SENSIBILITY AND ITS DIVERSE FORMS.

By M. Oltramare.

[Translated From the French, by the Marchioness Clara Lanza.]

From the feeble cry by which the infant affirms simultaneously its birth and its sensibility, to the last long drawn sigh which bids adieu to existence, human life oscillates constantly between two opposite conditions created by the nervous system—pleasure and pain, joy and sorrow.

Being creatures developed to a great extent under the influence of the senses, we experience to an extreme degree, the action of all exterior agents, and atone for such pleasures as are granted to us by our exquisite sensibility, with moral and physical suffering. Not satisfied with momentary impressions, we foresee the influences which are to reach us, and by means of our refined intelligence we create those two great incentives to our actions—apprehension and desire.

Being mortal and also conscious of the fact, we naturally have a presentiment of the final destruction of our bodies, and most of us fear this and look upon it with dread. Nothing of this kind, however, is to be met with in animals. The last hour of life, brutal and violent though it may be and totally unexpected, does not affect them. The dog licks his master's hand affectionately whether it be extended to caress or to kill. He is no more conscious of the possibility of death, than is the ox which is led to the slaughter house.

These higher animals have nevertheless, a sensiblity and individuality upon which their reason depends. They possess what we call instinct. But, as we descend further in the animal world, we see that this function gradually diminishes in proportion as the organisms become simplified, until finally we reach a point, where to cut a living creature in two, not only produces no perception of pain, but actually becomes a means of reproduction, each half being capable of forming a distinct organism precisely like the original.

Lower still, we come to plants, which are living organisms, although Linnæus, a naturalist of the highest rank, refused to admit their sensibility. He says: "Plants live and grow; animals live, grow and feel."

This theory recalls that of Aristotle, when the Grecian philosopher affirmed that all organized beings had a soul more or less developed.

To the vegetable soul he attributed two faculties—growth and reproduction. To the animal soul he assigned four faculties—growth, reproduction, sensibility and motion. To the human soul, five faculties. The four above mentioned, to which was added intelligence, or mind.

Neither Linnæus nor Aristotle admit of any sensibility in vegetable life, and yet this is as great an error as to deny the existence of this same faculty in animals. An error, which is almost universal even in the thinking world, and which certainly should no longer be allowed to exist. From the most minute plant, to the most perfect animal, we find sensibility under various forms, but always corresponding to Claude Bernard's definition: "Sensibility is the *ensemble* of all kinds of modifications, determined in living things by different stimuli, or rather, the aptitude to reply to the provocation of these stimuli by means of modifications."

Bichat distinguishes three forms of sensibility:

1. Conscious sensibility, which presides over relations to exterior movements.

2. Unconscious sensibility, representing internal movements.

3. Insensible, or imperceptible sensibility, so called because it is manifested in other ways than by movement.

Putting aside these fine distinctions, let us admit two forms of sensibility—conscious and unconscious—and we shall be able to demonstrate the possibility of a passage from one state to the other, which proves that they are but modifications of a single attribute.

When we learn to read, it is with considerable difficulty, and we doubt if any one ever mastered the art unconsciously. But later, can we not peruse page after page mechanically, without having an idea of their contents? A transformation has therefore taken place in two kinds of sensibility. It is precisely the same with walking and many other acts in which the brain—that is to say, the conscious agent—plays but a secondary part.

If I prick the foot of a frog with a needle the animal draws it away, and, forewarned by the pain, endeavors to escape. Sensibility here evidently assumes a conscious form. If, however, I decapitate the frog, that is, if I destroy the organ which is the *ego*, so to speak, and once more perform my experiment, the mutilated body draws the leg away, but makes no attempt to escape. The act is purely reflex, unconscious, and in this case, by a simple experimental artifice, I am able at once to substitute the second form of sensibility for the first.

We breathe without knowing it, without the intervention of our will; but if our attention is directed upon this mechanical act, we become immediately conscious of it.

In eating, when once our food is swallowed we know nothing more about it, and yet our sensibility is constantly played upon by these substances, which, physically and chemically modified, are introduced into the circulation of the blood, and thence carried to the anatomical elements, whose sensibility they incite to action. All vital properties, and, consequently, sensibility, reside in those little numberless organic unities which go to form living beings.

There exists a fundamental matter, protoplasm, an amorphous substance endowed with peculiar properties and which Huxley has justly termed the physical basis of life. This protoplasm, which sometimes alone constitutes an inferior living creature, not only moves but attaches to itself minute particles which it meets with in the water, digests them and assimilates them with itself. Ether, the great reagent of sensibility, causes it to lose its transparency, and its movements to disappear. Then, when it is evaporated, the fluid reappears with all the attributes of this inferior life. This is undoubtedly sensibility, but in an unconscious form.

If we begin to mount the organic ladder, we see gradually appear certain cells which specify sensibility, and which, created solely to perform this function, elevate and perfect it. These are the so-called nerve cells. They are scattered throughout living organisms; in the higher animals they are very numerous, and serve to centralize impressions and produce individuality. When they are united to others called cephalic cells, they admit not only of sensation, but also the interpretation of sensation which then becomes conscious.

Thus, beginning with this infinite attribute of living matter which Haller and Glisson, being too timid to call sensibility, termed irritability, we gradually come to the highest forms, whence originate the greater portion of intellectual and physiological phenomena.

In man, all the sensible nerve cells are united in one mass called the cerebro-spinal axis, or the encephalo-medullary mass. It is composed of the spinal cord, the medulla oblongata, and the brain, each of its departments representing one form of sensibility. The spinal cord, properly speaking, corresponds to unconscious sensibility. This is illustrated by that involuntary and spontaneous movement which we call reflex action. The medulla oblongata controls sensations which, like respiration for instance, are frequently unconscious, but which, however, by an effort of the will, can be interpreted as precisely the opposite. The brain possesses the highest form of sensibility, and it is here that the greater part of our physical and intellectual acts are performed. By means of the mi-

croscope we are able to-day, to separate in each nervous centre, the sensitive cells from others of a like kind performing different functions which can be recognized by their shape, dimension and situation.

It is useless here to go into minute details concerning this point. I will call attention, however, to the fact that each sensitive nerve cell is connected with exterior agents by a long fibre called the cylinder axis, which resembles a telegraph wire carefully concealed by a layer of fat, and which, surrounded by numerous protecting membranes, extends throughout portions of the body, and produces sensibility. All these nerve fibres, whose receptive apparatus is in the encephalo-medullary mass, are grouped together and form those little white filiments which we designate as nerves. If the end of a nerve is touched, or the root, a modification can instantly be determined, which carried to the nervous centres, becomes a sensation. This sensation is, of course, not always the same, but is in accordance with the determining agent, optic, acoustic, gustative, etc.

If for instance, we cut the nerve which conducts light from the eye to the brain, this sensation will immediately be felt; but if, on the contrary, one of the skin nerves be cut, intense pain will be experienced. It is not, therefore, as M. Delboeuf very justly remarks, the nature of the excitation which determines that of the impression, but the manner in which the brain centre is brought into activity; so that if the optic and acoustic nerves be cut, united and inverted, a noise would be interpreted by a sensation of light, and *vice versa*. The sight of a picture would determine sounds in relation to the brilliancy of the paint employed, while an orchestra would produce colors varying, according to the sounds. Sensations experienced in consequence of exterior impressions do not therefore depend upon the character of the latter, but upon the nature of our nervous cells. We do not feel that which occurs upon our body, but only that which takes place in our brain. If, therefore, all our nerve cells were identical, the exterior world would doubtless produce sensations, but they would be precisely alike, merely differing in intensity. There are certain animals which exist in this condition.

M. Helmholtz and other physiologists have calculated the amount of time required for the transmission of the excitation to the sensitive nerves, and have decided upon thirty metres a second—that is to say, a rapidity equal to an express train advancing at full steam power. Imagine a man whose brain is in Paris while the extremity of one of his limbs is in Geneva, and we will see that it must require precisely four hours and forty-four minutes for a sensation to pass from the latter city to the former.

Given the small distance which separates our extremities from the nerve centres, and the time of transmission is short. It is remarkable, however, that those organs which play the greatest *rôle* in the preservation and conservation of the individual, sight and hearing should be placed in close proximity to the brain. This produces a rapid transmission, and enables a speedy evasion of destructive objects—a disposition evidently acquired by natural selection. It seems, moreover, that the intensity of the impression is in accordance with the distance intervening between the excitation and the nerve centre. We may thus explain the extreme violence of neuralgia of the face and head, as compared with that affecting other portions of the body.

All the various forms of sensibility have an analogous basis. The connection and fundamental identity can be demonstrated by the action of narcotics. We shall see that this is the most general and characteristic property of life, and this axiom can be fully established—that everything which lives, whether animal or vegetable, feels and can be rendered insensible.

It is a well known fact that certain plants rebound when they are touched. The sensitive one closes its leaves while a great number of carnivorous plants shut up like traps as soon as a fly alights upon them, imprisoning and crushing the poor insect which is to serve them as nourishment. The action of day and night has been equally verified in regard to plants. Some flowers only open when the sun shines, while others bloom solely in the dark. It has also been seen that the leaves sometimes turn towards the sun, but these phenomena have been called exceptional, many persons even placing them in the category of problematic occurrences, not wishing evidently to open their eyes to facts which they consider humiliating to the animal species.

Now, however, doubt is no longer possible. Ignorance upon this point can no longer be permitted, and every one must know that animals and plants alike possess sensibility. A great philosopher and physiologist, Claude Bernard, first demonstrated this important truth, not by means of tortuous reasoning, but by the brilliant light of experiment.

Provided with an anæsthetic agent, ether or chloroform, he was able to prove that the highest forms of conscious sensibility and the lowest forms of unconscious sensibility can be successfully affected. When the action of the narcotic begins to take place the *ego* sleeps and with it, conscious sensibility. That is sufficient for the surgeon who can then begin to cut and burn without the shadow of an *arrière pensée*.

Upon continuing the introduction of the fumes of ether into the organism, we see all the forms of unconscious sensibility gradually become annulled subsequent to conscious sensibility. After having acted upon the nerve cell, the anæsthetic destroys the sensibility of all the tissues, that is to say their vital characteristic, causing them to react upon exterior agents—in one word, it kills the indivldual.

If we pass on from the animal to the plant, we find that ether and chloroform act in identically the same manner. Subject the leaves of a sensitive plant to the fumes of either of these agents, and you will be able to handle them without eliciting the slightest movement on their part. They no longer feel the contact of the hand, for knowing as we do that anæsthetics respect the functions of movement, we can only attribute this inertia to the impotency of the excitation.

Let us now take a rapidly germinating seed, such as that of the water-cress and place it upon a sponge soaked in water. In twenty-four hours it will have blossomed into a tiny stem and root. Repeat the experiment under the same conditions of oxygen, water, light and heat, but place the sponge beneath a glass which has been dipped in ether. The seed will remain intact. It is not dead however, it merely sleeps, for if we remove the glass it will recover from its stupor and by the following day will have sprouted. This unseen life possessed by the seed, life which asks nothing more than to make itself apparent, is, however, subject to external and internal conditions. The first are the necessity of water, oxygen, heat and all physio-chemical conditions; but there is still something else, internal, inherent to the seed itself and constituting the essence of its life. It is sensibility. Destroy this function and notwithstanding the most favorable surroundings, the development will be effectually stopped.

Do not think that this is owing to any peculiarity of the plant and its embryonic condition, for a hen's egg, that latent condition of life of an organism belonging to a comparatively high order, cannot be hatched with any desirable result in an etherized atmosphere.

Germination, the first vital act of the individual, be it plant or animal, is therefore subject to sensibility and in this function we see it appear for the first time. Afterwards it is not difficult to follow it in its course through all the vital acts of the organism. The plant breathes and grows by assimilation, absorbing either the substances contained in the earth, or the carbonic acid in the air. For a long time this gaseous assimilation was

confounded with respiration, and the mistaken conception was spread abroad that plants breathe in direct opposition to animals by absorbing carbonic acid and exhaling oxygen. By means of anæsthetics we can separate these two phenomena. An aquatic plant placed in etherized water ceases to absorb carbonic acid and emit oxygen. It however, remains green, and breathes as animals do, a phenomenon which existed before, but was hidden by the assimilation of the carbon; still, further back, we can encounter one of those phenomena long considered chemical and which nearly escape vital acts inasmuch as in the laboratory some of them can be reproduced without the aid of life. I speak of fermentations. These are produced by a microscopic fungus, which decomposes fermentable matter, nourishing itself with a portion, while the remainder forms a new product which stays in the liquid. These fermentations, in spite of their extreme tenuity and their inferiority in the organic scale, are susceptible of being stupefied by ether and losing their active power. We may place them with impunity in close contact with the liquid, but the latter remains undisturbed.

Thus, from the very bottom of the ladder, from the simplest protoplasm, and the most insignificant fermentation to the most elevated creature to be found on the earth, we find always the same characteristic and fundamental property of life, modified, it is true, to a degree which forces us to follow the thread of its diverse forms step by step, but always identical in substance, and invariably demonstrable by those infallible reactive agents, anæsthetics. Without this property there can be no life, or rather no active life, no exterior manifestations. With it, any plant or animal, no matter how simple in construction, develops, grows, prospers and reproduces itself. It is easy to see, therefore, that sensibility is the principal attribute of all organic beings, and in some way the cause of everything that takes place within us. If, as Condillac says, we should take an immovable and insensible image and endow it gradually with all our senses, it would soon rise from nonentity and begin to augment the sphere of its knowledge. By giving it the sense of hearing, we open that vast field of observation and reasoning which procures sound, but it could form no idea of the existence of matter, or of sunshine, or of taste. It could only conceive one thing, until put in complete possession of the other senses.

Intelligence, that precious gift which alone renders us superior to other creatures, is, therefore, nothing more than the result of our accumulated impressions, controlled one by the other, and we may even affirm that the man who has felt is alone capable of thought. The development of our minds should be adequate to the development of our sensibility, and in fact, it can be observed everywhere, that those persons whose senses are the most refined, possess the highest form of intelligence. I may even go so far as to parody the famous proverb and say to my neighbor; "Tell me what you feel, and I will tell you what you think."

Not so very long ago, as we have seen, Linnæus refused to admit of sensibility in regard to plants, saying that it was an attribute of the animal world only. An attentive investigation, however, causes us to reject such distinctions to-day. Let us even go further back, leaving behind us the lowest forms of organic matter, and see if any phenomenon approaching sensibility is to be met with. In a word, let us ask the following question: Is matter sensible?

Referring once more to Claude Bernard's definition of the term, "sensibility is the *ensemble* of all kinds of modifications determined in living beings by different stimuli," we find no possibility of its application to the properties of matter, for it distinctly states that the condition is an attribute of living beings only. But a mere definition should not arrest our investigation, for it is nothing more than the result of knowledge hitherto acquired, and as such admits of change. The substance of it all amounts to this; given a living being placed in immediate contact with matter, and the matter will act upon the being, producing sensation. But how do we know that the living being does not in its turn act upon the matter and modify its condition? I will even affirm that life does act upon certain substances, for fermentation is a positive proof that this is the case. If I place a sweetened solution of wine in contact with the air, a short time will suffice to develop therein millions of tiny living creatures proceeding from atmospheric germs. This fermentation increases with great rapidity, producing a chemical effect, so that after a certain time the sugar will be transformed into carbonic acid and alcohol. The presence, therefore, of life in the liquid served to modify the properties, and in this we see one of those strange occurrences where the so-called vital forces are so closely allied to chemical processes, that we hardly know whether the phenomenon is the result of the biologists' skill or the chemist's. Each of these *savants* have claimed it as their own, and with reason too, for chemistry and biology are twin sisters who can never quarrel.

When the sugar is once transformed into alcohol another organism appears, which, in its turn, determines the transformation of this substance into another, acetic acid, by means of an analogous fermentation. It is a remarkable fact, however, that while the chemist has, as yet, been unable to produce alcoholic fermentation by means of the action of matter upon matter, he can, on the contrary, easily determine the second without the aid of life at all. It is, therefore, the presence of these bodies which acts, and not the construction of the fermentation. It is not that life decomposes the liquid, but that the liquid decomposes itself when assimilated with certain agents. It is therefore sensible of their action.

Once *en route*, it is not difficult to multiply examples and to demonstrate that light, heat, electricity and all other forces which operate upon our sensibility, are uniform modifiers of matter. What is a photographer's negative but a glass plate sensitive to the action of light? Is not a piece of wire about which we pass an electric current sensible of electricity, inasmuch as it acquires thereby a new property, that of attracting a like piece of wire? It becomes, in fact, magnetic.

Heat, as we can observe every day, modifies bodies to such an extent, that beneath its influence they liquify and evaporate. All these facts demonstrate clearly that matter is sensible of exterior agents. According to the second part of Claude Bernard's definition, it possesses the "aptitude to reply to the provocation of these stimuli by means of modifications."

Consequently, universal attraction, that law which affirms that all bodies attract each other in direct ratio to their mass, and in inverse ratio to the square of their distance, is merely a simple and general way of expressing the sensibility of matter.

CONTRIBUTION TOWARD A NEW COSMIC HYPOTHESIS.

By Samuel J. Wallace.

Our familiar knowledge and ideas in astronomy relate generally to matter in large bodies, and in great numbers of small bodies, which now and then fall into the larger as meteorites. This seems to show a condition of slow centralization, as if to finally collect all matter, however far distributed, into a few large bodies. And a consistent conception requires in its plan, somewhere, a means of decentralization, or distribution of matter through space again, to form a closed system of action.

Gravic force as one of the interchangeable forms of kin-