the rest. It would, then, like the rest, be a portion, an element, *an extract from the preceding one*, and would, like the rest, be found in the preceding one, in which it is included.

III. Let us now look at those laws in which the explanatory intermediate seems at first sight of a wholly different kind.—Every vibrating body whose vibrations are comprised within certain known limits of slowness and velocity excites in us the sensation of sound. Why so? Because its vibrations have, among other characters, the power of being propagated through the surrounding medium up to our acoustic nerve; in fact, take from them this property, which we do by the suppression of the medium and by setting the body in a vacuum, the vibrations continue, but, as they cease to be propagated, the sensation is no longer produced. Thus the reason which renders these initial vibrations actually sonorous, is the

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* "L'Unità delle forze fisiche, saggio di Filosofia Naturale," by Père Secchi.—M. Lamé has examined and adopted an analogous hypothesis.—See the development of the whole hypothesis in "La Physique Moderne," by M. Saigey, especially p. 146.

possiblity they have of being propagated, a property included in them and more general than they are, since it is met with elsewhere, for instance, in the vibrations of the luminous ether. Here again the two data, antecedent and consequent, are connected through the medium of a character comprised in the first, and it is the first which we must study *with all its circumstances* to extract from it the element which is the reason of the law.—Now, why does the vibration of the body, when propagated through the medium up to the acoustic nerve, excite in us the sensation of sound? Because it possesses, among other characters, the power of propagating itself further still, along the acoustic nerve, up to the acoustic centres of the brain; in fact, take away this property, which we find effected when the subject is deaf, and which we can effect by paralysing the brain with chloroform; the vibration will be propagated as far as the acoustic nerves, or even as far as their central termination; but, as it does not reach or does not disturb the cerebral centres, it will not excite the sensation of sound. Thus the reason which renders vibrations propagated up to the acoustic nerve actually sonorous is the possibility they have of being propagated beyond it up to the cerebral centres, a property included in them, and more general than they are, since it is met with elsewhere, particularly in the luminous vibrations transmitted to the retina, and, in general, in all the disturbances which external bodies impress on our sensory nerves. As before, the two data, antecedent and consequent, are connected through the medium of a character comprised in the first, and it is the first, I mean the vibration already propagated up to the nerve, which we must study *with all its circumstances*, to ascertain in it and detach from it the possibility of a further and complete propagation which is the reason of the law.

We see that, in this law, the intermediate datum is a character of the first datum, which is the vibration; just as, in the preceding law, gravitation is a character of the first datum, which is the planet.—In fact, between the two cases there is an important difference. In the first, the explanatory character is one of *the least stable* elements of the antecedent; whether the vibration be propagated or not, does not depend on itself, but on many superadded conditions, sometimes present, sometimes absent; it requires to meet with a favorable medium, an uninjured nerve, a healthy brain; if these circumstances are absent, it cannot be propagated; it may, then, exist without being propagated; this will happen if the surrounding medium is wanting, or if the nerve or cerebral centres are in an abnormal state. In the second case, on the contrary, the explanatory character is one of *the most stable* elements of the antecedent; even were the planet to be shivered into fragments and to fall upon another, its fragments would still tend towards the sun, and towards every mass with which they might be in relation.—But this difference of the two cases in no way alters their fundamental resemblance, and in the first, as in the second, the explanatory intermediate, stable or unstable, is a *more general character*, comprised with others in the antecedent, and which must be looked for in the group in which it occurs, that is to say in the first of the two data of the law.

IV. In the law associating the sensation with the vibration, the intermediate is composed of two *successive* intermediates, the power of the initial vibration to propagate itself up to the nerve, and the power of the propagated vibration to propagate itself up to the brain. In other laws, the intermediate is equally multiplex, but the intermediates of which it is composed are *simultaneous* and not successive.* Besides the cases in which the reason is a series of reasons, there are cases in which it is a group of reasons.—For instance, the earth describes a particular orbit about the sun. Now the reason which determines this orbit is a sum of distinct reasons, one of which is the initial impulsion, or tangential force, with its quantity in the case in question, another gravitation or the

* See, on all these points, the fine chapter in Mill's "System of Logic," book iii., chap. xii., "Of the Explanation of Laws of Nature."

centripetal force, with its quantity in the case in question, and the last, the distance from the earth to the sun at a fixed time and place. In these instances, if we ask the why, the answer is a sum of *becauses*; here especially there are three united reasons, three explanatory characters, three intermediate data, each of which, taken apart, is more general than the total antecedent, and which, included in it, concur by their assembled influences to determine the curve in question.—Hence an important consequence. Suppose a law in which the first datum is a whole, a compound of distinct parts, an assemblage of data separable in fact, or at all events mentally separable; it is evident that the explanatory intermediate will be, as in the preceding case, a sum of intermediates which we have here to seek out and detect, one by one, in the various separable data of which our first datum is the whole.

Such is the case with numbers and geometrical compounds. Every number, written according to our ordinary system of numeration, in which the sum of the digits is divisible by 9, is itself divisible by 9. Every convex polygon contains a number of angles which, together with four right angles, are equal to twice as many right angles as the figure has sides. Here are two laws in which the first datum is a sum of separable data; in fact, the written number is nothing more than the sum of its units of various orders, and the polygon is nothing more than the sum of its parts; hence it follows that the explanatory intermediates must be sought for in the units of various orders which make up the number, and in the parts which make up the polygon.—Let us first observe the number; the units of various orders which form its elements are already detached, prepared, and presented for analysis, and, to detect them, we have only to consider the digits representing them. Now it is easy to see that in every number the sum of the units of the second, third, fourth order, etc., is divisible by 9, with a remainder equal to the digit representing it; that, therefore, the sum of these sums is divisible by 9, with a remainder equal to the sum of the digits which represent it; that consequently the entire number itself is divisible by 9, with a remainder equal to the total sum of the digits which represent it; hence it follows that if the whole sum of the digits is itself divisible by 9, the remainder disappears, and the entire number, divided by 9, leaves no remainder.—Here the explanatory intermediate is a character included in all the elements of the number, except the first, and common to all the units represented by a digit placed to the left of the first; this character so repeated compels every number to be divisible by 9, with a remainder equal to the sum of its digits, and consequently, renders it divisible by 9, on the single condition that the sum of its digits is divisible by 9.

Let us now take the polygon; when it is presented to us, the portions of surface which form its elements are not yet distinct and separate; we are compelled, then, to create them, and for this, to effect divisions and trace lines; a construction must precede the analysis. We take any point in the interior of the polygon; from this point we draw straight lines to all its angles; we thus replace the polygon by a group of triangles whose number is equal to that of its sides. Now, in each of these triangles, the two angles at the base, together with the angle at the vertex, are equal to two right angles; therefore, if we take all the triangles, and if, adding together all the angles at their bases, we further add all the angles at their vertices, we shall have as many times two right angles as there are triangles, that is to say sides in the polygon. But these angles at the bases are precisely the angles of the polygon; so that the angles of the polygon, if we add to them the angles at the vertices, are equal to twice as many right angles as the polygon has sides. Now we know independently that the angles at the vertices are together equal to four right angles; hence it follows that the polygon contains a number of angles which, together with four right angles, are equal to twice as many right angles as there are sides.—Here the explanatory intermediate is a character comprised in all the elements of the polygon that is to say common to all the triangles of which it is the whole; this character, thus repeated, compels every polygon to contain a number of angles which, estimated in right angles and increased by a constant number of right angles, is double the number of its sides.

But it is not only in arithmetical and geometrical compounds that intermediates of this kind occur. Take a carnivorous animal like the tiger, or a ruminant animal like the ox. A number of precise laws connect each of its organs, and each fragment of each of its organs, with the rest. The naturalist who dissects one organ, knows beforehand what he will find in the others; from the external appearance, he predicts the internal structure, and can delineate the form of the stomach, the brain, the heart, the skeleton, before he has laid them bare. If he is asked why, in this animal, a particular portion constructed in a particular way involves some other portion, he can answer: his predecessors, from Galen to Cuvier and Richard Owen, have discovered an explanatory intermediate which, common to all these very various parts, is the principal reason of their structure and relations. This intermediate is the property of being *useful;* each organ performs a function which contributes, with the rest, to a total effect; therefore, it is appropriate to its function; therefore, it is determined by its function. But this function is itself determined by the others which contribute with it to the total effect; hence it follows that the organs determine one another with a view to a total effect. In other words, the organs reconcile their characters in such a way as to reconcile their functions, and they reconcile their functions in such a way as to maintain the circuit of loss and reparation which forms the life of the individual and the succession of individuals which forms the race.—Consequently, a particular kind of teeth involves a particular kind of intestines, and conversely. If we find an intestine fitted to digest flesh only, and raw flesh, the animal has jaws constructed to devour its prey, claws fitted to seize and tear it, teeth fitted to cut and divide it, a system of motor organs fitted to catch it, senses capable of perceiving it at a distance, the instinct to hide itself in order to surprise it, and a liking for flesh. "Hence follows," says Cuvier, "a certain form of the condyle in order that the jaws may fit together like scissors, a certain volume in the crotaphyte muscle, a certain depth of the fossa which receives it, a certain convexity of zygomatic arcade through which it passes, and a host of characters of the skeleton, the articulations, and the motor muscles. . . . The form of the tooth involves that of the condyle, that of the omoplate, that of the talons, just as the equation of a curve involves all its properties, and just as, by taking each property separately as the base of a particular equation, we should rediscover the ordinary equation and all the other properties, so the talon, the omoplate, the condyle, the femur, and all the other bones, taken separately, give the tooth, and are conversely given by it."—This is so true that, in the same animal, the metamorphosis of one organ involves an appropriate metamorphosis of the rest. The tadpole, which is not carnivorous, requiring a very long canal to digest its food, has an intestine ten times the length of its body; when changed into a carnivorous frog, its intestine is but twice the length from mouth to anus. The voracious larva of the cockchafer has an œsophagus, a vast muscular stomach, surrounded with three crowns of little cæcums, a small intestine, an enormous large intestine three times the size of the stomach, and filling up the whole posterior third of the body: when it has become a cockchafer and more temperate, all that remains of this apparatus is a slender canal destitute of enlargements.—By this discovery of the explanatory intermediate, the face of the animal world is entirely changed. Before, we had descriptive anatomy only; we knew that in fact certain characters accompanied one another; but we did not know why they accompanied one another. They were then simply in juxtaposition; they are now necessarily connected; in addition to their constant concurrence, as we ascertain their obligatory connection. Every organ, and further, every physical or moral element, of the living animal, comprises, included in itself, a property repeated in all the others, that is to say the particularity of tending to harmonize with the rest, in such a way as to concur with them in a certain final and total effect; and this common intermediate explains not merely a prodigious number of characters in the animal, already enumerated by descriptive anatomy, but also an infinite number of other more delicate and intimate characters which our scalpels and microscopes are too clumsy to have yet attained.

We may now form an idea of the intermediate.—Take a law, or a couple of data connected together. What is their link? Whence comes their consolidation? What is the reason, the *because*, the interposed condition, which connects the second to the first? The reader has just followed this intermediate, and finds it reappear, always alike, under its different forms.—Sometimes it is simple, like the force of gravitation, which explains the fall of heavy bodies.—Sometimes it is multiplex; composed of many intermediates. Two cases then present themselves.—Either the components are successive—as is, with the sonorous vibration, the power of propagating itself in the surrounding medium, and then the power of propagating itself along the nerve as far as the cerebral centres; or else the components are simultaneous—as are the characters which combine to direct the earth in its course round the sun. Here again we must make a distinction.—Sometimes the simultaneous intermediates are of different kinds; as are, in the preceding case, the tangential force, the centripetal force, and the given distance from the earth to the sun. Sometimes the simultaneous intermediates are of the same kind, and are reduced to the same intermediate repeated in all the elements of the object. This last case is itself divisible into two branches.—Either the elements in which the intermediate is repeated are similar, like the units of the number, or the triangles of the polygon; or they are dissimilar, like the organs of the animal.—But simple or multiplex, composed of successive or of simultaneous intermediates, of different intermediates, or of the same intermediate repeated, of the same intermediate repeated by similar elements, or of the same intermediate repeated by dissimilar elements, the explanatory intermediate is always shown to us as a character or a sum of characters *included* in the first datum of the couple, *more general* than that datum when they are considered apart, and *accessible* to our grasp, from being comprised in it and separable from it, by our ordinary processes of isolation and extraction.

V. When once the intermediate is detected and represented in the mind by a corresponding idea, it effects within us an internal process which we term demonstration. Take one of the above-mentioned laws: every planet tends to approach a central mass with which it is in relation—the sun. This law is a couple of two data, one, which is the planet, the other, which is the tendency of the planet to approach the central mass, and the intermediate connecting them is a general datum, common, not only to all the planets, but to all bodies situated at their surfaces and to an infinite number of other bodies; I mean the property of being a mass, every mass having this character that it tends to approach the central mass with which it is in relation. Let us compare these three data with one another.—The first, the planet, contains the intermediate, that is to say the property of being a mass; it contains the intermediate as one of its characters among many others; with relation to the planet, the intermediate is an extract only. The planet, then, is more complex than the intermediate, and the intermediate is more abstract, that is to say more general, than the planet. On the other hand, this intermediate contains the last datum, the tendency to approach the central mass; it contains this datum as one of its characters, among many others; with relation to the intermediate, this datum is an extract only. The intermediate then, is more complex than the last datum, and the last datum is more abstract, that is to say more general, than the intermediate.—Thus the first datum of the law contains the intermediate, which contains the second. In another aspect the first datum is more complex than the intermediate, which is more complex than the second. In another aspect again, the second datum is more abstract and general than the intermediate, which is itself more abstract and more general than the first datum.—Having settled this, let us associate the three data in pairs; we shall have three couples of data, or laws. Every planet is a mass; now every mass tends to approach the central mass with which it is in relation; therefore, every planet tends to approach the central mass with which it is in relation, that is to say, the sun.—Of these three couples, the first associates the first datum and the intermediate; the second associates the intermediate and the second datum; the third associates the first datum and the second, and is found to be the law which required demonstration.—If we conceive the three couples in this order, we have three propositions corresponding to them and composed of three ideas, associated in pairs, as the three laws are composed of three data associated in pairs. Of these three ideas, the first, which is more comprehensive than the second, contains the second, which is more comprehensive than the third, and which contains the third, and the mind passes from the most comprehensive to the least comprehensive by means of the third, which is of medium comprehension.* Of these three propositions, the two first, being preliminary, are termed *premises*, and the third, being consecutive, is termed *conclusion*. The two premises are composed, one, of the first idea, the most comprehensive of all, associated to the second, which is of medium comprehension; the other, of the second idea, which is of medium comprehension, asso-

* In my opinion, it is in this order, according to comprehension and not according to extension, that the terms should be arranged. In this way, reasoning becomes an analysis, and not a logical trick, like the ordinary syllogism.

ciated to the third, the least comprehensive of all; and finally, the conclusion is composed of the first idea associated to the third, that is to say of the most comprehensive idea associated to the least comprehensive. Three propositions of this kind assembled in this order constitute a syllogism, and the syllogism, according to the saying of Aristotle, becomes a scientific demonstration, when, as in the preceding case, the intermediate by which it connects two data is the explanatory reason† of their connection.

§ II.

I. Let us leave to logicians the task of following out in all their details the properties of the syllogism, and the necessary relations of its propositions or terms; these are but the curiosities of science; the essential thing for the mind is to know what are the special characteristics and exact position of the explanatory intermediate, so as to be able to seek for, find, and recognize it. From its nature and situation, as we have ascertained them, we can arrange a general method of inquiry. Let us examine this method successively in the sciences of construction and in the sciences of experience.

Take a law of arithmetic, of algebra, of geometry, or of pure mechanics; the proposition which expresses it is termed a theorem; and this proposition affirms that a particular datum constructed by the mind—a number of any kind, a multiplicand, a square, a square root, a triangle, a sphere, an ellipse—comprises a particular property. It is here a question of demonstrating the theorem, that is to say of distinguishing in the first datum an intermediate which comprises the property enounced.—We have, then, to decompose the first datum so as to extract from it the intermediate, and it is this decomposition which, later back, when dealing with axioms, we termed *analysis*. In the Sciences of Construction,

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* δι' αἰτίων καὶ προτέρων. "Posterior Analytics," book i. chaps. ii. iv. vi. αἰτία signifies not merely the cause, but the *because* demanded. These second Analytics of Aristotle are very superior to the first, and are still worthy the attention of students of special sciences.

it can always be accomplished; there is no internal obstacle which prevents our detecting the intermediate; it is included in the first datum as constructed by our mind. In fact, the combination we have fabricated is purely mental; it is not bound to correspond to a real combination. It differs in this from the other mental combinations by which we conceive real objects; it runs no risk, as they do, of presenting blanks, of passing by any important character included in the real object, of omitting the explanatory intermediate which connects the enounced property with the real object; freed from this obligation, it is exempt from this risk. Once formed, it is complete, and whatever be the ideal object—number, square, straight line, figure, geometrical solid, velocity, mass, force—if the definition furnished is well constructed, the object is entirely and exactly expressed by it.* For, by hypothesis, there is nothing more in the ideal object than what we have put into it, and all we have put into it are certain elements grouped in a certain order, and expressed, together with their order, by the definition. Now, if this group has a property, it is through the medium of some character included in its elements or in their mode of assemblage, as expressed by the definition; hence it follows that the explanatory and demonstrative intermediate connecting the property to the group will be found by analyzing the terms of the definition.

Such is in fact the method employed in the Sciences of Construction. All the theorems are demonstrated by *analysis*, by the analysis of the terms of the definitions. We have already seen this in those first theorems with whose demonstration we dispense, and which we term axioms. We have defined equal magnitudes, the straight line, parallel lines, velocity, force, mass, and have found that the properties attributed by the axioms to each primitive compound are connected with it through the interposition of some latent, but inherent character, enclosed and concealed in its definition.

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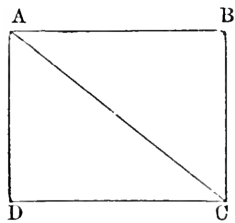
* See part ii., book iv., chap. i., pp. 175 *et seq.*

So it is with the later theorems concerning more complex compounds. Here, too, the explanatory and demonstrative intermediate is a character, more frequently a series of characters, included in the definition of the compound.—We all know how a theorem of geometry is demonstrated, as for instance, that which says that the opposite sides of a parallelogram are equal. We refer back to the definition of the parallelogram and find that it is a four-sided figure of which the opposite sides are parallel. As this double property is included in the definition, we extract it by analysis, and have the first of the intermediates we are in search of.—We analyze this, and on referring back to the properties of parallel lines, we find that, if we draw the diagonal A C, the two angles B A C, D A C, are equal to the two A C D, B C A, each to each, being alternate angles; which gives us a second intermediate. —But, on the other hand, the diagonal has formed triangles as well as angles; we then analyze this third intermediate, and, on referring back to the properties of triangles, we observe that the two triangles are equal, as having a common side, the diagonal, comprised between two angles equal each to each; hence it follows that A B is equal to D C, and A D to B C.—Thus, the first intermediate—the parallelism of each couple of opposite sides—is derived from the definition; the second—the equality of the two alternate angles which the diagonal forms with each couple of parallel lines—is derived from the first; the third—the equality of the triangles which the diagonal forms on each side with the parallel lines—is derived from the second, and finally, the equality of the opposite sides of the parallelogram is derived from the third. The definition, then, contains the first intermediate, which contains the second, which contains the third, which contains the fourth, which contains the property enounced. This forms, as it were, a series of boxes enclosed

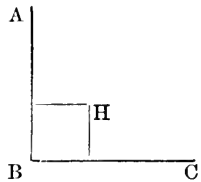


in one another; the largest is the first definition, and the smallest the last attribute; each larger box encloses a smaller one, and we cannot get at any one box till we have opened in turn all those enclosing it.—Observe the difficult part of the operation. Each intermediate contains many characters in addition to the one which we extract and which leads us up to the property enounced; we must not fall into error, and overlook the right one, to extract another. In other words, and to continue the comparison, every larger box contains, in addition to the smaller box in which we shall at last find the property enounced, several other smaller boxes which it would be useless to open; we must set our hand, then, on the right box, and if there are, as in the preceding case, five boxes to open, we must five times consecutively have the tact to make a proper choice.—Besides this, it is common to find boxes which do not open readily, a skilful turn of the key is required; we have been compelled to make a construction, to add a line to the figure, to draw the diagonal. And this turn of the key has, in opening one lock, opened by correspondence a second; in fact, this well chosen diagonal has not only given the two pairs of alternate internal angles—it has also given two equal triangles. In this lies the talent of the geometrician; he must, by a prompt instinct, or by numerous trials, successively open, without a mistake, the series of useful boxes, and must find out the appropriate turn of the key.

Let us now follow his steps: he begins by constructing very simple compounds, the single straight line, the straight line cutting another, the straight line perpendicular to another, two parallel straight lines. According to the process we have just seen, and through an intermediate, or arrangement of intermediates included in the definition of the compound, he connects with it several properties.—Then, combining together his primitive compounds, he constructs ulterior compounds, triangles, quadrilaterals, and polygons, by means of two, three, and more straight lines cutting each other in pairs; the circle, by a straight line turning about one of its extremities; the plane, by a revolving perpendicular which while revolving remains perpendicular to the straight line with the relation to which it was at first perpendicular; after this polyhedra, by planes terminating in polygons; the sphere, by a semicircle revolving about its diameter, etc. To these new compounds, he connects new properties by means of new theorems. What intermediates does he employ?—They may be recognized at a glance; they are the already demonstrated properties of the preceding compounds. The more complex compound has simpler compounds as its factors, and the properties of its factors, introduced into it with those factors, are the intermediates by which we connect to it the properties with which it is itself furnished. Just now we saw that the properties of the parallelogram were attached to it through the properties of the two pairs of parallel lines which form its elements. We should see in the same way that the properties of the sphere are attached to it through the properties of the revolving semicircle which generates it, and, in general, that the properties of any compound are attached to it through the properties of the simpler compounds which are its factors.—In this way, each new compound is a larger box into which we put several smaller boxes, with all they contain. In the one we term parallelogram, we put two pairs of parallel lines cutting each other. In the one we term circle, we put an infinite number of equal straight lines, having one common point. In the one we term sphere, we put an infinite number of equal semicircles having a common diameter, and the properties of the large box so constructed are attached to it through the properties of the smaller boxes which it contains with their contents.—Hence it follows that the ultimate reason, the ultimate *because*, the ultimate explanatory and demonstrative intermediate, which connects a property to any geometrical compound, recedes from box to box, and from containing to being contained, in proportion as we pursue it from the sphere to the revolving semicircle, from the revolving semicircle to the revolving line, from the revolving line to the simple line—that is to say, from the compound to its factors, from them to their factors, and so on, to allow itself to be seized at last in the primitive factors—that is to say, in the little elementary boxes in which it is included. Arrived here, we have in hand the ultimate reason of the geometrical law. It is given, in all the sciences of construction as in geometry, by the axioms; and the axioms give it, because they enounce the properties of the primitive factors.

Let us carefully consider this expression; the *ultimate* reason of a law. The laws we have discovered in the sciences of construction are of enormous number, and this number increases daily. Now the ultimate intermediates which explain and demonstrate them are the properties of five or six primitive factors, enounced by a dozen axioms, which are themselves, as we have seen, cases or applications only of the axiom of identity. From this single source, spread out into a dozen rivulets, flow the innumerable streams and waves of science. Such is the value of the primitive factors or elements, when they are as simple, as abstract, and as general as possible: from their laws are derived the laws of their less general and less abstract compounds, and so on, from stage to stage, by a gradual descent, without ever a failure of continuity, between stage and stage, from the highest wave to the lowest level. It is, then, to the primitive factors that the principal efforts of our method should be directed.—Hence a new way of considering magnitudes, and especially geometrical magnitudes. Take a straight line, or curved lines, and those principally among curves, which we were unable in the beginning to define except by the nature of the solid from which they are derived, as was the case with the sections of the cone—that is to say the ellipse, parabola, and hyperbola, and with other still more complex curves. Each of them has a form, and, when once the line is drawn, we see this form in the concrete. But the line is made up of primitive factors or *elements* which are its points, and its form is but a whole, the whole of the distinct positions occupied by its distinct points.

Hence it follows that there is a reason, a *because*, an intermediate to explain and demonstrate all the properties we can ascertain in the line and its form, and that this intermediate is met with in the elements of the line and of its form—that is to say, in the various points possessed of distinct positions of which the line and form are but the total.—Now, how do we determine the position of a point? Among other means, there is a very convenient one, which consists in taking in a plane two fixed axes A B, B C, which cut one another at a known angle, in drawing to the point, lines parallel to these axes, and in giving the lengths of these parallels. These two lengths, which we term co-ordinates, are magnitudes which, when compared together, present a certain relation. Here, then, we have the position of the point defined by the mutual relation of two auxiliary magnitudes.—Instead, now, of a single point, let us suppose a continuous series of points—that is to say a line, such that this relation may be *the same* for all its points; the line and its form will be wholly defined, and defined by a character common to their elements.



Thus, to confine ourselves to the simplest examples, if, the two axes being given, the line in question bisects the angle between them, all the points of the bisecting line have this common character that, for each of them, one of the two co-ordinates is equal to the other. If the line in question is a circumference, and the two axes are perpendicular to one another and pass through the centre of the circle, all the points of the circumference have this common character that, for each of them, the sum of the squares of the two co-ordinates is equal to the square of the radius. This constant relation which is everywhere maintained through all the pairs of co-ordinates, gives rise, when ascertained, to an equation; for the bisecting line, the first co-ordinate x added to the second co-ordinate y is equal to $2x$; $x + y = 2x$; similarly, for the circumference $x^2 + y^2 = r^2$.—This formula is what is termed the equation to the line; there is one for the ellipse, for the parabola, the hyperbola, for every curve, for every surface. There is a branch of geometry which makes an analysis in this way of a line or a surface, and on decomposing it into its elements, discovers in these elements an algebraical character common to them all; this science is termed analytical geometry. From the character expressed by the equation, we derive all the properties of the line; in other words, in order to attach the properties to the line, we find an intermediate, a reason, a *because* included in the equation which is the definition of the line.

We see how important is the consideration of the elements; in fact, it has been necessary to gain a true notion of magnitude, and to give to mathematics all their scope; it is this study which, under the name of infinitesimal calculus, constitutes the higher portion of the science. Instead of comparing two magnitudes taken in the mass, we compare the infinitely small increments of the two magnitudes, increments which are their component factors and their primitive elements. "It would be wrong," says a philosophical mathematician,* "to take this second mode of expression for nothing more than a conventional abbreviation, a form of language, apparently more convenient because more usually employed. It is, in fact, more convenient, but simply because it is the natural expression of the mode of generation or extinction of magnitudes, *which increase or decrease by elements smaller than any finite magnitude.* Thus, when a body cools, the relation between the elementary variations of the heat and time is the true reason of the relation which is established between the variations of these same magnitudes when they have acquired finite values. This last relation, it is true, is the only one which can fall directly under our ob-

* Cournot, "Traité de l'Enchaînement des Idées Fondamentales," i. 87, and "Traité Elémentaire du Calcul Infinitésimal," i. 82.—"In this respect we may truly affirm that infinitely small quantities exist in nature."

servation, and, when we define the first by the second through the intervention of the idea of limit, we conform to the conditions of our human logic. But, once in possession of the idea of the first relation, we conform to the nature of things, by making it the principle of explanation of the value which observation assigns to the second relation. This is why the notation of infinitesimal quantities, imagined by Leibnitz, constitutes an invention of capital importance which has marvellously increased the power of mathematics as an instrument, and the field of its applications to natural philosophy."

In all directions, the same conclusion springs up. In the sciences of construction, every theorem which enounces a law is an analytical proposition. Of the two data whose connection forms the law, the second is connected with the first, obscurely or clearly, directly or indirectly, by a third datum, reason, explanatory and demonstrative intermediate, which is contained in the first datum, and itself contains a series of subsequent intermediates enclosed in one another. Finally, if we inquire into the ultimate reason of the law, the ultimate intermediate, the ultimate *because*, after which every question is at an end, because the supreme explanation is furnished and the demonstration complete, we find that it is *a character included in the definition of the factors or primitive elements* of which the first datum is but the collection and the total.

II. We come now to the sciences of experience. Here the resources are fewer and the difficulties greater.—Let us take one of the laws examined above—namely, that cooling produces dew, that is to say the liquefaction and deposition of the watery vapor in the surrounding air.—Of the two data, cooling and liquefaction, whose couple forms the law, the first, according to the theory expounded, must comprise an explanatory character by whose intervention it is connected to the second. It is necessary, then, to decompose it in order to derive from it this intermediate.—But I am unable to effect this decomposition; the analysis which had entire grasp of mental combinations has not an equal grasp of real combinations. Having constructed the first, I know all they contain, since, by supposition, they contain nothing but what I have put in them. Not having constructed the second, I do not know all they contain, and to the portion of knowledge I possess, I must add by further discoveries the various portions I do not possess.—What is this cooling of watery vapor? At the time I establish the law by induction, I am ignorant of this. All I know of it is, that it is a change of state, occurring in the vapor, which excites in me the sensation of cold. This change is in itself unknown to me; all I know of it is one of its effects, and this I only know through a sign. We have now, with the aid of this sign and other indications, such as the variations of the thermometer, to study this change, to ascertain its intrinsic properties, and, for this purpose, again to employ induction.—Now, we discover by induction that cold applied to a body in whatever state, gaseous, liquid, or solid, *tends* to bring its molecules mutually together, and in fact does always bring them together, except in some exceptional cases, in which the tendency is neutralized by certain contrary tendencies which the bringing together may sometimes develop.* Here is a first explanatory intermediate, included in the characters of the chilled body and set apart by induction.—Now other inductions establish that a solid, liquid, or gaseous body is a system of molecules placed apart and possessed of attracting and repelling forces in relation to each other; that in proportion to their mutual proximity, the mutual proportions of the attracting and repelling forces are changed and reversed; that, during a first period—the gaseous state—the attracting forces may be considered as annulled by the enormous amount of the repelling forces, which explains the force of tension in vapors and gases; that at the end of this period, when the molecules are sufficiently proximate, there comes an epoch of equilibrium between the attracting and repelling

* For instance, the maximum of density, or of the bringing together the molecules of water, is found at 4 degrees (centigrade), and not below.

forces, an epoch differing according to the different constitution of the different bodies; that, during this stage, repulsion and attraction being almost neutralized by one another, the molecules which have neither mutual attraction nor repulsion suffer themselves to be readily disjoined, put forth no effort against what contains them, group themselves in a surface parallel to the horizon; in short, are fluid and present the sensible characters which constitute the liquid state, instead of the sensible characters which constitute the gaseous state; that later on, beyond this second period, when the molecules are again brought still closer, an epoch is presented in which the attracting forces have not only equality but marked ascendancy, an epoch differing according to the different constitution of the different bodies; that, during this third stage, the grouped molecules offer a more or less energetic resistance to forces attempting to detach them from the system, and, instead of the sensible characters which constitute the liquid state, present the sensible characters which constitute the solid state. Hence it follows that when a certain period is passed, the gas, whose molecules are brought sufficiently together, must become liquid, and the watery vapor must become water. Now we know independently by induction the limit at which this period comes to an end in the case of watery vapor; it is a particular degree of the thermometer for a particular quantity of watery vapor suspended in the air. Here is the second intermediate required.—If the cooling produces liquefaction of the surrounding vapor, this arises from its bringing the molecules of vapor together beyond a certain limit; if, beyond this limit, the approximating molecules arrive at the liquid state, this is because, when this limit is passed, the excess of the repelling over the attracting forces ceases without being turned in the contrary direction, and in consequence of this equilibrium, the molecules cease to have any noticeable mutual adherence or repulsion, which is precisely the liquid state. Approximation of molecules, equilibrium between the attracting and repelling forces of the molecules after a certain degree of approximation—these are the two intermediates by which the first datum of our law—cooling, is attached to the second—liquefaction, and the approximation is a property of the molecules of the chilled vapor. Equilibrium is a property of these molecules when brought sufficiently close. And finally, the liquid state as our senses perceive it, is a property of the equilibrium so attained.

Thus the first datum of the law contains among its characters the first explanatory intermediate, which contains the second, which contains the second datum of the law. Plainly, this enclosure is similar to that which we have already observed in the demonstration of the theorems.—No doubt, we have not here obtained the intermediates by the same method as before. It has not been sufficient for us to consult our conception of a cooling body; there were too many gaps in it; it taught us nothing except that the body which excites a sensation of cold in ourselves and a lowering of the mercury in the thermometer undergoes an unknown alteration. Experiments and an induction were required to discover this alteration, which consists in an approximation of molecules. And so, it was not enough for us to consult our conception of a body whose molecules approximate; here again there were too many gaps, it taught us nothing as to the effects of approximation. The great induction of Newton was required to enable us to recognize that the attraction of the molecules increases in the inverse ratio of the squares of their distances, whence it follows that, when a certain degree of proximity is passed, the attracting forces must form equilibrium with the repelling forces; and the inductions of other physicists were necessary to ascertain what degree of cooling induces this degree of proximity between the molecules of watery vapor.—But, if the processes of discovery have been different, the structure of things has been shown to be the same. In the experimental law as in the mathematical theorem, the first datum is a large box which, through a series of gradually diminishing boxes, encloses as its final contents the second datum. Only, in the experimental law it is not sufficient, as in the mathematical theorem, to set the hand each time on the proper box and to open it; we do not find the box at hand, in the mind; we must go els where, beyond the mind, and seize it where it is, that is to say in nature, and derive it thence with a great array of experiments and inductions. When this is effected, we transfer it into the mind, we fix it there in its place in the box from which it was missing, and when, by these excursions, we have thus procured all the necessary boxes, we have only to open them in their order, to pass uninterruptedly, as in a theorem, from the first to the second datum of the law.

Let us now consider those of the experimental sciences which are in a very advanced state, applied mechanics, physical astronomy, optics, acoustics, in which many of these boxes have been discovered and enclosed. Between the real compounds, of which these sciences treat, and the ideal compounds, of which the sciences of construction treat, the analogy is striking.—Take some of these real compounds, the motion of a cannon-ball impelled with a certain initial velocity along a tangent to the earth, the orbit described by Venus or some other planet, a certain succession of sonorous or luminous waves. Each of these compounds has its properties like the parallelogram or the sphere, and the proposition connecting some property to it, like the theorem connecting some property to the parallelogram or sphere, enounces a general law. Now, in this compound, as in the parallelogram or sphere, there are factors or more simple compounds which, introduced into it, have brought with them their characters; and if the compound possesses the property indicated by the law, it is owing, as in the parallelogram or sphere, to the isolated or combined characters of its factors. If the cannon-ball has a certain range, describes a certain curve, and undergoes a certain diminution of velocity, it is owing to the combined presence of a particular initial impulsion, of terrestrial attraction and the resistance of the air. If two luminous rays are in places extinguished by one another, or if two continuous sounds are at times pushed by one another, it is owing to the velocities of the two series of propagated waves which, in certain places and at certain times, interfere with and annul one another.—Hence it follows that, in the experimental as in the geometrical law, the properties of a more complex compound are connected with it through the intervention of properties of its factors or more simple compounds, that so it is with each of these factors, and that therefore, if we seek the ultimate intermediates, the ultimate reasons, the ultimate explanatory and demonstrating characters which establish the law, we shall see them recede, from the more complex to the less complex compounds, to permit themselves to be seized at last in certain very simple factors or primitive elements whose properties they are.

In fact, in each of the sciences we have mentioned, there are some very general laws corresponding to axioms; these give, like axioms, the ultimate reason of the established law, and they give it because, like axioms, they enounce the properties of the primitive factors. Such, for instance, is the principle in applied mechanics, that if a body loses or acquires a certain quantity of motion, the same quantity is acquired or lost by some other body. Such are the two principles on which astronomy is founded, the one which attributes to the planetary bodies of our system a tendency to move in a straight line with a uniform velocity along the tangent to their orbits, the other which attributes to them a tendency to fall towards each other and towards the central mass, a tendency in proportion to their masses and inversely as the squares of their distances. Such is, in acoustics and optics, the assumption of elastic media, through which waves of certain lengths are propagated with certain velocity in the direction of their primitive impulsions, or in a direction perpendicular to those impulsions.—From these laws there flow, as from so many axioms, a prodigious number of partial laws;

and the only difference separating sciences so constructed from the mathematical sciences, is that as, in these last, the axioms have been obtained by construction, we can mount by analysis higher than the axioms, to the principle of identity, which is their common source, while in the former, the fundamental laws having been obtained by induction, to mount above them we must again have recourse to induction, which to-morrow perhaps we may be able to effect, but which to-day we are unable to effect, and which compels us provisionally to consider them as primitive, until further discoveries place over them more general laws, and so depose them from the first to the second rank.

III. The same arrangement is found in the other less advanced branches of experimental science, in the theory of heat, of electricity, of chemical, vital, and historical phenomena. Here, too, the particular laws which we first attain, and which enounce the properties of the more complex compounds, find their explanation and demonstration in the more and more general laws which we subsequently attain, and which enounce the properties of more and more simple factors. Accordingly as we consider the different branches, we find that the operation, which is everywhere similar, has been pushed to greater or less distances; experimental science, as a whole, thus resembles a cathedral commenced in various points at once. Its pillars are of unequal height, some almost completed, others half built, others again scarcely provided with their first stages. But they all indicate by their gradual diminution and converging directions, that a loftier arch must finally reunite them.

Now this constant convergence shows us in what direction to apply our efforts, and what subsequent labor is required to continue the edifice. We have just seen that the properties of a compound are connected with it by intermediates, which are the properties of its factors, components, or elements; this is the universal rule. These elements, then, are what it is principally necessary to discover, and it is to their properties that we should direct our whole attention. The more readily, therefore, these elements fall under our observation, the more readily shall we explain and demonstrate the properties of the compounds formed by their assemblage. —This is precisely the case with the most complex compounds of all, those which are the object of the natural and historical sciences. And I venture also to assert, that the philosophical and higher portion of science is nowhere more advanced than here. A living body, plant or animal, is a society of organs; now, each of these organs is sufficiently large to be grasped by our senses, measured by our instruments, detailed by our descriptions, pictured by our drawings. It lends itself directly to study, and compared with those analogous to it, manifests properties which, joined with those of its associates, explain the character of the body whose elements they are.—There are two properties common to all the organs of a living body. One of them, mentioned above,* and explained at length by Cuvier, is the property of being *useful*, which imposes on the organ the obligation of its characters harmonizing with those of all the other associated organs, in such a way as to bring about some total and final effect, that is to say to render possible a certain kind of life, carnivorous, frugivorous, insectivorous, in the water, in the air, or on land, in presence of certain prey and certain enemies, in short, in a certain medium; we have indicated the infinite consequences of this property of every organ; they are so numerous and so certain that anatomists have reconstructed fossil animals from some of their fragments. There is a second property, discovered by Geoffroy Saint-Hilaire, and still more fruitful in consequences, that of *holding a place in a plan*. By the first, the organ is an instrument which fulfils an office; by the second, it is a part appertaining to a type. In this respect, whatever be the secondary modifications imposed on it by its passage from one animal to a different one, and its consequent adaptation to a new

* Part ii, book iv. ch. iii. p. 268.

usage, it remains fundamentally the same; it is never transposed; we find it always in the same place, and it shows itself through all the elongations, consolidations, impoverishments, changes of part, and even losses of employment, which it has undergone in its deformed, transformed, and atrophied state. The same group of anatomical articulations supplies the arm and hand in man, the wing in the bat, the paw in the cat, the leg in the horse, the fin in the seal; the natatory bladder of the fish is the respiring lung of the mammal. We often find in birds a little useless bone on the border of the wing, furnished, when they are young, with a nail, without use, except as representing a degraded finger; the crawling boa has vestiges of limbs, and we find in the slow-worm a rudimentary shoulder, sternum, and pelvis; the same slow-worm has, in its youth, two small projecting tubercles, the surviving and temporary remnants of stunted hinder limbs. A part, then, has the property of exciting by its presence the presence of a whole system of parts, arranged according to a fixed pattern, which gives us the rough framework of the whole animal, and has, besides, the property of determining by its structure and function, the structure and function of the other parts which gives us the whole structure and group of the functions of the complete animal. In this way, two properties common to the elements of the group explain nearly all the characters of the group, and philosophical anatomy furnishes the reason of the laws which descriptive anatomy had ascertained.

And so, in those human societies whose fixed or changing characters are the subject-matter of history, the elements, which are readily seized, enable us to comprehend the whole. For these elements are the human individuals of whom a society at any given epoch is the collection only, and we have no difficulty in detecting their common characteristics. By means of existing records, and by the exact processes of methodical reconstruction, we are at present able to suppress the distance of time so as to represent to ourselves by more or less numerous specimens, the Frenchman or Englishman of the seventeenth century or of the Middle Ages, the ancient Roman and even the Hindoo of the Buddhist epoch, to picture to ourselves his life, private, public, industrial, agricultural, political, religious, philosophical, literary, in short, to construct the descriptive psychology of his moral and mental state and the circumstantial analysis of his physical and social medium, then, to pass from these elements to still simpler elements, to discern the aptitudes and tendencies which were found effective and preponderant in all the processes of his mind and heart, to note the general conceptions which determined every detail of his ideas, to mark the general inclinations which determined the directions of all his actions; in short, to distinguish the primordial forces which, present and in action at each moment of the life of each individual, impress on the total group, that is to say on the society and the age, the characters which observation has recognized there.* Wherever we are able thus to isolate and observe the elements of a compound, we can, from the properties of the elements, explain the properties of the compound, and, from a few general laws, can deduce a host of particular laws. This is what we have done here; we have first descended by degrees to the ultimate elements of cognition, to ascend thence stage by stage up to our simplest cognitions, and thence, still by degrees, up to more complex ones; in this scale, each step possesses its characters by the intervention of characters which were manifested in the lower steps.

This is why, when, in this progressive decomposition, we arrive at compounds in which our consciousness, senses, and instruments are unable to discover simpler elements, explanation is at a standstill and is reduced to conjectures. On

* I have attempted to apply this method in many historical essays, and have explained it in the preface to "Essais de Critique et d'Histoire," and in that to "Historie de la Littérature Anglaise."

our road we have met with sensations, those of touch, smell, and taste, in which we have been unable to distinguish elementary sensations, and all that analogy permits us is to conceive that there are such. A similar limit is created by a similar difficulty in the other experimental sciences.—By means of the microscope, physiologists and embryogenists have resolved living tissues into anatomical elements, little bodies which are most frequently cells of various forms and variously grouped; but they have not grasped the elements of the cell, they are ignorant of their properties, at least, they are not at present ignorant of them; in the liquid formless pulp which becomes organized into a little cell furnished with a nucleus, they are unable to distinguish the particles and *à fortiori* to distinguish their properties. At the most, they conjecture that these elements are chemical molecules of extreme complexity, and that their mutual reactions group them in a certain visible form.—So again, chemists and physicists establish by their experiments that the ultimate particles of a homogeneous body are molecules or little masses exactly alike, that, if the body is simple like oxygen, each molecule is simple and consists entirely of oxygen; that, if the body is compound like water, each molecule is composed of two or more little elementary masses, one of which is oxygen and the other hydrogen. But as to these molecules, no one has seen or can see them; we are ignorant of their form, their weight, their distance, their mutual situation, the magnitude of the attracting and repelling forces which maintain them in equilibrium, the amplitude and velocity of the vibrations which we suppose they have about a supposed centre of oscillation. At the most, following these indications, we conclude that, from these unknown properties, are derived the known properties of the whole body, the greater or less affinity it has for some other body, the reaction it excites or undergoes, the property it has of combining with some other body in definite and invariable proportions, the equivalence of a certain weight of the first and a certain other weight of the second to combine with the same weight of a third, etc.

In face of elementary sensations, living cells, chemical molecules, ethereal atoms, the scientific man is in the position of a short-sighted person before ant-hills of various kinds; his dull sight can only attain effects of the mass, changes of the whole, the entire form of the edifice; the little workmen escape him; he does not see them labor. He can take a quarter or half of one of their constructions, can upset it with its inhabitants on another, can observe, first, an agitation, a confusion, then an abatement, an arrangement, and a new development; nothing more. As he is a skilful handler of experience and induction, he has finally recognized that there are in each heap invisible inhabitants, and in each different heap different inhabitants, that certain mixtures succeed better than others, that it is always necessary to preserve certain proportions, that after the mixture the new edifice presents characters which are not manifested in either of the two unmixed heaps. But he would require far more piercing eyes to discover the economy of the two primitive constructions, the instinct of their ants, the dealings set up between the two associated populations, and the final economy of the subsequent edifice which they together construct. Assume that, in these societies of molecules we term bodies, the inhabitants and materials are one and the same thing; the comparison will be exactly applicable.

Thus, at a certain limit, our explanation is at a standstill, and though, from age to age, we push it further on, it is possible that it may always stop before a certain limit. If ever we know exactly the form, distance, magnitude, and weight of molecules of oxygen or sodium, as well as the amplitude and velocity of their oscillations, we shall perhaps be in face of a system analogous to our solar system, a kind of vortex whose roughly similar elements require a further decomposition, and whose properties only admit of explanation by the wholly different properties of their elements—so again, with the elements of their elements, and so on, up to infinity. For magnitude is always relative; there is nothing to prevent our molecules from having as elements different molecules as small with relation to them as they themselves are with relation to a planet, and so on, without truce or termination. In this case, the successive layers of more and more simple factors would differ as the successive digits of a non-recurring decimal.—Perhaps, on the other hand, at a certain point of decomposition, all difference between the compound and the factors is at an end, and the properties of the compound are nothing more than the sum of those of its factors, just as the whole weight of a body is nothing more than the sum of the weights of its molecules; in which case the limit would be attained, since, knowing the properties of the compound, we should thereby know the properties of its final elements. In this case, the successive layers of more and more simple factors would be similar, after a certain limit, as are, after a certain limit, the successive digits of a recurring mixed fraction.—But whether the properties of the compound and its factors are similar or different is of no importance; and we invariably direct our observations or conjectures to the properties of the factors. The structure of things, then, is the same in the sciences of experience as in those of construction, and, in both, the explanatory and demonstrative intermediate which serves as a link between any property and any compound is *a character*, or *a sum of characters*, different or similar, *included in the elements of the compound.*

IV. There remains a surplus of requirement special to the experimental sciences. When we construct by thought some number, some polygon, or some cylinder, we have not to explain its origin; it does not in fact exist in nature; it is possible only, and not real. Perhaps indeed, with a nature constituted like that which we observe, it is not possible; but this is unimportant. We suppose its elements combined in the required manner, and explain by their properties the properties of the construction thus effected, without encumbering ourselves with the inquiry as to the forces by which they were themselves assembled. It is enough for us that the compound is given; we do not inquire why it is given.—Things do not happen thus when real compounds are in question. We are bound to explain their properties by the properties of their elements, and further, to explain the concurrence of their elements. Then come in questions of origin, the most curious, but most difficult, of all. For, as this concurrence is in most cases of very great antiquity, and can have had no witnesses, we can neither observe it directly nor know it by tradition, and are reduced to conjecture it from present concurrences, which are but approximately similar, and are sometimes entirely wanting. All the experimental sciences have thus their historical chapter, more or less conjectural, according as more or less precise indications, more or less correct analogies, more or less complete records, permit our mental reconstruction more or less exactly to replace the missing evidence of our consciousness or our senses.

For instance, there is a question for the astronomer, as to the formation of the various planets, for the geologist, as to the formation of the successive strata of the outer crust of the globe, for the mineralogist, to discover how the different rocks were formed, for the naturalist, to know how our species of plants and animals were formed, for the historian, to detect the formation of the successive epochs of one and the same human society, and the different traits of a national character. They all start from an anterior state denoted by converging indications, or attested by transmitted records, and from this probable or certain state they deduce, according to existing laws, the following state, then the next following state, and so on, up to the existing state.

Thus Laplace assumes that our system was at first an immense nebula extending round a central nucleus;* that this vast atmosphere, becoming condensed as it cooled, was divi-

* "Exposition du Système du Monde," ii. 425.

ded into concentric zones of vapor similar to the rings of Saturn; that, by a subsequent condensation and cooling, these zones became collected into planets, which were first gaseous, then liquid, then solid; and, from this gradual condensation, combined with the law of gravitation, he deduces, by a marvellous adjustment, the principal characters and even the singular peculiarities which our system nowadays presents. —Taking up this supposition at the point where Laplace left it, geologists trace with probability the thickening of the terrestrial crust, and explain, from epoch to epoch, with gaps becoming gradually fewer, the deposition and superposition of the strata, their partial upheavals, their erosions, their ruptures, the present disposition of our continents and seas, by the prolonged play of the mineral or organic forces in the midst of which we are now still living.†—At their side, their allies, mineralogists and chemists, see that rocks and amalgams similar to those which the earth presents are formed under their hands and eyes, by slow actions, by prolonged heat, by continued compression, by molecular additions,‡ and from the processes they now observe in their little artificial laboratories, they draw conclusions, with fitting precautions, as to the analogous processes by which the amalgam and the rock were formed of old in the great laboratory of nature.

Here come in the naturalists. Darwin starts with a fundamental character common to all the species of animals and vegetables, the struggle for life, from which there follows the destruction of all individuals less properly adapted to their medium, the exclusive survival of the individuals best adapted to their medium, the privilege these have of propagating the race, the successive acquisition of useful characters, the transmission to descendants of all the accumulated treasure of useful characters, and finally, through this, the progressive

† See, as to this, Lyell's "Principles of Geology."

‡ Crystals of granite have been found at Plombières, in the concrete on which the Romans built. They have been formed there by the infiltration of water for eighteen hundred years.—M. Daubrée and M. de Sénarmont have produced in their laboratories a great number of natural compounds.

modification of the species, the gradual perfectionment of the organs, and the slow adaptation of the individual to its definitive medium.—Provided with this existing law, he explains, by its former presence, the assemblage of the organs of which Geoffroy Saint-Hilaire and Cuvier had ascertained the properties.—By one of these properties the organ is a part in a plan and in a type; that is, the legacy of a common ancestor. All mammals are descended from a mammal* "which had its limbs constructed on the existing general pattern which we now find throughout the whole class." All insects are descended from an insect "which had an upper lip, mandibles, and two pair of maxillæ, these parts being perhaps very simple in form." If the type is found to be the same throughout so many different species, it is because all these species repeat, by virtue of inheritance, the characteristics of their common progenitor.—By the other of these properties, the organ is a useful instrument which brings its structure and function into harmony with those of the others, in such a way that the different species can subsist in their different media; this is because, owing to continuous selection, the common pattern bequeathed by the common progenitor is modified, here in one direction, there in another, so as to accommodate its details to the differences and changes of the medium. The same parts of the same limb become thin and elongated in the bat-shortened and soldered in the whale, so as to be fitted for flying in the first case, and swimming in the second. If the type varies from species to species, it is because circumstances have varied from group to group, and the variety of circumstances has produced the variety of acquisitions.—When this is settled, we are capable of tracing mentally through the immense duration of geological periods, from the protococcus and amœba up to man, the formation, addition, and assemblage of the parts which now constitute an organized body. It is a

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* Darwin, on "The Origin of Species," p. 435.—See, as to the theory of evolution as a whole, the very bold, precise, and most suggestive work of Herbert Spencer, "Principles of Biology."

living edifice in which selection has superimposed, from species to species, and upon a common type transmitted by inheritance, useful differences. Just as, in a house, the carpenters and masons first construct the walls and lay down the floors, after which come joiners, painters, and upholsterers to arrange the apartments. We see that the second set of workmen has succeeded to the first, to resume and complete the commenced construction. And so, many generations of ancestors have successively labored to construct each of our species. One of these generations, the primitive and most ancient of all, has established the most general type which is common to all animals of every subkingdom, articulate or vertebrate. The second, a later one, issuing from this last, has superimposed differences which constitute the class—that is to say the bird, the fish, or the mammal. Then has come the third, which starting with the mammal, has elaborated the transmitted work and formed families—that is to say the cetacea, the cheiroptera, the ruminantia, the carnivora, the primates. Then, finally, have the descendants of the primates, by their distinct developments and increasing divergencies, constituted genera, the gorilla, the orang-outang, and man, the latter being distinguished from the rest by a particular conformation of limbs, and a more delicate structure of the brain.

Here comes in the historian: he takes a people at a given moment. By the combined influence of the former state and of hereditary aptitudes and faculties, he explains the social, intellectual, and moral state at the given moment; by the combined influence of this new state and of the same hereditary aptitudes and tendencies, he explains the social, intellectual, and moral state at the later moment, and so on, either by reascending the course of time from the contemporary epoch up to the most ancient beginnings of history, or by descending the course of time from the most ancient beginnings of history down to the contemporary epoch.—We may conceive that in this prodigious evolution, which extends from the formation of the solar system to that of modern man, the gaps are great and numerous; this is in fact the case, and our materials for filling them are often reduced to conjectures. A history like this is a torn, blotted book, in which some chapters, the last especially, are almost entire, in which, of other earlier ones, there subsist but two or three scattered pages, in which, of the earliest chapters, the titles alone remain.—But every day a new discovery restores a page, and the sagacity of scientific men has detected some portion of the general thought. Thus it is that, within the last fifteen years, we have rediscovered the traces and marked the successive advances of the human race preceding our geological epoch; and an entirely recent law, that of the conservation of force, derives by transformation all existing forces from the primitive forces which the nebula of Laplace comprised in its earliest state.*

From all these great fragments of rigorous or approximative explanation, a universal truth is manifested: that the question of origins is no more mysterious than that of characters. When given a compound, its properties are explained by the properties of its united elements. When given this union, it is explained by the properties of these same elements and by the antecedent circumstances. It is, like so many others, an effect only, and, like all the others, it has as reason the combined presence of a group of fixed with a group of changing conditions.—To form the planet, there was a fixed state, the gravitation of the gaseous molecules carried round the central nucleus, and a changing condition, the progressive cooling and consequent gradual condensation of these same molecules.—To form the species, there was a fixed condition, the transmission of an older general type, and changing conditions, the new circumstances which, selecting the subsequent ancestors, added to the type the characters of the species.—To form a particular historical epoch, there was a

* See, as to this, Helmholtz, "Mémoire sur la Conservation de la Force" (tr. Pérard), pp. 31–34 *et seq.*

fixed condition, the maintenance of the national character. and a changing condition, the new state in which the nation happened to be placed on emerging from the preceding epoch. —Hence it follows that, in questions of origin, as in other questions, there is an explanatory and demonstrative intermediate, that the re-union of the elements has its reason of existence, just as the characters of the compound have their reason of existence, that it is, like them, a product, and that all the difference between the two products consists in this, that, as the first is historical and the second not historical, the first comprises a factor more than the second, namely, the influence of the historical moment, that is to say of the preliminary circumstances and the antecedent state.

§ III.

I. Let the reader now collect and glance over the conclusions to which we have just arrived; he will find that they converge, and will be led by their convergence, towards a universal law of a higher order, which governs every law. Take any couple whatever of any data whatever; as soon as they are actually connected, there is a reason, a *because*, an intermediate which explains, demonstrates, and necessitates their connection.—This is true for cases, or couples of particular data, just as for laws strictly so called, or couples of general data; there is a reason for the fall of this leaf which has just come to the ground, and for the gravitation of all the planets towards the sun, for this night's dew, and for the liquefaction of all vapor, for the beat of the pulse I feel at this very moment in my wrist, and for the presence of any function or apparatus in any living being.—It is true for the laws in which the first datum is a more complex compound, as for the laws in which the first datum is a more simple compound; there is a reason for the total acts of a human society, and for the individual acts of its members, for the properties of a chemical compound, and for the properties of its constituent substances, for the effects of a machine, and for the effects of its wheelwork.—It is true again for the laws concerning mental compounds as for the laws concerning real compounds; there is a reason for the properties of the ellipse or cylinder as for the properties of water or of granite.—It is true again for the laws governing the formation of a compound as for those by which it possesses its characters; there is a reason for the formation, as well as for the properties, of a planet or of a species.—But the most remarkable point is, that it is true for the laws whose explanation is still wanting as for those whose explanation we now possess. There is a reason for the attraction which all masses exercise on one another, for the properties of oxygen, for the formation of a living cell, for the origin of our nebula. At all events, we believe this. We cannot show this reason, but we are persuaded that it exists; we anticipate it by a bold affirmation as to our future discoveries, and even as to discoveries which perhaps we shall never make.

Besides this, we indicate beforehand the position and principal characteristics of the intermediate which still escapes us.—We assume that if two masses attract one another, it is by virtue of a simpler and more general character, included in the group of characters which constitute these masses, such as would be an incessantly repeated impulsion superadding at every moment an effect to the preceding effect, which we express by saying that attraction is a force whose action is not momentary but continuous, which enables us to conceive the velocity of the falling mass as the sum of all the velocities acquired since the first moment of its fall, which has led some physicists to explain the attraction of two masses by the continuous impulsion of a surrounding ether.—We assume that if oxygen presents such or such characters, it is by virtue of simpler and more general characters appertaining to its elements, and consisting of the masses, distances, and internal movements of its component atoms.—We assume that if a formless liquid becomes organized into a cell, it is owing to the mutual reactions and previous state of the very complex particles of which it is the aggregate, and that if our nebula formerly sprung into being, it was due to the forces of its molecules, and to the influence of a previous state which we cannot, even by conjecture, represent to ourselves.—In our view, not only does the explanatory and demonstrative intermediate exist in all these couples, though it may elude our grasp; but further, it is a simpler and more general character than the first datum of the couple, it is included in that datum and appertains to its elements, and the properties of that datum, as well as its origin, have as their ultimate reason of existence the characters and previous state of its ultimate elements.

On these indications, our thought flies off to extend this structure of things beyond our world and history, throughout the two gulfs of space and time, beyond all the distances to which imagination can attain, beyond all the confines which numbers or quantities, fruitlessly swollen and heaped together, can denote to the pure reason. Are we justified in acting thus? And what motives can we allege to authorize a supposition which anticipates, not only all future experience, but all possible experience, and involves in the immensity of its forecast the immensity of the universe?

II. Two series of cases confront us, a considerable one made up of all the facts and laws whose reason we know, another prodigiously disproportioned and infinitely greater, since it is infinite and made up of all the facts and laws whose reason we do not know. Here are two indications, one positive, the other negative, one favorable to our supposition, the other seemingly unfavorable.—But this unfavorableness is apparent only. For if, when we know the reason of a fact or law, we can conclude its existence, we cannot, from our ignorance of it, conclude its absence. This reason may exist, though unknown, and, in fact, if we look back on the past states of our knowledge, we find that on many occasions it existed, though unknown. We see daily, in proportion as science becomes extended and precise, the first series increasing at the expense of the second, and analogy leads us to believe that cases still comprised in the second are similar to those which have ceased to be comprised in it. The further our extended experience drives back our horizon in time and space, the more explanatory reasons do we add to our store. It is sufficient to examine the history and nature of experimental science to recognize that, if there were or still are voids in this store, it never arises from the explanatory reason failing or having failed in things, but always from its failing or having failed in our minds. It was existing in nature; but scientific men were imperfectly instructed, and had not yet discovered it. It now exists in nature; but we are unable, and perhaps shall never be able, to detect it there. The gap arises not through its absence, but through our ignorance or impotence, and the fault is not in things, but in ourselves.—If in Kepler's days the motion of the planets could not be explained, it was because gravitation was then unknown. If, at present, we are unable to explain why pure carbon, according to its different states, furnishes, with the same molecules, compounds as different as the diamond and graphite, it is because we do not know the velocities and masses of its molecules, and so cannot define their various states of equilibrium. To detect the explanatory reason, as we have defined it, certain conditions are required, and if these conditions are not fulfilled, the reason may indeed be present, we shall not be able to distinguish it. To detect the reason explaining the characters of a compound like graphite, it is necessary that we should know the properties of its elements, the molecules of carbon. To detect the reason which explains the origin of the first organic compound, it is necessary that we should know, besides the properties of its elements, the primordial circumstances in which they were assembled. This is why we shall be unable, while these preliminaries fail us, to know the explanatory reason. So long as they are attained by simple conjecture, it will be attained by simple conjecture, and we shall be at a greater or less distance from it, according as we are a greater or less distance from them.—Hence it follows that our ignorance of it is never an indication of its absence, from which it follows that we have no ground to suppose its absence, at any period even for events which preceded the origin of our nebula, or at any place even beyond the furthest points of the visible firmament. That our experimental science has gaps is incontestable: but its structure is sufficient to account for them, and it is against all the rules of hypothesis to account for them by the arbitrary and useless addition of an unascertained cause to the ascertained cause which is sufficient.

Excluded on one side, presumptions are compelled to turn to the other. As there is no choice except between the presence and absence of the explanatory reason, the chances, when no longer in favor of its absence, become in favor of its presence, and the balance inclines towards the other scale. —It would incline further still in this direction if we could point out sciences free from the conditions imposed on experimental science, and thereby finding an explanatory reason for all their laws. For such a contrast would afford room for the belief that the gaps of experimental science have the conditions to which it is subject, not only as their *sufficient*, but also as their *single* cause; from which it would follow that experimental science, when freed from these conditions, would thereby fill up these gaps, and that the explanatory reason, being everywhere discovered, would exist everywhere.—Now this is precisely the contrast presented by the sciences of construction when compared with the sciences of experience. In the first, all the explanatory and demonstrative intermediates which connect any property to any compound, from the first to the last, are known and therefore exist; there is not one of their laws which does not manifest and which therefore does not possess, its *because* and its reason.—It is to be presumed, then, that if we could employ in our experimental sciences the processes we employ in our sciences of construction, we should arrive at the same discoveries, and that just as every law in the last has its reason of existence, so has every law in the first.

This probability becomes stronger still, when we observe that the laws of the second may be discovered, like the laws of the first, by the inductive method, and that if we follow this method in the second as in the first, the reason of the law then remains unknown though present. Consequently, the inductive process is the sole cause of our ignorance in this case: hence it follows with all probability that in other cases, that is to say in the experimental sciences, it is still the sole cause of our ignorance, and that, in other cases as in this, the explanatory reason is always present, though it may always elude us.—In fact, suppose, as we did before,* the case of a man of very exact and very patient mind, very skillful at induction, but capable of induction only; we request him to ascertain the number of right angles to which the angles of any quadrilateral are together equal. Let us assume this time that he has at hand a number of perfect quadrilaterals, that his instruments of measurement are perfect, and that he applies them with perfect exactness. By a series of inductions similar to those we have described, he will finally discover that the angles of every quadrilateral of whatever kind, trapezium, parallelogram, rhombus, rectangle, or square, are together equal to four right angles; but his knowledge of quadrilaterals will stop here, that is to say at the point attained by the most advanced branches of our experimental science. He will ascertain a law which will be inexplicable to him, just as some chemical or physical law is inexplicable to us. He will have connected to every quadrilateral a constant property, the equality of its angles to four right angles, as we connect to every white crystal of carbon a constant property, octohedric structure. But he will not have discovered, any more than ourselves, the intermediate which necessitates the connection. In his case, this intermediate is a property of the two elementary triangles of which

* Part ii, book iv., chap ii, p. 226.

the quadrilateral is the possible sum. In our case, this intermediate is a property of the elementary molecules of which the white crystal of carbon is the real sum. He will miss his intermediate, then, as as we miss ours, by a defect of method, which can be remedied in his case, but which cannot be remedied in ours. We have, then, every ground for belief that if, like him, we could apply a remedy, and if to inductive experience we could add, in our case, as in his, deductive analysis by way of supplement, the attained intermediate would manifest its presence in our case as it does in his.

We thus arrive at considering the sciences of construction as a preliminary copy, a reduced model, an indication revealing to us what the sciences of experience might be, an indication similar to the little waxen edifice which architects construct beforehand with a more manageable substance, to represent on a small scale the proportions and total aspect of the great monument they are in process of erecting, and which perhaps they will never complete.—In fact, if we look at the ideal and the real world, we perceive that their structure is similar. In the first, as in the second, there are elements and compounds, elements of elements and compounds of compounds, objects capable of being classified, species, genera, and families, families of lines and surfaces ranged beneath one another according to the degree of their equations, less general laws explained by more general laws, and a number of other characteristics no less essential, and common to both. Therefore, the two orders are analogous.—But, besides, all the materials of the first are found in the second. For we have seen that numbers, lines, surfaces, solids, motions, velocities, forces, exist, not only in the mind, but also in nature; it is in nature that the mind discovers them, and from nature that it extracts them. All its special work consists in combining them in its own way, without troubling itself to inquire whether there are in nature real outlines which adapt themselves to the mental outlines, whether there is any actual sphere or ellipse corresponding to the ideal sphere or ellipse.—There remains, then, a single difference which separates our artificial compounds from natural compounds; the first are more simple, and the second more complex; Euclid's straight line is simpler than the imperceptibly bent line which a ball describes in the first metre after it leaves the cannon; the slightly indented ellipse described by a planet is more complex than the geometrical ellipse. For this reason we study the mental compound before the real compound, and the knowledge of the first leads us to the knowledge of the second. Herein lies the whole secret of the services which the sciences of construction render to the sciences of experience; thus it is that the first have their application in the second. Given two compounds, one mental, the other real, they become adapted to one another with this difference, that the second comprises supplementary and perturbing elements in addition to the elements which constitute the first, and this renders the first simpler, and the second more complex. We take account, by turns, of this general adaptation and this subsidiary difference. We discover by the sciences of construction, the properties of the first compound, the geometrical straight line or ellipse; then, on account of this general adaptation, we attribute them provisionally to the path of the bullet or the planet's ellipse, and thus obtain ideas which are almost, but not wholly, exact Having done this, on account of this subsidiary difference, we gladly introduce into our ideas the supplementary and perturbing elements in nature which bend the path of the ball or indent the planet's ellipse. Thus, from the provisional path and ellipse, which were too simple, and therefore approximate only, the mind passes gradually to the definitive path and ellipse which, while growing complicated, become exact. By this progressive rectification, our idea, which was at first rigorously adjusted to the ideal compound only, finally becomes rigorously adjusted to the real compound. It was in a science of construction that it took its origin, and it is in a science of experience that it finds its use.

Hence follows a consequence of capital importance, that at every place and time, outside our history and world, as well as in our history and world, the theorems are capable of being applied. In fact, it is sufficient for this that the real compounds, whether near or distant, should enter into our mathematical outlines, and they necessarily enter them, when they have number, situation, or form, when they possess motion, velocity, or mass, when they are subject to forces, that is to say to any conditions of motion. Stuart Mill, then, is wrong to say that "in distant parts of the stellar regions, where the phenomena may be entirely unlike those with which we are acquainted, it would be folly to affirm confidently the prevalence of any law, general or special," and that, "any one accustomed to abstraction and analysis, who will fairly exercise his faculties for the purpose, will, when his imagination has once learnt to entertain the notion, find no difficulty in conceiving that in some one, for instance, of the many firmaments into which sidereal astronomy now divides the universe, events may succeed one another at random, without any fixed law; nor can anything in our experience, or in our mental nature, constitute a sufficient, or indeed any, reason for believing that this is nowhere the case."—No doubt it is possible that bodies do not there attract one another. But there, as with us, if, through the application of any force, a body takes, for a time as short as we please, a uniform rectilinear motion, it will tend to continue it indefinitely; for, the axiom being necessary, as soon as the first of its two data exists in fact, the second cannot fail to exist in fact.—And moreover, whatever be the body and whatever be its motion, if this motion be regarded in a purely mechanical aspect, it will, there as with us, be necessarily wholly determined by the magnitudes and directions of the forces whose effect it is; so that, there as with us, it will be found by the solution of a mechanical problem, and will only resist solution, if the complication of its elements be so great that our formulæ are not yet sufficiently advanced to comprehend them; for, not only, as we have seen, are the sciences of construction, being necessary, universal, but again, their application is thereby universal. Indeed real compounds, so far as they are formed of the same elements as mental compounds, are subject to the same universal and necessary laws, and nature, in this aspect, is nothing more than applied arithmetic, geometry, and mechanics.

It remains to be seen whether nature is not more than this. Now, as far as we can judge, and according to recent discoveries, all changes of a body, physical, chemical, or vital, are reduced to movements of its molecules; and so again, heat, light, chemical affinities, electricity, gravity itself perhaps, all forces producing these changes and producing movement itself, are reduced to movements. Hence it follows that in visible nature there are nothing but bodies in motion, bodies motor or movable, motor and movable in turn, motor when their preliminary motion is the condition of the motion of another, movable when their consecutive motion is the effect of the motion of another; which reduces all corporeal change to the passage of a certain quantity of motion transferred from the motor to the movable body, an operation which, as we are assured, takes place without gain or loss, so that at the end of the circuit, the expenditure is exactly covered by the receipt, and the final force is found to be equal to the initial force.—If this admirable reduction were true, first for our world, and then besides for all beyond our world, not only all our physical, chemical, and physiological problems, but further all problems concerning any actual body whatever, would be at bottom pure mechanical problems. Observable compounds would differ in nothing, except complication, from constructed compounds; and just as the formation, properties, alterations, and transformations of every mental compound, whether arithmetical, geometrical, or mechanical, have their reason of existence, so would there be a *reason of existence* for the formation, properties, alterations, and transformations of every real compound.

III. We have here considerable probabilities, and may sum them up by saying that there is no analogy to authorize our supposing the absence, in any case, of the explanatory reason, while many analogies lead us to suppose its presence in all cases. Still we have here probabilities only, and must examine whether the enounced principle has no better support. On commencing any new inquiry, scientific men assume the principle, and indeed, are compelled to do so; for, without it, as we have seen, they could not perform induction.* Given any phenomenon, they invariably assume beforehand conditions forming its reason of existence and whose reunion is sufficient to produce it, so that the phenomenon cannot fail in any of the cases in which these conditions are reunited. "There is an absolute determinism," says Claude Bernard,† "in the conditions of existence of natural phenomena, as well for living, as for inanimate bodies. . . . When the condition of a phenomenon is once known and fulfilled, the phenomenon must invariably and necessarily be reproduced at the will of the experimenter. . . . . Phenomena can never contradict one another if they are observed under the same conditions; if they exhibit variations, this necessarily depends on the intervention or interference of other conditions which cloak or modify these phenomena. Hence there is room for attempting to know the conditions of these variations; for we could not have the effect there, without a cause. This determinism thus becomes the basis of all scientific progress and criticism. If, on repeating an experiment, we find discordant or even contradictory results, we ought never to admit real exceptions or contradictions, for this would be anti-scientific; we must simply and necessarily conclude that there are differences of conditions in the phenomena, which may or may not here explain them. . . . As soon as the laws are known, we cannot have exceptions. . . .

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* Part ii. book iv. chap. ii. p. 202 *ante*.

† "Introduction à l'étude de la Médecine Expérimentale," pp. 115 *et seq.*

We must forcedly admit as an axiom that, in identical conditions, every phenomenon is identical, and that as soon as the conditions are no longer the same, the phenomenon ceases to be identical." We see that the words *necessarily, forcedly, axiom*, are here employed.—Helmholtz employs equivalent expressions.* According to him, we cannot otherwise conceive the world. Our eyes cannot perceive extension except as colored; and so, our intelligence cannot conceive facts except as explicable. There is nothing conceivable by us except what is explicable, just as there is nothing visible by us except what is colored. The internal eye has, like the external, its innate structure from which it cannot be set free, and which imposes on all its conceptions a necessary character. Helmholtz seems here to believe that this constraint has for ultimate cause, the structure of our mind.—With him and Claude Bernard, we recognize the constraint as a fact; but we do not conceive its ultimate cause to be in the structure of our mind; for we have already seen many analogous necessities of belief. There is one such for each of the axioms of mathematics; they all exert on our mind the same ascendancy as the axiom of explanatory reason; and still, we have demonstrated them; we have shown that they have a foundation in things, that they are valid, not only for us, but in themselves, that their empire is absolute, not only over our intelligence, but also over nature, that if the two ideas by which we conceive them are forcedly connected, it is because the two data which constitute them are also forcedly connected, and that, if the constraint experienced by our mind in their presence has, as first cause, our mental structure, it has, as ultimate cause, the adjustment of our mental structure to the structure of things. It is probable, then, that this great axiom is of the same nature as the rest, and that analysis will, as with the rest, be sufficient to demonstrate it.

* "Physiologische Optik," p. 455.

Take a couple of actually connected data, one subject or less general, the other attribute or more general. We express the same thing by saying that the subject possesses the attribute. This attribute may be more or less transitory or permanent; for instance, in this falling drop of rain, the fall is an entirely momentary and transitory attribute, since it is at an end when once the drop has touched the earth; the chemical structure is a more permanent attribute, since a chemical combination or decomposition is needed to destroy it; weight is an entirely permanent attribute, since there is no known circumstance which can suppress it.—Here, as in all true propositions, the subject possesses the attribute, whether transitory or permanent, and, as we see, the attribute is more general than it, that is to say, common to other subjects than it.—I say now that there is *an explanatory reason* for this possession of the attribute by the subject, and, by explanatory reason, is meant, as we have shown, one or more characters of the subject, included in it like a fragment in a whole, more abstract and more general than it, and which, being themselves connected to the attribute, connect the attribute to the subject. This, then, amounts to saying that the attribute is not connected to the whole entire subject itself, but to one or more abstract and general characters of the subject.

To demonstrate this proposition, let us analyze in turn the attribute and the subject. We have said that the attribute is common to the subject and to others. This means that it is the *same* in the subject and in others. Thus the fall, the chemical structure, the weight, are the same in one drop of rain and in its neighbors. Thus the equality of the opposite sides is the same in this parallelogram and in all parallelograms, in the right-angled parallelogram and in the parallelogram whose angles are not right. Therefore, to say that the subject possesses an attribute common to it and to others, is to say that other subjects, real or possible, possess the same attribute as it. The equality of the opposite sides is the same in my parallelogram and in this other one; the chemical structure is the same in my drop of rain and in this other one. In other words, taken in itself, with the omission and suppression of the distinct subjects in which they reside, the equality of the opposite sides of my parallelogram is confounded with the equality of the opposite sides of the other, and the chemical structure of my drop of rain is confounded with the chemical structure of the other, just as a particular triangle, when detached from the position it occupies, and transferred by superposition upon some other, coincides with the other and is absolutely confounded with it.

Let us now consider the subject. What we call a subject, a distinct subject, is a sum or reunion of characters which do not all occur rigorously the *same* in any other subject, however similar we may imagine it. This drop of rain, even if we suppose it to have a form, volume, temperature, and internal structure, exactly the same as the one next to it, or following it, further possesses characters which are not possessed either by the one next to it or the one following it, namely, its situation in time with reference to those preceding it, and in space, with reference to those surrounding it. This parallelogram, even if we suppose its sides precisely the same in length and its angles exactly the same in expansion as the sides and the angles of the other, possesses in addition at least one character which the other does not possess, namely, its particular position in space, on my paper, or on this board. The analysis is the same, if in this place of an individual subject, as this drop of rain or this parallelogram, we consider a more or less general subject, like the parallelogram in itself or water in general. Water is liquid like mercury, and the parallelogram has its opposite sides equal like the regular hexagon; but water compared with mercury, just as the parallelogram compared with the regular hexagon, is a distinct subject, which, being distinct, forcedly possesses, like this drop of rain, one or more characters by which it is distinguished from every other more or less similar subject with which it is compared.

Here, then, we arrive at this conclusion, that our subject, being distinct from another subject, is *not the same*, and nevertheless, possesses the *same* attribute. Let us replace the terms by their definition. Distinct subject, signifies sum or reunion of characters of which one or more are absent in the other subject; it is to this sum or reunion that the attribute directly or indirectly appertains. Hence three possible hypotheses, and three hypotheses only.—Either the attribute appertains directly to the sum of reunited characters; or it appertains indirectly, that is, by appertaining to that portion of the sum which is composed of characters absent in the other subject, or by appertaining to the other portion. Now the two first hypotheses are contradictory.—In fact on the one hand, the attribute cannot appertain to that portion of the sum which is composed of the characters absent in the second subject; for then it would not appertain to the second subject, in which those characters are wanting; now, by definition, the attribute belongs to that subject.—On the other hand, the attribute cannot belong to the sum of the united characters; for then it would not belong to the second subject, in which this reunion is wanting; now, by definition, it belongs to that subject.—These two suppositions being excluded, the third alone remains. Hence it follows that the attribute belongs to that portion of our subject which is composed of characters present in it and in the second subject, that is to say common to both, that is to say, general. Hence it also follows that it appertains solely to a portion of our subject, in other words to a fragment, to an extract, to an abstract included in our subject; which is what had to be proved.*

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* We have just demonstrated the axiom by means of the notion of *identity;* we can also demonstrate it by means of the notion of *indifference;* and this sec-

The axiom, thus demonstrated and understood, is readily seen to reduce itself to the enunciation of the consequences of a mental construction. Just as with other axioms, it develops a pure supposition; this it develops by detecting *something the same* in the two data it connects, and it is reduced to the principles of identity, of the alternative, and of contradiction. So again, it lays down no datum as real; all it establishes is an outline to which real data may adapt themselves. It does not affirm that there are in fact distinct subjects, nor that two or more distinct subjects possess in fact the same attribute. Experience alone can instruct us as to this.—But, when experience has instructed us, and when, on considering all the propositions of our experimental sciences, we find throughout nature distinct subjects possessed of the same attribute, then the axiom applies: being demonstrated like a geometrical axiom, it has the same range, and, like a geometrical axiom, it extends its empire, not only

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ond demonstration is well suited to the particular form under which the axiom has been presented by Claude Bernard.

When given a subject under certain circumstances, take a second subject exactly similar to the first, and in circumstances exactly similar to the first circumstances, so that there may be no difference between the first and second case but that of time or place. Let us further assume that this difference is *indifferent*, that is to say, without influence or any event which occurs in the first subject, and that, in relation to this event, it may be considered as *null*.—This supposition is not always true; the time and position have often an influence; the same heavy body-falls more quickly in the second minute than in the first; the same pendulum oscillates differently at the bottom of a mine and at the summit of the adjacent mountain.—But subsequent experiences intervene to confirm or contradict our supposition, and, whether confirmed or contradicted, we shall learn something by it. Meanwhile, let us consider it as a pure mental construction, and see what follows from it. Since, by supposition, the difference of the two cases has no influence or is *null*, the second case is absolutely and rigorously confounded with the first, and may be substituted for it as legitimately as any triangle may for another equal and similar triangle; therefore, the event which occurs in the first subject will also occur in the second, or, to use Claude Bernard's expression, "in identical conditions, phenomena are identical."—The reader will observe the analogy of the axiom thus enounced and proved with the above demonstrated axioms of mechanics.

over all fragments of duration and extension which are accessible to our observation, but beyond and to infinity, to all points of duration and extension in which two distinct subjects present the same attribute.

Hence follow vast consequences, and first of all the proof of the principle on which induction rests. We had only supposed it true, provisionally and by analogy;* we had only assumed that a general character invariably indicates the presence of another general character to which it is connected; we are now able to demonstrate this presence.—A general character is an attribute, the same in several distinct subjects. Now, according to the axiom, it does not appertain to such or such a distinct subject directly, but to all indirectly by the intermediate link of a portion common to them, and which, in this respect, is a general character; in this way, it supposes the presence of another general character to which it belongs; thus, its presence is *sufficient* to guarantee to us the presence of this other.—Moreover, this other character to which the first appertains is general; in other words, the first appertains to the second, whatever be the subject, whatever the medium, whatever the place, whatever the moment; in other words again, the presence of this other is sufficient to involve, and therefore to guarantee to us, the presence of the first.—Thus, in general, the presence of the one, which is already known, is *sufficient* to guarantee to us the presence of the other, which is as yet unknown, and which we are attempting to discover. Now, we have seen that on this *sufficiency* are founded all the processes of elimination, the methods of agreement and difference, of which induction is composed.

On the other hand, take any subject considered at two successive moments, and in which some particular attribute is the same at both moments, that is to say common to the two moments, and consequently, general. After what we

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* Part ii. book iv. ch. ii. p. 202 *ante*.

have just said, this attribute has its condition, which is a character common to both moments of the subject; and, as its condition is sufficient to involve it, while its condition persists, it will itself persist. Consequently, if, in fact, at the third moment it ceases to exist, this is because its condition has ceased to exist; hence it finally follows that the suppression of a character has, as condition, the suppression of another character. Now every alteration in a subject is the suppression of one of its characters, so that every alteration has a condition, which we express by saying that it has a *cause*, and that this cause is another alteration. Here we have the axiom of causalty; considered with reference to the axiom of explanatory reason, it is a consequence and an application of that axiom. That axiom has many others. Leibnitz, who termed it Principle of Sufficient Reason, constructed from it all his idea of the universe. And, in fact, it is by this axiom that we arrive at the highest conception of a general aggregate, at the idea of one necessary whole, at the persuasion that *existence* is itself explainable. For, since existence is a general character, and the most general of all characters, we must conclude from our axiom that it has, like every general character, its condition or explanatory reason, other than itself. Mathematicians assume nowadays that real quantity is only a case of imaginary quantity, a special and singular case, in which the elements of imaginary quantity present certain conditions which are wanting in the other cases. May we not similarly assume that real existence is only a case of possible existence, a special and singular case, in which the elements of possible existence present certain conditions which are wanting in the other cases? With this assumption, may we not inquire into these elements and these conditions? We are here on the threshold of metaphysics.

We will not enter; we are here concerned with cognitions alone. The reader has seen how they are formed, and by what adjustments they correspond to things. They have, as materials, sensations of various kinds, some primitive and excited, others spontaneous and reviving, attached to one another, counterbalanced by one another, purposely organized by their connections and their antagonism, composed of elementary sensations smaller than themselves, these again of still smaller ones, and so on, till their differences are finally effaced and permit us to divine the existence of wholly similar infinitesimal elements whose various arrangements explain their various aspects.—Thus in a cathedral, the ultimate elements are grains of sand agglutinated into stones of various forms, which, attached in pairs, form masses, whose thrusts oppose and balance each other; all these associations and all these mutual pressures being co-ordinated in one grand harmony. Such is the simplicity of the means, and such the complication of the effect, and both the simplicity and the complication are as admirable in the mental as in the real edifice.