California and Spain. Third belt, Dureago (Mexico), Peru and China. Fourth belt, Malacca and Banca. Fifth. Bolivia, (S. America) Queensland and Northern New South Wales, in Australia, in about the parallel of 22° to 23° S. Lat.

5. *Lead.* The diamagnetic arrangement of the localities in which this metal is most abundantly found, may be rendered equally apparent, whether we follow the Galena and other ores in belts, on parallels around the globe, or connect these metallic deposits by curves from the Boothia Felix focus, for North America, and the Scandinavian focus for Europe. Thus, first belt in North America, from Arctic focus, Idaho, Wisconsin, Iowa, Northern Illinois, Vermont, New Hampshire and Maine; second belt, Nevada, Utah, Colorado, Missouri, Southern Illinois, New York, Connecticut; third belt, California, New Mexico, Arkansas, Tennessee, and North Carolina; fourth, Fort Yuma, and Arizona; fifth, the argentiferous Galena of Mexico.

In Europe there are from the Scandinavian focus four belts; first, that of Scotland and Saxony; second, of England and Bohemia; third, the lead mines of France; fourth, those of Spain, often argentiferous.

6. *Zinc.* From the Scandinavian focus, we trace one curve, which marks the zinc belt of England, Belgium and Germany; another that of France and Austria. In Asia, from the North Siberian focus, a belt connects the zinc of the Alati mountain with that of China. In the United States, if we take the Lake Superior focus as a center, we can bring within one belt the various zinc ores of Tennessee, Virginia, Pennsylvania, and the abundant deposits of New Jersey, as well as the zinc localities of New York, Vermont, New Hampshire and Maine.

7. *Antimony.* From the Lake Superior focus, a semicircle unites, in one belt, the ores of Antimony found in Maryland, New Hampshire and Maine, while just outside is a curve or zone uniting the mines worked in Sonora (Mexico) with those of New Brunswick.

In Europe, with Mount Rosa for a center, the Tertiary circles (radius nine degrees), described in the former communication, passes through the zinc of Cornwall (England), of Spain and of Hungary.

8. *Bismuth.* A belt in the United States, with Lake Superior for a center, unites the bismuth found in Montana, Arizona and Colorado, with that of Georgia and South and North Carolina.

In Europe, the bismuth of Norway and Sweden are in one curve from the Scandinavian focus; that of England, Saxony and Bohemia constitutes a second curve. Bismuth is also found in Australia, nearly on the parallel of latitude on which it is obtained in Chili and Bolivia (South America).

These demonstrations, or coincident facts, may, perhaps, suffice to test the truth of the law, which appears to be similar in character to that governing the formation of land.

Metals and metallic ores would seem, then, most frequently, to have arranged themselves, particularly when diamagnetic, as a large majority of bodies are, in curves, equi-distant from some dynamic focus.

It is hoped the above generalization may aid the miner and mineralogist in their search after mineral wealth.

THE UNITY OF NATURE.

By the Duke of Argyll.

II.

Man is included in the Unity of Nature, in the first place, as regards the composition of his body. Out of the ordinary elements of the material world is that body made, and into those elements it is resolved again. With all its beauties of form and of expression, with all its marvels of structure and of function, there is nothing whatever in it except some few of the elementary substances which are common in the atmosphere and the soil. The four principal gases, with lime, potash, and a little iron, sodium, and phosphorus, these are the constituents of the human body —of these in different combinations—and, so far as we know, of nothing else. The same general composition, with here and there an ingredient less or more, prevails throughout the whole animal and vegetable world, and its elements are the commonest in the inorganic kingdom also. This may seem a rude, and it is certainly a rudimentary view of the relation which prevails between ourselves and the world around us. And yet it is the foundation, or at least one of the foundations, on which all other relations depend. It is because of the composition of our body, that the animals and plants around us are capable of ministering to our support—that the common air is to us the very breath of life, and that herbs and minerals in abundance have either poisoning properties or healing virtue. For both of these effects are alike the evidence of some relation to the organism they affect; and both are in different degrees so prevalent and pervading, that of very few things indeed can it be said that they are wholly inert upon us. Yet there is no substance of the thousands which in one manner or another affect the body, which does not so affect it by virtue of some relation which it bears to the elements of which that body is composed, or to the combinations into which those elements have been cast.

And here we ascend one step higher among the facts which include Man within the unities of Nature. For he is united with the world in which he moves, not only by the elements of which his body is composed, but also by the methods in which those elements are combined—the forces by which they are held together, and the principles of construction according to which they are built up into separate organs for the discharge of separate functions. Science has cast no light on the ultimate nature of Life. But whatever it be, it has evidently fundamental elements which are the same throughout the whole circle of the organic world; the same in their relations to the inorganic; the same in the powers by which are carried on the great functions of nutrition, of growth, of respiration, and reproduction. There are, indeed, infinitely varied modifications in the mechanism of the same organs to accommodate them to innumerably different modes by which different animals obtain their food, their oxygen, and their means of movement. Yet so evident is the unity which prevails throughout, that physiologists are compelled to recognise the fundamental facts of organic life as "the same, from the lowest animal inhabiting a stagnant pool up to the glorious mechanism of the human form." [1]

This language is not the expression of mere poetic fancy, nor is it founded on dim and vague analogies. It is founded on the most definite facts which can be ascertained of the ultimate phenomena of organic life, and it expresses the clearest conceptions that can be formed of its essential properties. The creature which naturalists call the Amœba, one of the lowest in the animal series, consists of nothing but an apparently simple and formless jelly. But simple and formless as it appears to be, this jelly exhibits all the wonder and mystery of that power which we know as Life. It is in virtue of that power that the dead or inorganic elements of which it is composed are held together in a special and delicate combination, which no other power can preserve in union, and which begins to dissolve the moment that power departs. And as in virtue of this power the constituent elements are held in a peculiar relation to each other, so in virtue of the same power does the combination possess peculiar relations with external things. It has the

[1] On the Nervous System, by Alex. Shaw. Appendix to Sir Charles Bell's "Anatomy of Expression."

faculty of appropriating foreign substances into its own, making them subservient to the renewal of its own material, to the maintenance of its own energy, and to the preservation of its own separate individuality. It has the faculty, moreover, of giving off parts of itself, endowed with the same properties, to lead a separate existence. This same substance, which when analyzed has always the same chemical composition, and when alive has always the same fundamental properties, is at the root of every organism, whether animal or vegetable. Out of its material all visible structure is built up, and the power which holds its elements together is the same power which performs the further work of molding them into tissues—first forming them, and then feeding them, and then keeping them in life. This is as true of the highest organism of Man as it is of the lowest, in which visible structure begins to be. The phenomena of disease have convinced physiologists that all the tissues of the body are freely penetrated by the protoplasmic corpuscles of the blood, and that the primordial properties displayed in the substance of an Amœba, which has no distinguishable parts and no separate organs, afford the only key to the fundamental properties of every animal body. One eminent observer assigns so high a place to this protoplasmic matter as the primary physical agent in the building of the House of Life, and in its renovation and repair, that he considers all its other materials, and all its completed structures as comparatively "dead."

But the unity of Man's body with the rest of Nature lies deeper still than this. The same elements and the same primary compounds are but the foundations from which the higher unities arise. These higher unities appear to depend upon and to be explained by this—that there are certain things which must be done for the support of animal life, and these things are fundamentally the same from the lowest to the highest creatures. It is for the doing of these things that "organs" are required, and it is in response to this requirement that they are provided. Food—that is to say, foreign material—must be taken in, and it must be assimilated. The circulating fluids of the body must absorb oxygen; and when this cannot be done more simply, a special apparatus must be provided for the separation of this essential element of life from the air or from the water. Sensation must be localized and adapted to the perception of movements in surrounding media. The tremors of the atmosphere and of the luminiferous ether must first be caught upon responsive—that is to say, upon adapted—surfaces, and then they must be translated into the language of sensation—that is to say, into sight and hearing. The heat evolved in the chemical processes of digestion and of oxygenation of the blood must be made convertible into other forms of motion. The forces thus concentrated must be stored, rendered accessible to the Will, and distributed to members which are at its command. These and and many other uniform necessities of the animal frame constitute a unity of function in organs of the widest dissimilarity of form, so that however different they may be in shape, or in structure, or in position, they are all obviously reducible to one common interpretation. They do the same things—they serve the same purposes—they secure the same ends—or, to use the language of physiology, they discharge the same functions in the animal economy.

But more than this; even the differences of form steadily diminish as we ascend in the scale of being. Not only are the same functions discharged, but they are discharged by organs of the same general shape, formed on one pattern, and occupying an identical position in one plan of structure. It is on this fact that this science of comparative anatomy is founded, and the well-established doctrine of "homologies." The homology of two organs in two separate animals is nothing but the unity of place which they occupy in a structure which is recognized as one and the same in a vast variety of creatures—a structure which is one in its general conception, and one in the relative arrangement of its parts. In this clear and very definite sense, the body of Man, as a whole, is one in structure with the bodies of all vertebrate animals; and as we rise from the lowest of these to him who is the highest, we see that same structure elaborated into closer and closer likeness, until every part corresponds—bone to bone, tissue to tissue, organ to organ. It is round this fact that so many disputants are now fighting. But all the controversy arises, not as to the existence of the fact, but as to its physical cause. The fact is beyond question. In a former work[2] I have dwelt at some length on the bearing of this fact on our conceptions of "Creation by Law," and on the various theories which assume that such close relationship in organic structure can be due to no other cause than blood relationship through ordinary generation. At present I am only concerned with the fact of unity, whatever may be the physical cause from which that unity has arisen. The significance of it, as establishing Man's place in the unity of Nature, is altogether independent of any conclusion which may be reached as to those processes of creation by which his body has been fashioned on a plan which is common to him and to so many animals beneath him. Whether Man has been separately created out of the inorganic elements of which his body is composed, or whether it was born of matter previously organized in lower forms, this community of structure must equally indicate a corresponding community of relations with external things, and some antecedent necessity deeply seated in the very nature of those things, why his bodily frame should be like to theirs.

And, indeed, when we consider the matter, it is sufficiently apparent that the relationship of Man's body to the bodies of the lower animals is only a subordinate part and consequence of that higher and more general relationship which prevails between all living things and those elementary forces of Nature which play in them, and around them, and upon them. If we could only know what that relationship is in its real nature and in its full extent, we should know one of the most inscrutable of all secrets. For that secret is no other than the ultimate nature of Life. The great matter is to keep the little knowledge of it which we possess safe from the confusing effect of deceptive definitions. The real unities of Nature will never be reached by confounding her distinctions. For certain purposes it may be a legitimate attempt to reduce the definition of Life to its lowest terms—that is to say, it may be legitimate to fix our attention exclusively on those characteristics which are common to Life in its lowest and in its highest forms, and to set aside all other characteristics in which they differ. It may be useful sometimes to look at Life under the terms of such a definition, in order, for example, the better to conceive some of its relations with other things. But in doing so we must take care not to drop out of the terms so defining Life anything really essential to the very idea of it. Artificial definitions of this kind are dangerous experiments in philosophy. It is very easy by mere artifices of language to obliterate the most absolute distinctions which exist in Nature. Between the living and the non-living there is a great gulf fixed, and the indissoluble connection which somehow, nevertheless, we know to exist between them is a connection which does not fill up that gulf, but is kept up by some bridge being, as it were, artificially built across it. This unity, like the other unities of Nature, is not a unity consisting of mere continuity of substance. It is not founded upon sameness, but, on the contrary, rather upon difference, and even upon antagonisms. Only the forces which are thus different and opposed are subordinate to a system of adaptation and adjustment. Nor must we fail to notice the kind of unity which is implied in the very words "adaptation" and "adjustment"—and, above all others, in the special adjustments connected with organic Life. There are many unions which do not involve the idea of adjustment, or which involve it only in the most rudimentary form. The mere chemical union of two or more elements—unless under special conditions—is not properly an adjustment. We should not naturally call the formation of rust an adjustment between the oxygen of the atmosphere and metallic iron. When the combinations effected by the play of chemical affinities are brought about by the selection of elements so placed within reach of each other's reactions as to result in a given product, then that product would be accurately described as the result of co-ordination and adjustment. But the kind of co-ordination and adjustment which appears in the facts of Life is of a still higher and more complicated kind than this. Whatever the relationship may be between living organisms and the elements, or elementary forces of external Nature, it certainly is not the relationship of mere chemical affinities. On

[2] "The Reign of Law."

the contrary, the unions which these affinities by themselves produce can only be reached through the dissolution and destruction of living bodies. The subjugation of chemical forces under some higher form of energy, which works them for the continued maintenance of a separate individuality—this is of the very essence of Life. The destruction of that separateness is of the very essence of death. It is not Life, but the cessation of Life, which, in this sense and after this manner, effects a chemical union of the elements of the body with the elements around it. There is indeed an adjustment—a close, an intricate adjustment—between these and the living body; but it is an adjustment of them under the controlling energy of a power which cannot be identified with any other, and which always presents phenomena peculiar to itself. Under that power we see that the laws and forces of chemical affinity, as exhibited apart from Life, are held, as it were, to service—compelled, indeed, to minister but not allowed to rule. Through an infinite variety of organisms, this mysterious subordination is maintained, ministering through an ascending series to higher and higher grades of sensation, perception, consciousness, and thought.

And here we come in sight of the highest adjustment of all. Sensation, perception, consciousness, and thought—these, if they be not the very essence of Life, are at least—in their order—its highest accompaniments and result. They are the ultimate facts, they are the final realities, to which all lesser adjustments are themselves adjusted. For, as the elementary substances and the elementary forces of Nature which are used in the building of the body are there held by the energies of Life under a special and peculiar relation to those same elements and to those same forces outside the body, so also are they held in peculiar relations to those characteristic powers in which we are compelled to recognize the rudimentary faculties of mind, Sensation is the first of these, and if it be the lowest, it is at least the indispensable basis of all the rest. As such, it cannot be studied too attentively in the first stages of its appearance, if we desire to understand the unity of which it is the index and result. We have seen that the mechanism of living bodies is one throughout the whole range of animal Life—one in its general plan, and one even in the arrangement of many of its details. We have seen, too, that this unity rests upon that other—in virtue of which all organisms depend for the maintenance of their life, upon adjustments to certain physical laws which are held, as it were, in vassalage, and compelled to service; doing in that service what they never do alone, and not doing in that service what they always do when freed from it.

And now we have to ask what that service is? We can only say that it is the service of Life in all its manifestations, from those which we see in the lowest creatures up to the highest of which, in addition, we are conscious in ourselves. I say "in addition"—because this is the fundamental lesson of physiology and of comparative anatomy—that the principle and the mechanism of sensation are the same in all creatures, at least in all which have the rudiments of a nervous system. This identity of principle and of structure in the machinery of sensation, taken together with the identity of the outward manifestations which accompany and indicate its presence in animals, makes it certain that in itself it is everywhere the same. This does not mean, of course—very far from it—that the range of pleasure or of pain consequent on sensation—still less the range of intelligent perception—is the same throughout the animal kingdom. The range of pleasure or of pain, and still more the range of intelligent perception, depends on the association of higher faculties with mere sensation, and upon other peculiarities or conditions of organization. We all know by our own experience, when comparing ourselves with ourselves in different states of health or of disease, and by observing the like facts in others, that the degree of pleasure or of suffering, of emotion or of intellectual activity, which is connected with sensation, may be almost infinitely various according to various conditions of the body. But this does not affect the general proposition that sensation is in itself one thing throughout the animal kingdom. It cannot be defined in language, because all language is founded on it, assumes it to be known, and uses the metaphors it supplies for the expression of our highest intellectual conceptions. But though it cannot be defined, this at least we can say concerning it, that sensation is the characteristic property of animal life; that it is an affection of the "anima," of that which distinguishes animate from inanimate things, and that as such it constitutes one of the most essential of the fundamental properties of mind. So true is this, that the very word "idea," which has played a memorable part in the history of speculation, and which in common speech has now come to be generally associated with the highest intellectual abstractions, has had in modern philosophy no other definite meaning than the impressions or mental images received through the senses. This is the meaning attached to it (although, perhaps, no writer has ever adhered to it with perfect consistency) in the writings of Descartes, of Locke, and of Bishop Berkeley; and it is well worthy of remark that the most extreme doctrine of Idealism, which denies the reality of matter, and, indeed, the reality of everything except mind, is a doctrine which may be as logically founded upon sensation in a Zoophyte as upon sensation in a Man. The famous proposition of Bishop Berkeley, which he considers as almost self-evidently true, "that the various sensations, or ideas imprinted on the sense, cannot exist otherwise than in the mind perceiving them," is a proposition clearly applicable to all forms of sensation whatever. For every sensation of an organism is equally in the nature of an "idea" in being an affection of the living principle, which alone is susceptible of such affections; and it is plainly impossible to conceive any sense-impression whatever as existing outside a living and perceiving creature.

We are now, indeed, so accustomed to attach the word "idea" to the highest exercises of mind, and to confine the word "mind" itself to some of its higher manifestations, that it may startle some men to be told that sensation is in itself a mental affection. We have, however, only to consider for a moment how inseparably connected sensation is with appetite and with perception, to be convinced that in the phenomena of sensation we have the first raw materials and the first small beginnings of Intelligence and of Will. It is this fundamental character of sensation which explains and justifies the assertion of philosophers—an assertion which at first sight appears to be a mere paradox—that the "ideas" we receive through the senses have no "likeness" to the objects they represent. For that assertion, after all, means nothing more than this—that the impressions made by external things upon living beings through the senses, are in themselves mental impressions, and as such cannot be conceived as like in their own nature to inanimate and external objects. It is the mental quality of all sensation, considered in itself, which is really affirmed in this denial of likeness between the affections of sense and the things which produce those affections in us. It is one of the many forms in which we are compelled to recognize the inconceivableness of any sort of resemblance between Mind and Matter, between external things and our own perceptive powers.

And yet it is across this great gulf of difference—apparently so broad and so profound—that the highest unity of Nature is nevertheless established. Matter built up and woven into "organs" under the powers of Life is the strong foundation on which this unity is established. It is the unity which exists between the living organism and the elements around it which renders that organism the appropriate channel of mental communication with the external world, and a faithful interpreter of its signs. And this the organism is—not only by virtue of its substance and composition, but also and especially by virtue of its adjusted structures. All the organs of sense discharge their functions in virtue of a purely mechanical adjustment between the structure of the organ and the particular form of external force which it is intended to receive and to transmit. How fine those adjustments are can best be understood when we remember that the retina of the eye is a machine which measures and distinguishes between vibrations which are now known to differ from each other by only a few millionths of an inch. Yet this amount of difference is recorded and made instantly appreciable in the sensations of color by the adjusted mechanism of the eye. Another adjustment, precisely the same in principle, between the vibrations of Sound and the structure of the ear, enables those vibrations to be similarly distinguished in another

special form of the manifold language of sensation. And so of all the other organs of sense—they all perform their work in virtue of that purely mechanical adjustment which places them in a given relation to certain selected manifestations of external force, and these they faithfully transmit, according to a code of signals, the nature of which is one of the primary mysteries of Life, but the truthfulness of which is at the same time one of the most certain of its facts.

For it is upon this truthfulness—that is to say, upon a close and efficient correspondence between the impressions of sense and certain realities of external Nature—that the success of every organism depends in the battle of life. And all Life involves a battle. It comes indeed to each animal without effort of its own, but it cannot be maintained without individual exertion. That exertion may be of the simplest kind, nothing more than the rhythmic action of a muscle contracting and expanding so as to receive into a sac such substances as currents of water may bring along with them; or it may be the more complex action required to make or induce the very currents, which are to bring the food; or it may be the much more complex exertions required in all active locomotion for the pursuit and capture of prey; all these forms of exertion exist, and are all required in endless variety in the animal world. And throughout the whole of this vast series the very life of every creature depends on the unity which exists between its sense-impressions and those realities of the external world which are specially related to them. There is therefore no conception of the mind which rests on a broader basis of experience than that which affirms this unity—a unity which constitutes and guarantees the various senses with their corresponding appetites, each in its own sphere of adapted relations to be exact and faithful interpreters of external truth.

A still more wonderful and striking proof is obtained of the unity of Nature, and a still more instructive light is cast upon its source and character, when we observe how far-reaching these interpretations of sense are even in the very lowest creatures; how they are true not only in the immediate impressions they convey, but true also as the index of truths which lie behind and beyond—of truths, that is to say, which are not expressly included—not directly represented—in either sensation or perception. This, indeed, is one main function and use, and one universal characteristic of all sense-impressions, that over and above the pleasure they give to sentient creatures, they lead and guide to acts required by natural laws which are not themselves objects of sensation at all, and which therefore the creatures conforming to them cannot possibly either see or comprehend. It is thus that the appetite of hunger and the sense of taste, which in some form or other, however low, is perhaps the most universal sensation of animal organisms, is true not only as a guide to the substances which do actually gratify the sense concerned, but true also in its unseen and unfelt relations with those demands or laws of force which render the assimilation of new material an indispensable necessity in the maintenance of animal life. Throughout the whole kingdom of Nature this law prevails. Sense-perceptions are in all animals indissolubly united with instantaneous impulses to action. This action is always directed to external things. It finds in these things the satisfaction of whatever desire is immediately concerned, and beyond this it ministers to ends of which the animal knows nothing, but which are of the highest importance both in its own economy and in the general economy of Nature.

The wonderful instincts of the lower animals—the precision and perfection of their work—are a glorious example of this far reaching adjustment between the perceptions of sense and the laws which prevail in the external world. Narrow as the sphere of those perceptions may be, yet within that sphere they are almost absolutely true. And although the sphere is indeed narrow as regards the very low and limited intelligence with which it is associated in the animals themselves, it is a sphere which beyond the scope of their intelligence can be seen to place them in unconscious relation with endless vistas of co-ordinated action. The sentient actions of the lower animals involve not merely the rudimentary power of perceiving the differences which distinguish things, but the much higher power of profiting by those relations between things which are the foundation of all voluntary agency, and which place in the possession of living creatures the power of attaining ends through the employment of appropriate means. The direct and intuitive perception of things which stand in the relation of means to ends, though it may be entirely dissociated from any conscious recognition of this relation in itself—that is to say, the direct and intuitive perception of the necessity of doing one thing in order to attain to another thing—is in itself one of the very highest among the preadjusted harmonies of Nature. For it must be remembered that those relations between things which render them capable of being used as means to ends are relations which never can be direct objects of sensation, and therefore the power of acting upon them is an intuition of something which is out of sight. It is a kind of dim seeing of that which is invisible. And even if it be separated entirely in the lower animals—as it almost certainly is—from anything comparable with our own prescient and reasoning powers, it does not the less involve in them a true and close relation between their instincts and the order of Nature with its laws.

The spinning machinery which is provided in the body of a spider is not more accurately adjusted to the viscid secretion which is provided for it, than the instinct of the spider is adjusted both to the construction of its web and also to the selection of likely places for the capture of its prey. Those birds and insects whose young are hatched by the heat of fermentation have an intuitive impulse to select the proper materials, and to gather them for the purpose. All creatures, guided sometimes apparently by senses of which we know nothing, are under like impulses to provide effectually for the nourishing of their young. It is, moreover, most curious and instructive to observe that the extent of prevision which is involved in this process, and in the securing of the result, seems very often to be greater as we descend in the scale of Nature, and in proportion as the parents are dissociated from the actual feeding or personal care of their young. The Mammalia have nothing to provide except food for themselves, and have at first, and for a long time, no duty to perform beyond the discharge of a purely physical function. Milk is secreted in them by a purely unconscious process, and the young need no instruction in the art of sucking. Birds have much more to do—in the building of nests, in the choice of sites for these, and after incubation in the choice of food adapted to the period of growth. Insects much lower in the scale of organization, have to provide very often for a distant future, and for stages of development not only in the young but in the *nidus* which surrounds them.

There is one group of insects, well-known to every observer—the common Gall-flies—which have the power of calling on the vegetable world to do for them the work of nest-building; and in response to the means by which these insects are provided, the Oak or the Rose does actually lend its power of growth to provide a special *nidus* by which the plant protects the young insect as carefully as it protects its own seed. Bees, if we are to believe the evidence of observers, have an intuitive guidance in the selection of food, which has the power of producing organic changes in the bodies of the young, and by the administration of which, under what may be called artificial conditions, the sex of certain selected individuals can be determined, so that they may become the mothers and queens of future hives.

These are but a few examples of facts of which the whole animal world is full, presenting, as it does, one vast series of adjustments between bodily organs and corresponding instincts. But this adjustment would be useless unless it were part of another adjustment between the instincts and perceptions of animals and those facts and forces of surrounding Nature which are related to them, and to the whole cycle of things of which they form a part. In those instinctive actions of the lower animals which involve the most distant and the most complicated anticipations, it is clear that the prevision which is involved is a prevision which is not in the animals themselves. They appear to be guided by some simple appetite, by an odor or a taste, and they have obviously no more consciousness of the ends to be subserved, or of the mechanism by which they are secured, than the suckling has of the processes of nutrition.

The path along which they walk is a path which they did not engineer. It is a path made for them, and they simply follow it. But the propensities and tastes and feelings which make them follow it, and the rightness of its direction towards the ends to be obtained, do constitute a unity of adjustment which binds together the whole world of Life, and the whole inorganic world on which living things depend.

I have called this adjustment mechanical, and so, in the strictest sense, it is. We must take care, however, not to let our conceptions of the realities of Nature be rendered indistinct by those elements of metaphor which abound in language. These elements, indeed, when kept in their proper places, are not only the indispensable auxiliaries of thought, but they represent those perceptions of the mind which are the highest and the most absolutely true. They are the recognition—often the unconscious recognition—of the central unities of Nature. Nevertheless, they are the prolific source of error when not closely watched. Because all the functions and phenomena of Life appear to be strictly connected with an apparatus, and may therefore be regarded as brought about by adjustments which are mechanical, therefore it has been concluded that those phenomena, even the most purely mental, are mechanical in the same sense in which the work is called mechanical which human machines perform. Are not all animals "automata?" Are they not "mere machines?" This question has been revived from age to age since philosophy began, and has been discussed in our own time with all the aid which the most recent physiological experiment can afford. It is a question of extreme interest in its bearing on our present subject. The sense in which, and the degree to which, all mental phenomena are founded on, and are the result of mechanical adjustments, is a question of the highest interest and importance. The phenomena of instinct, as exhibited in the lower animals, are undoubtedly the field of observation in which the solution of this question may best be found, and I cannot better explain the aspect in which it presents itself to me, than by discussing it in connection with certain exhibitions of animal instinct which I had occasion to observe during the spring and summer of 1874. They were not uncommon cases. On the contrary, they were of a kind of which the whole world is full. But not the less directly did they suggest all the problems under discussion, and not the less forcibly did they strike me with the admiration and the wonder which no familiarity can exhaust.

IMPROVEMENT OF THE MISSISSIPPI RIVER.*

By Prof. W. H. Ballou.

The Mississippi River is the most gigantic parasite known to men. The least possible estimate, computed from data in hand, shows that the annual average for the last thirty years, of money expended on it for improvements, and lost through its depredations, exceeds $7,000,000. Fully one-third of this sum is used by the government, States and private individuals to keep the stream and its tributaries in an "improved condition." The table will show the average of the expenditures obtained for the last thirty years:

Expenditures of the States of Mississippi, Louisiana and Arkansas on levees since 1849	$100,090,000
Expended by the government and private individuals—estimate	50,090,000
Damage by floods, ice gorges, etc., to levees, property, life etc.	80,000,000
Total	$230,090,000
Average per annum, $7,669,666.	
To this may be added 26,772,370 acres of land granted to the above States by the government in 1849, the value being about $10 per acre	267,773,790
Total	$497,813,790
Average per year, $16,000,000.	

Only those who are acquainted with the stream and its peculiarities have an idea how unmanageable it is. The unstable condition of the soil of the country through which it flows renders it an object of distrust to the inhabitants of its border. Such is the treacherous condition of its relations that for sixty-two years the ingenuity of man has contrived no check on its action. The causes of this condition of things are found partly in the river-bed. The sedimentary deposit varies from 60 to 100 feet in depth. It is generally composed of silt, with a mixture of clay and sand, which, having been deposited by the river, is at its disposal to lie still or be shifted about. It is evident that no ordinary construction can long stand unless it has a foundation penetrating this bed to a rock stratum. The great bridge at St. Louis, for instance, has its piers resting on the limestone bed-rock, under a sedimentary deposit of seventy feet. The railway bridge at the mouth of the Minnesota river has its piers lodged on a slender stratum of hard earth sixty feet beneath the river's bottom. It is further admitted that in boring through this stratum a soft layer was struck, which would not uphold the rod's weight. At Cairo, Ill., in 1877, the United States corps of engineers, under Lieutenant D. W. Lockwood, made borings to a depth of 87 feet without encountering any stratum harder than sand. At this point the machinery broke down and operations were suspended. At a depth of 33 feet the auger penetrated a cottonwood log, hardly ready to decay, showing conclusively the facility with which the river makes its own bed. At the same place it is stated on good authority that piles, one on another, have been driven to a depth of 125 feet without encountering a rocky stratum.

The story of its great width is even more remarkable. Near Cairo, Ill., the river moved a mile out of its course in one year, and is continually changing at that point. Still more remarkable are the operations of the Missouri river. At one time Council Bluffs enjoyed its presence in the immediate proximity, and the benefits of its commerce, in consequence of which the city became the terminus for Western railways in preference to Omaha, three times its size. These railroads erected depots and stationed offices of general Western superintendents there. The Union Pacific constructed an immense bridge, and in common with other railways built a union depot at the Bluffs. No sooner was the work completed, than the Missouri performed the rare feat of moving its course to Omaha, three miles away. There is no end to instances of this kind on a smaller scale. It may be safely asserted that from its narrowest point the Mississippi varies to twenty miles in width. It is no wonder, then, that the present embankment system is inadequate. Appropriations are only asked at present for embankments as far north as Cairo. It is evident, however, that the sedimentary bed extended nearly to the source of the Mississippi, and that not only must the 110 miles from New Orleans to Cairo be embanked, but also the greater shore line above the latte city on both this river and the Missouri. An explanation of the frequent destruction of levees, dikes and embankments is found in the method of their construction. When the current leaves the middle and runs along one side of the stream, the bank is rapidly torn down. At this point the corps of engineers proceed to build a dike to resist the destructive force. A rip-rap is first constructed which consists of a raft covered with long poles, placed cross-wise in alternate layers. This is loaded with heavy stones and sunk near the shore. Outside of it long poles are driven to a depth of twenty or thirty feet, and sometimes to twice these depths. Brush and stones are heaped upon their foundation until a perpendicular embankment is completed on a level with the top of the bank. One would think that this ponderous dike would stand for ages. But so vacillating is the silt bed underneath that the water keeps working the outer edge with powerful results. The embankment settles, sometimes toppling over, and again dropping suddenly from sight. Often the water works in behind these constructions and leaves them out in the stream. Thus it happens that the river is at work at innumerable points, tearing away its banks and defying the structures in use to hold it in check.

In its work of destruction the current has some formidable aids. In the winter ice floats down continually. So immense are these cakes at times that three, and even two coming down stream abreast will get caught on the sides of the river, in some narrow channel, and form a bridge. This bridge effectually holds back all oncoming ice. The great and small cakes coming down in large quantities join under, over and behind the bridge, piling up to a great height, forming a gigantic gorge. This mass finally breaks away; no power yet inaugurated by the hand of man is able to withstand it. Embankments, boats, live stock, people,

* Read before the A. A. A. S., Boston, 1880.