groups made out in the north-west; that is to say, the hydro-mica and magnesian schists, and the carbonaceous and arenaceous black slates.

This leaves two series of rocks untouched by the scope of either the Huronian or the Taconic, as these systems were at first defined; namely, the mica-schist group, and the granite and gneiss with gabbro group. In the term 'Montalban,' proposed for these groups by Dr. Hunt, the two are united; and the constant distinctness which they seem to maintain is not recognized. The granite and gabbro group has affinities with the overlying cupriferous rocks, and perhaps, as Irving has suggested, should be considered the base of that series; whereas the mica-schist group has, without exception, been assigned to the same system and age as the underlying groups. The granite and gabbro group has likewise been designated differently. The gabbro has been called Laurentian, Labradorian, and Norian; and the granite and gneiss have received, under one of their modified conditions, the special designation Arvonian. Professor Winchell thought he had already shown that the Arvonian rocks are interstratified with the cupriferous, and are modified sediments of that series. Instead of being near the bottom of the 'Huronian' in the north-west, they overlie all the groups that have been assigned to the Huronian by Irving, and constitute a part of the great series of younger gneisses, which by Brooks has been marked as the 'youngest Huronian.'

It is evident, that at present it is an impossible undertaking, to assign the groups of the crystalline rocks of the north-west to any of the terranes that have been named farther east, without violating somebody's system of nomenclature. Respecting the horizon known as 'Laurentian,' there is an approach to unanimity and agreement. This, however, consists more in a tacit consent to style the lowest known rocks Laurentian, than in any agreement among geologists as to the nature and composition of the strata. The Taconic of Emmons has been generally ignored. The original Huronian has grown from the dimensions of a single group (the quartzite and marble group), so as to include all the crystalline rocks lying above that group, spreading from the Laurentian to the unchanged sediments of the upper Cambrian. This has in some cases become so obviously wrong, and has included groups of rocks so plainly extra-Huronian, that a double and triple nomenclature has been applied to a part of these upper rocks. These new names, with the exception of the name Montalban, seem to be of value only as regional designations; the strata which they represent being igneous or metamorphic, and hence liable to be wanting in some places, and to be non-crystalline in others. They further complicate the stratigraphic nomenclature, since they are probably only the locally modified lower parts of the New-York system.

In conclusion, the chief points brought out in this discussion may be re-stated more concisely:

1. The crystalline rocks of the north-west are comprised under six well-marked, comprehensive groups.

2. The Taconic of Emmons, so named in 1842, and more correctly defined in 1846, included three of those groups.

3. The Huronian of Canada is the equivalent of the lowest of the Taconic groups, and the perfect parallel of only the lowest of the groups in the north-west that have been designated Huronian.

4. The uppermost of the groups in the north-west is local in its existence and exceptional in its characters, and has received, therefore, a variety of names.

5. There are, therefore, confusion and conflict of authority in the application of names to the crystalline rocks of the north-west.

CATAGENESIS; OR, CREATION BY RETROGRADE METAMORPHOSIS OF ENERGY.[1]

THE general proposition, that life has preceded organization in the order of time, may be regarded as established. It follows necessarily from the fact, that the simple forms have, with few exceptions, preceded the complex in the order of appearance on the earth. The history of the lowest and simplest animals will never be known, on account of their perishability; but it is a safe inference from what is known, that the earliest forms of life were the rhizopods, whose organization is not even cellular, and includes no organs whatever. Yet these creatures are alive; and authors familiar with them agree that they display, among their vital qualities, evidences of some degree of sensibility.

After recalling the proposition laid down years ago by Lamarck, regarding the effect on structure of the use and disuse of organs, the speaker explained kinetogenesis as the production of animal structures by animal movements; and archæstheticism as the doctrine that sensibility or consciousness has ever been one of the primary factors in the evolution of animal forms. The influence of motion on development is involved in Spencer's theory of the origin of vertebrae by strains; and the speaker maintained that the various agencies mentioned by Lamarck as producing change are simply stimuli to motion.

In the present address he proposed to pursue the question of the relation of sensibility to evolution, and to consider some of the consequences which it involves; though in the present early stage of the subject he could only point out the logical conclusions derivable from facts well established, rather than any experimental discoveries not already known. Those who object to the introduction of metaphysics into biology must consider that they cannot logically exclude the subject. As in one sense a function of nervous tissue, mind is one of the functions of the body. Its phenomena are everywhere present in the animal kingdom. It is only want of familiarity with the subject which can induce a biologist to exclude the science of mind from the field.

[1] Abstract of an address delivered before the section of biology of the American association for the advancement of science, at Philadelphia, Sept. 4, by Prof. E. D. COPE, of Philadelphia, vice-president of the section.

The hypothesis that consciousness has played a leading part in evolution would seem to be negatived by the well-known facts of reflex action, automatism, etc., where acts are often unconsciously performed, and often performed in direct opposition to present stimuli. But while it is well understood that these phenomena are functions of organized structure, it is believed that the habits which they represent were inaugurated through the immediate agency of consciousness. It is not believed that a designed act can have been performed for the first time without consciousness, on the part of the animal, of the want which the act was designed to relieve or supply. We know, that, so soon as a movement of body or mind has been acquired by repetition, consciousness need no longer accompany the act. The act is said to be automatic when performed without exertion, either consciously or unconsciously; and in those functions now removed from the influence of the unconscious mind, such acts are called reflex. The *origin* of the acts is, however, believed to have been in consciousness, not only for the reasons above stated, but also from facts of still wider application. The hypothesis of archaestheticism, then, maintains that consciousness as well as life preceded organism, and has been the *primum mobile* in the creation of organic structure. It will be possible to show that the true definition of life is, *energy directed by sensibility, or by a mechanism which has originated under the direction of sensibility*. If this be true, the two statements, that life has preceded organism, and that consciousness has preceded organism, are co-equal expressions.

Regarding, for the time being, the phenomena of life as energy primitively determined by consciousness, we may look more closely into the characteristics of this remarkable attribute. That consciousness, and therefore mind, is a property of matter, is a necessary truth, which to some minds seems difficult of acceptance. Clearly it is not one of the known so-called inorganic forces. Objects which are hot, or luminous, or sonorous, are not on that account conscious; so that consciousness is not a necessary condition of energy. On the other hand, in order to be conscious, bodies must possess a suitable temperature, and must be suitably nourished; so that energy is a necessary condition of consciousness. For this reason some thinkers erroneously regard consciousness as a form or species of energy. We all understand the absurdity of such expressions as the equivalency of force and matter, or the conversion of matter into force. They are not, however, more absurd than the corresponding proposition more frequently heard, that consciousness can be converted into energy, and *vice versa*.

The energetic side of consciousness, however, may be readily perceived. Acts performed in consciousness involve a greater expenditure of energy than the same acts unconsciously performed: the labor is directly as the consciousness involved. The dynamic character of consciousness is also shown in its exclusiveness: two opposite emotions cannot occupy the mind at the same moment of time. But there is no fact with which we are more familiar than that consciousness in some way determines the direction of the energy which it characterizes. The stimuli which affect the movements of animals at first, only produce their results by transmission through the intermediation of consciousness. Without consciousness, education, habits, and designed movements would be impossible. So far as we know, the instinct of hunger, which is at the foundation of animal being, is a state of consciousness in all animals.

On the other hand, as consciousness is an attribute of matter, it is of course subject to the laws of necessity to which matter and energy conform. It cannot cause two solid bodies to occupy the same space at the same time, make ten foot-pounds of energy out of five foot-pounds of energy, nor abolish time more than it can annihilate space.

What is, then, the immediate action of consciousness in directing energy into one channel rather than another? Why, from a purely mechanical point of view, is the adductor muscle of the right side of the horse's tail contracted to brush away the stinging fly from the right side of the horse's body, rather than the left adductor muscle? The first crude thought is, that consciousness supplies another energy which turns aside the course of the energy required to produce the muscular contraction; but consciousness, *per se*, is not itself a force (= energy). How, then, can it exercise energy?

The key to many weighty and mysterious phenomena lies in the explanation of the so-called voluntary movements of animals. The explanation can only be found in a simple acceptance of the fact, that *energy can be conscious*. If true, this is an ultimate fact, neither more nor less difficult to comprehend than the nature of energy or matter in their ultimate analyses. But how is such an hypothesis to be reconciled with the facts of nature, where consciousness plays a part so infinitesimally small? The explanation lies close at hand, and has already been referred to. *Energy become automatic is no longer conscious*, or is about to become unconscious. What the molecular conditions of consciousness are, is one of the problems of the future. One thing is certain: the organization of the mechanism of habits is its enemy. *It is clear that in animals, energy, on the loss of consciousness, undergoes a retrograde metamorphosis*, as it does later in the history of organized beings on their death. This loss of consciousness is first succeeded by the so-called involuntary and automatic functions of animals. According to the law of catagenesis, the vegetative and other vital functions of animals and plants are a later product of the retrograde metamorphosis of energy. With death, energy falls to the level of the polar tensions of chemism, and the regular and symmetrical movements of molecules in the crystallization of its inorganic products.

It has been already advanced, that the phenomena of growth-force, which are especially characteristic of living things, originated in the direction given to nutrition by consciousness and by the automatic movements derived from it. There remain, however, some other phenomena which do not yield so readily to this analysis. These are, first, the conver-

sion by animals of dead into living protoplasm; second, the conversion of inorganic substances into protoplasm by plants; and, third, the manufacture of the so-called organic compounds from the inorganic by plants. It is also well known that living animal organisms act as producers, by conversion, of various kinds of inorganic energy, as heat, light, motion, etc. It is the uses to which these forces are put by the animal organism, that give them the stamp of organic life. We recognize the specific utility of the secretions of the glands, the adaptation of muscular motion to many uses. The increase of heat to protect against depression of temperature, and the electricity as a defence against enemies, display unmistakably the same utility. We must not only believe that these functions of animals were originally used by them, under stimulus, for their benefit, but, if life preceded organism, that the molar mechanism which does the work has developed as the result of the animal's exertions under stimuli. This will especially apply to the mechanism for the production of motion and sound. Heat, light, chemism, and electricity doubtless result from molecular aptitudes inherent in the constitution of protoplasm. But the first and last production of even these phenomena is dependent on the motions of the animal in obtaining and assimilating nutrition; for without nutrition all energy would speedily cease. Now, the motion required for the obtaining of nutrition has its origin in the sensation of hunger. So, even for the first steps necessary to the production of inorganic forces in animals, we are brought back to a primitive consciousness.

To regard consciousness as the primitive condition of energy, contemplates an order of evolution in large degree the reverse of the one which is ordinarily entertained. The usual view is, that life is a derivative from inorganic energies, as a result of high or complex molecular organization, and that consciousness (= sensibility) is the ultimate outcome of the nervous or equivalent energy possessed by living bodies. The failure of the attempts to demonstrate spontaneous generation will prove, if continued, fatal to this theory. Nevertheless, the order cannot be absolutely reversed. Such a proceeding is negatived by the facts of the necessary dependence of the animal kingdom on the vegetable, and the vegetable on the inorganic, for nutrition and consequently for existence. So the animal organism could not have existed prior to the vegetable, nor the vegetable prior to the mineral. The explanation is found in the wide application of the 'doctrine of the unspecialized.' From this point of view, creation consists of the production of mechanism out of no mechanism, of different kinds of energy out of one kind of energy. The material basis of consciousness must, then, be a generalized substance which does not display the more automatic and the polar forms of energy. From a physical standpoint, protoplasm is such a substance. Its instability indicates weakness of chemical energy. The readiness with which it undergoes retrograde metamorphosis shows that it is not self-sustaining. Loew and Bokorny suggest, that "the cause of the living movements in protoplasm is to be sought for in the intense atomic movements, and therefore easy metamorphosis, of its aldehyde groups of components;" the molecular movements becoming molar. The position now presented requires the reversal of the relations of these phenomena. Generalized matter must be supposed to be capable of more varied molecular movements than specialized matter; and it is believed that the most intense of all such movements are those of brain tissue in mental action, which are furthest removed of all from molar movements. From this point of view, when molar movements are derived from molecular movements, it is by a process of running-down of energy, not of elevation; by an increase of the distance from mental energy, not an approximation to it.

The manner in which protoplasm is made at the present time is highly suggestive. The first piece of protoplasm had, however, no paternal protoplasm from which to derive its being. The protoplasm-producing energy must, therefore, have previously existed in some form of matter not protoplasm. In terms of the theory of catagenesis, the plant-life is a derivative of the primitive life, and it has retained enough of the primitive quality of self-maintenance to prevent it from running down into forms of energy which are below the life level; that is, such as are of the inorganic chemical type, or the crystalline physical type.

If, then, some form of matter other than protoplasm has been capable of sustaining the essential energy of life, it remains for future research to detect it, and to ascertain whether it has long existed as part of the earth's material substance or not. The heat of the earlier stages of our planet may have forbidden its presence, or it may not. If it were excluded from the earth in its first stages, we may recognize the validity of Sir William Thomson's suggestion, that the physical basis of life may have reached us from some other region of the cosmos by transportation on a meteorite. If protoplasm in any form were essential to the introduction of life on our planet, this hypothesis becomes a necessary truth.

Granting the existence of living protoplasm on the earth, there is little doubt that we have some of its earliest forms still with us. From these simplest of living beings, both vegetable and animal kingdoms have been derived. But how was the distinction between the two lines of development, now so widely divergent, originally produced? The process is not difficult to imagine. The original plastid dissolved the salts of the earth, and appropriated the gases of the atmosphere, and built for itself more protoplasm. Its energy was sufficient to overcome the chemism that binds the molecules of nitrogen and hydrogen in ammonia, and of carbon and oxygen in carbonic dioxide. It apparently communicated to these molecules its own method of being, and raised the type of energy from the polar non-vital to the adaptive vital by the process. But consciousness apparently early abandoned the vegetable line. Doubtless all the energies of vegetable protoplasm soon became

automatic. The plants in general, in the persons of their protist ancestors, soon left a free-swimming life and became sessile. Their lives thus became parasitic, more automatic, and in one sense degenerate.

The animal line may have originated in this wise: Some individual protists, perhaps accidentally, devoured some of their fellows. The easy nutrition which ensued was probably pleasurable, and once enjoyed was repeated, and soon became a habit. The excess of energy thus saved from the laborious process of making protoplasm was available as the vehicle of an extended consciousness. From that day to this, consciousness has abandoned few if any members of the animal kingdom. In many of them, it has specialized into more or less mind. Organization to subserve its needs has achieved a multifarious development. Evolution of living types is, then, a succession of elevation of platforms, on which succeeding ones have built. The history of one horizon of life is that its own completion, but prepares the way for a higher one, furnishing the latter with conditions of a still farther development.

If the principles here announced be true, it is highly probable that *all forms* of energy have originated in the process of running-down or specialization from the primitive energy. One of the problems to be solved by the physicists of the present and future is that of a true genealogy of the different kinds of energy. In this connection a leading question will be the determination of the essential differences between the different forms of energy, and the material conditions which cause the metamorphosis of one kind of energy into another.

That the tendency of purely inorganic energy is to 'run down,' is well known. Inorganic chemical activity constantly tends to make simpler compounds out of the more complex, and to end in a satisfaction of affinities which cannot be farther disturbed except by access of additional energy. In the field of the physical forces, we are met by the same phenomenon of running down. All inorganic energies or modes of motion tend to be ultimately converted into heat, and heat is being steadily dissipated into space.

The process of creation by the retrograde metamorphosis of energy, or, what is the same thing, by the specialization of energy, may be called *catagenesis*. It may be denied, however, that this process results in a specialization of energy. The vital energies are often regarded as the most special, and the inorganic as the most simple. If we regard them, however, solely in the light of the essential nature of energy, i. e., power, we must see that the chemical and physical forces are most specialized. The range of each species is absolutely limited to one kind of effect, and their diversity from each other is total. How different this from the versatility of the vital energy! It seems to dominate all forms of conversion of energy, by the mechanisms which it has, by evolution, constructed. Thus, if the inorganic forces are the products of a primitive condition of energy which had the essential characteristics of vital energy, it has been by a process of specialization. As we have seen, it is this specialization which is everywhere inconsistent with life.

If we consider the relations of the different kinds of energy to each other and to consciousness, it is difficult to draw the line between conscious and unconscious states of energy. One reason is, that, although a given form of energy may be unconscious, consciousness may apprehend the action by perceiving its results. The relations may be expressed as follows: —

A. *Designed* (always molecular).	*Examples.*
I. Conscious.	
1. Involving effort	'Voluntary' acts.
2. Not involving effort	Passive perception. / Conscious automatism.
II. Unconscious.	
3. Involving mental process	Unconscious automatic.
4. Not involving mental process	Reflex.
B. *Not designed.*	
I. Molecular.	
5. Electric.	
6. Chemical, / 7. Physical,	Crystallific and non-crystallific.
II. Molar.	
8. Cosmic.	

The only strictly molar energies of the above list are the cosmical movements of the heavenly bodies. The others are molecular, although they give rise to molar movements, as those of the muscles, of magnetism, etc. Some molar movements of organic beings are not, *in their last phases*, designed; as those produced by nervous diseases.

The transition between the organic and the inorganic energies may be possibly found in the electric group. Its influence on life, and its resemblance to nerve-force, are well known. It also compels chemical unions otherwise impracticable; thus resembling the protoplasm of plants, whose energy in actively resisting the disintegrating inorganic forces of nature is so well known. Perhaps this type of force is an early-born of the primitive energy, one which has not descended so far in the scale as the chemism which holds so large a part of nature in the embrace of death.

Vibration is inseparable from our ideas of motion or energy, not excluding conscious energy. There are reasons for supposing that in the latter type of activity the vibrations are the most rapid of all those characteristic of the forces. A centre of such vibrations in generalized matter would radiate them in all directions. With radiant divergence the wave-lengths would become longer, and their rate of movement slower. In the differing rates of vibrations, we may trace not only the different forms of energy, but diverse results in material aggregations. Such may have been the origin of the specialization of energy and of matter which we behold in nature.

Such thoughts arise unbidden as a remote but still a legitimate induction from a study of the wonderful phenomenon of animal motion, — a phenomenon everywhere present, yet one which retreats, as we pursue it, into the dimness of the origin of things. And when we follow it to its fountain-head, we seem to have reached the origin of all energy, and it turns upon us, the king and master of the worlds.