been made under Prof. Thurston's direction, shows that the final deduction is substantially the same for all the usually attainable conditions of practice, and further, that, of all the available fluids, steam is fortunately the best.

That the results of scientific investigation may be the more readily appreciated, it is necessary that the study of physical science should be more thorough in our schools. The stereotyped argument for the retention of the old system of education to the exclusion of the new, was, and is to-day, the assertion that the old system strengthened the intellect and broadened the views of the student, while the new subjects are *merely useful;* but the wisdom and the expediency of a modification of old ways, in this respect, is now rapidly becoming acknowledged, and the new education may be considered as fairly and safely introduced. Science will never, we may be sure, displace entirely the older departments of education; but science will henceforth take a place beside them as no less valuable for mental discipline.

With science recognized as a respectable companion of the dead languages, we shall have better trained students, — students who will be better able to lead in the industries, and so aid material prosperity. As it is the duty of government to so regulate affairs that each man may have the power of improving his condition to the utmost, so will it be the duty of science to point out to government how it may direct its regulations to the greatest advantage of the individual. Men of science, each in his own department, are the natural advisers of the legislator. Citizens and legislators are both entitled to claim this aid from those who have made the sciences of the several arts their special study, and from those who have devoted their lives to the study of the sciences of government, of social economy, and of ethics.

Of all the many fields in which the men of science of our day are working, that which most nearly concerns us, and that which is of most essential importance to the people of our time, is that department of applied science which is most closely related to the industries of the world, — mechanics. The development of new industries becomes as much a part of the work of science in the future as is the improvement of those now existing. The new industries must evidently be mainly skilled industries, and must afford employment to the more intelligent and more finely endowed of those to whom our modern systems of education are offering their best gifts. The enormous advancement of the intellectual side of life must inevitably, it would seem, result in the production of a race of men peculiarly adapted to such environment as science is rapidly producing. Thus accomplishing, under the guidance of science, such tasks as lie before him to accomplish, the 'coming man,' with his greater frontal development, his increased mental and nerve power, his growing endurance and probably lengthening life, will be the greatest of the products of this scientific development, and the noblest of all these wonderful works.

THE CRYSTALLINE ROCKS OF THE NORTH-WEST.[1]

Until very recently, it has been the practice of geologists, almost without exception, to refer every crystalline rock in the north-west either to the Huronian or to the Laurentian. But when, on more careful examination, it is found that this nomenclature is imperfect, we are thrown into much difficulty and doubt. In order that some of the difficulties of the situation may be made clear, Professor Winchell proposed to review concisely the broad stratigraphic distinctions of the crystalline rocks that have lately been studied in Michigan, Wisconsin, and Minnesota.

Omitting the igneous rocks, which in the form of dikes cut through the shales and sandstones of the cupriferous formation, and are interbedded with them in the form of overflows, we may concisely arrange the crystalline rocks, disregarding minor differences and collating only the broad stratigraphic distinctions, in the following manner, in descending order: 1°. Granite and gneiss with gabbro; its thickness is unknown, but certainly reaches several hundred feet. 2°. Mica schist; maximum thickness, five thousand feet. 3°. Carbonaceous and arenaceous black slates, and black mica schists; thickness, twenty-six hundred feet. 4°. Hydro-mica and magnesian schists; maximum thickness, forty-four hundred and fifty feet. 5°. Quartzite and marble; normal thickness, from four hundred to a thousand feet. 6°. Granite and syenite with hornblendic schists; thickness unknown, but very great.

These six great groups compose, so far as can be stated now, the crystalline rocks of the north-west. Their geographic relations to the non-crystalline rocks, if not their stratigraphic, have been so well ascertained that it can be stated confidently that they are all older than the cupriferous series of Lake Superior, and hence do not consist of, nor include, metamorphosed sediments of Silurian, or any other age. The term 'Silurian' here is understood to cover nothing below the base of the Trenton.

Examining these groups more closely, we find: 1°. We have, beneath the red tilted shales and sandstones, a great granite and gabbro group. The gabbro is certainly eruptive, but the associated granite and gneiss are probably metamorphic. The gabbro does not always appear where the granite is present; but in other places these rocks are intricately mingled, although the gabbro can be considered in general as the underlying formation. 2°. Below this granite and gabbro group is a series of strata that may be designated by the general term 'mica schist group.' This division is penetrated by veins and masses of red biotite-granite, which appear to be intrusive in somewhat the same manner as the red granite in the gabbro. These granite veins penetrate only through the overlying gabbro and this underlying mica schist.

[1] Abstract of an address to the section of geology and geography of the American association for the advancement of science at Philadelphia, Sept. 4, by Prof. N. H. Winchell of the University of Minnesota, Minneapolis, Minn., vice-president of the section.

They are wanting or comparatively rare throughout the rest of the crystalline rocks. 3°. The next lower grand division might be styled the 'black mica slate group.' This group contains much carbon, causing it to take the form of graphitic schists, in which the carbon sometimes amounts to over forty per cent. These schists are frequently quartzose and also ferruginous. Associated with these black mica slates, which often appear also as dark clay-slates, are actinolitic schists; the whole being, in some places, interstratified with diorite. 4°. Underneath this is a very thick series of obscure hydro-micaceous and greenish magnesian schists, in which, along with gray quartzite and clay slates, occur the most important deposits of hematitic iron-ore. This division of the crystalline rocks has numerous heavy beds of diorite. 5°. Below this series of soft schists is the great quartzite and marble group. The marble lies above the quartzite, and in the Menominee region has a minimum thickness of at least a thousand feet. This is a most persistent and well-marked horizon. In northern Minnesota, the great slate-conglomerate of Ogishke Muncie Lake, with a thickness exceeding six thousand feet, seems to represent the lower portion of the great quartzite of this group, and to be the equivalent of the lower slate-conglomerate of the 'typical Huronian' in Canada.

Now, the difficulties of the situation arise when we cast about to find names for these parts. What are the eastern representatives of these western groups, and by what designations shall they be known?

We meet, at the outset, with the question, Is there a formation such as claimed by Emmons, — the Taconic? On this geologists are yet divided. Having given the subject very careful consideration, Professor Winchell was ready to state his very positive conviction that Dr. Emmons was essentially right, and that the Taconic group will have to be recognized by geologists, and adopted in the literature of American geology.

In the first presentation of the Taconic system, Dr. Emmons extended it geographically too far east, and unfortunately chose a name for it which is appropriate only to a part of that eastward extension. Dr. Emmons's claim, however, in all its essential points, remains intact. This consists in the existence of a series of sedimentary deposits, largely metamorphic, below the Potsdam sandstone, and separating the Potsdam from the crystalline rocks known as 'primary' in an orderly chronological scheme. It is not necessary to refer to the controversies that arose from the creation of the imaginary Quebec group, nor to characterize in deserved terms the attempt to bury the Taconic in the Quebec coffin.

There may be reasons why the current literature of American geology is almost silent respecting the great work of Emmons, and why the Taconic is not known among the recognized geological formations. But we have nothing to do with these at this time. We have now only to say, that it seems necessary to admit, that when Dr. Emmons insisted on a great group of strata belonging to the age of the lower Cambrian, lying below the Potsdam sand-rock in New York, he had some foundation more substantial than imagination or mere hypothesis.

If we examine the descriptions given by Dr. Emmons of his Taconic system, we shall find that he makes the following broad stratigraphic distinctions: 1°. His highest member is what he designates 'black slate,' which he declares, in some cases plunges apparently beneath the 'ancient gneiss,' and contains a considerable amount of carbonaceous matter. 2°. Under the black slate his next grand distinction was the so-called Taconic slate, which he described as argillaceous, siliceous, and 'talcose;' thickness about two thousand feet. 3°. Below the great mass of soft schists, he described a mass of five hundred feet of limestone, designated 'Stockbridge limestone,' which graduates downward into 'talcose' or magnesian sandstones and slates; the whole having a thickness of about seventeen hundred feet. 4°. Under this limestone is his 'granular quartz' rock, more or less interstratified with slates, and becoming, in some places, an immense conglomerate with a 'chloritic paste.' 5°. The 'ancient gneiss,' on which the Taconic system was said to lie unconformably.

Now, it requires but a glance to perceive how clearly this order coincides with that which has been independently and laboriously worked out in the north-west. We have in both instances a 'black slate,' and below this in both cases is an immense series of soft hydro-mica and magnesian schists. These, again, are followed by crystalline limestone, or marble, which changes downwards to slate, and a hard sand-rock. Below this is the great bed of quartzite; which is, at the base, coarsely conglomeritic with masses of rock from the great underlying series of gneiss.

We are now, however, confronted with another difficulty. The geologists of Michigan and Wisconsin have set aside Dr. Emmons's identification of the Menominee rocks with the Taconic, in 1846, and have called them Huronian. It becomes necessary, therefore, to ascertain of what the Huronian system consists.

The 18,000 feet of the Huronian system on the shores of Lake Huron include 900 feet of limestone, 2,000 feet of 'chloritic and epidotic slates,' and 15,100 feet of quartzite and conglomerate. Perhaps 5,000 feet of this thickness may be considered intrusial. This will leave 12,000 feet, at least, for the aggregate thickness of quartzite and conglomerate, being nearly double that observed in the same horizon in northern Minnesota. It is plain to see, that, if there be any parallelism between these beds and the various groups made out in the north-west, the whole of these strata must be made the equivalent of group 5, or the quartzite and marble group.

There is, therefore, a conflict between the Taconic and the Huronian, both in respect to the horizon which they are intended to cover, and in the horizon of rocks which they actually compass. The Huronian, however, in its original and typical description, can be parallelized with only the very lowest of the strata that were included in the typical and original Taconic; while the Taconic stretches upward at least as far as to include the fourth and third grand

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.