FOSSIL SHELLS

OF THE

SILURIAN AND DEVONIAN ROCKS.

BY

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PART I.

A SHORT SKETCH OF GEOLOGY.

A SKETCH OF GEOLOGY.

The name “Geology” is derived from the Greek words "ge," the earth, and "logos," a discourse, thus indicating a science of the earth, a science investigating the different materials of which the earth is composed, and also the manner in which these materials are arranged. Geology gives us, also, the history of our planet from its beginning to the present time—examining all the processes through which the earth has passed, from its original gaseous condition until it acquired its present form and structure. It furthermore enables us to obtain extensive and valuable information about the animal and vegetable life which covered our globe during bygone ages.

Geology is a science of comparatively recent date, though we find some geological knowledge among the ancient Romans and Greeks, and in the writings of the middle age. All that knowledge, however, amounted only to a few isolated speculations, nearly always based upon erroneous suppositions, and never resulting in the establishment of a regular system. Geology as a science was originated during the last century, but received its main development during the present one. In spite of its short existence, it has outgrown many of its sister sciences, and ranks to-day among the most important ones at the head of the scale. Its founders and chief promoters are mainly found among the English, German and French savants, and during the present century our own country has contributed its full share to its advancement. The names of Lyell and Murchison, of Leopold von Buch and Goldfuss, of Cuvier and Verneuil, and of our own eminent geologist, Professor James Hall, of New York, and many others, will be known to the students of this noble science throughout the coming ages.

Geology has for its territory the whole earth, as far as the same is accessible to its investigations. These are not confined to the surface, but penetrate as deep into the interior as artificial excavations for mines and artesian wells allow. Still greater and better opportunities than these artificial openings, which are limited in numbers and dimensions, are offered the geologist, for his researches, by the peculiar figuration of our planet's surface, where deep valleys alternate with high mountains, and where the strata are bent to such a degree that we find them at one place deep below the surface, whilst at a distance of a few miles the very same layers may be outcropping at the slope of a hill, or may even form the surface rocks of extensive districts.

Vast as the geological field appears, and in reality is, it, nevertheless, forms only a small portion of the whole contents of our globe. The deepest excavations rarely extend to a depth of 2,000 feet below the level of the sea, though their absolute depth may be greatly in excess of this, inasmuch as most of them are in mountainous regions. The bending of the strata very often gives us an insight into greater depths, but even this amounts only to a few miles, and forms only a small portion of the earth's radius. Beyond these depths geology is barred, as far as actual observations are concerned, but its inquiries may penetrate deeper; it may speculate about the nature and condition of the earth's interior. About this matter different theories have been advanced, but as all of them are based on mere speculation, none have met with a general acceptance by the scientific world. Whether the center of our globe is solid or fluid, whether it is a vacuum or filled with compressed air, we are unable to decide with certainty. Some facts speak for a solid and others for a fluid center, and still others can not be accounted for by either condition.

Some European scientists, like Leslie and Halley, consider the earth a hollow sphere, which, according to Leslie, was filled with imponderable material, possessing an enormous repulsive force. These philosophic speculations of savants were taken up by Captain Symmes, of Kentucky, who, by adding his own fantastic dreams, enlarged them to the so-called "Symmes' Theory." Symmes insists that the interior of our globe is not only hollow, but that it is also inhabited by animals and plants; that it possesses a very mild climate, and is illuminated by two planets, which he calls Pluto and Proserpina. He felt so convinced of the existence of his subterranean country, that he repeatedly extended private and public invitations to Alexander von Humboldt, Sir Humphrey Davy, and other celebrated scientists of this country, and of the old world, to accompany him on his intended subterranean expedition.

ROCKS.

The solid portion of the earth is composed of different materials or rocks.
The term "rock," as commonly understood, signifies a hard and stony mass, such as granite, quartz or limestone, but in its geological meaning, it embraces all solid constituents of our globe, the hard and stony, as well as the soft and incoherent matter; thus, loose sand and soft clay are just as well included in that term as basalt and quarrystone. Before geology enlightened the people, it was the general belief that all the rocks, with their present form and arrangement, were thus created. This belief, though still adhered to by the ignorant masses, and by bigots, has disappeared from the minds of all who ever came under the influence of geological reasoning. Geology informs us, that all the rocks in their present structure, composition and arrangement, are the products and results of many different conditions under which our earth existed,

and of many different processes through which it has passed during the many ages of its existence. By whatever influences the rocks may have received their present characters, they received their original form and structure by the agency of fire. All the rocks, without exception, passed, in the beginning, through a molten condition, out of which, by subsequent cooling, they received their first form as solids. But in the course of time another agent appeared and changed many of the existing forms. Water, the powerful opponent of fire, went into action, and by its chemical, as well as mechanical influence, dissolved a large portion of the fire-produced formations, and carried them to distant localities, where, under favorable conditions, they were deposited as sediments, forming those rocks which are mainly characterized by their arrangement into strata or layers. Again, we find many of these sediment-formations have been subjected to the influence of heat, by which they lost some of their former characteristics. Their crystallization, and the total absence of organic remains, prove the action of heat, while, on the other hand, their stratification, which is generally retained, testifies to their sedimentary origin. Thus we will notice a natural division of all the rocks into the following three classes:

1. Rocks originally formed by fire and not afterwards changed, the igneous rocks.
2. Rocks formed in water by sediments, the stratified or sedimentary rocks.
3. Rocks originally formed as sedimentary deposits, but afterwards changed by heat, without losing their stratification, called metamorphic rocks.

The igneous rocks are generally subdivided into volcanic and plutonic rocks. Their difference is caused by the condition under which the cooling of the molten masses took place. In the volcanic rocks, the molten matter appeared either on the surface of the earth, or at least very near to the same, where the cooling was rapid, and where the forming rocks were not subjected to the heavy pressure of the superimposed strata.

The plutonic rocks resulted from greatly different conditions. Here the molten masses did not penetrate the surface strata, but remained deep in the interior of the earth, or at least at the bottom of deep oceans, where the cooling process was retarded, and where the new formations were compressed by the weight of the overlying layers.

In the column of strata we generally find the plutonic rock at the bottom. Next above come the metamorphic formations, which are superimposed by the sedimentary and volcanic rocks. This arrangement led the earlier geologists to the belief that the plutonic and metamorphic rocks were older than the others, consequently, they called the lower primary formations, and the upper the secondary formations. The older school of geologists adhered to the so-called neptunian theory, according to which all the rocks, with the only exception of the volcanic lava formations, were considered as produced by water, or to be of aqueous origin. If this theory had proved correct, the views of the old school about the comparative age of the different rocks would be sustained. But progress in geological science has upset the neptunian theory, and established in its place the plutonic theory, which makes fire or subterranean heat the main agency in the production of the plutonic and metamorphic rocks.

This new theory does not admit the classification of primary and secondary rocks. The first rocks ever produced, which formed the first thin crust of our globe, were dissolved by water and removed to other localities, where they furnished the constituents of the sedimentary formations. Even a large portion of these have been ground up by weather and water, to provide the material for later deposits. Rocks of all the different classes have been formed, during the past, simultaneously, and may be in process of formation at the present time. The terms primary and secondary are, therefore, obsolete, inasmuch as they indicate the comparative age of the different rocks.

SEDIMENTARY OR STRATIFIED ROCKS.

Though all the different classes of rocks are of great interest to the geologist, still the most important of all is that including the sedimentary formations. The rocks of this class are always arranged in layers or strata, and they are, therefore, generally referred to as stratified rocks. They are of greater importance to the geologist than the other formations, because they furnish him the main material for his investigations. Most, if not all, of them have been formed since the beginning of organic life on our planet, as proved by the remains or traces of animal and vegetable organism preserved in their strata.

The most important among the different points which the geologist has to consider in regard to the sedimentary rocks, are: their mineral composition, their arrangement in strata, their relative age, and, most of all, their organic remains.

In regard to their mineral composition, we may divide them into three groups, the siliceous, or arenaceous rocks; the clayey, or argillaceous rocks ; and the calcareous rocks, or limestone. The main constituent of the first group is silica, in the form of quartz-grains or sand; that of the second group is clay, a mixture of siliceous matter, with a large amount of alumina and oxide of iron, and that of the third group is carbonate of lime. It is impossible to separate these three groups by a well defined division line. Some rocks form a kind of connecting link between the first and second, and others between the second and third group, while again, others may combine the siliceous and calcareous rocks. The first group is represented by sandstone, the second by shale, and the third by limestone. Argillaceous rocks are easily identified by the peculiar earthy odor which they emit when breathed upon, while the limestones may be detected by the aid of muriatic acid, which causes effervescing when applied to them. Upon sandstone acids have no effect whatever.

STRATIFICATION.—Stratification is the arrangement of rocks into different layers or beds. It is a characteristic feature of all the sedimentary formations. Stratification can only be produced by sedimentation, and the latter can, as far as geological strata are concerned, only take place in water charged with solid or earthy matter, which is kept in suspense in the shape of mud. Solid material has generally a greater density, or specific gravity, than water, and, therefore, can be kept in suspense by the latter only so long as the lateral motion of the water overcomes the action of gravitation. As soon as the water ceases to move, the mud falls to the bottom, where it forms the sediment which afterwards, under the enormous pressure of superimposed masses, transforms into solid rock. If such sediment formation had gone on continuously, and always under exactly the same conditions, throughout a whole geological period, all the rocks of that formation would form a solid, unbroken mass. But the sediment formation suffered frequent interruptions, extending over shorter or longer periods, and was subjected to many changes in its material. These circumstances caused a differentiation in the deposits. Any interruption of the formation, or any change in the material, were indicated by lines or planes of separation, while the different layers, thus produced, were distinguished by color and texture.

The solid or earthy materials with which the waters are charged, are derived partly from the dry land by the influence of heat, frost and rain, and partly by the never-resting waves of the oceans grinding up the cliffs and beaches of the seashores. These agencies are employed to reduce the elevations of the dry lands to the level of the oceans, and, if they were not counteracted by other forces, would accomplish their task in less than six millions of years. It is estimated that the average elevation of all the continents and islands does not amount to fully one thousand feet; and, on the other hand, the work accomplished by denudation is computed to be one foot in six thousand years, extending over the whole area elevated above the ocean. Such calculations are only mere approximations, based upon conditions which may change considerably in the course of time, and should never be used for framing deductions, without making great allowances. That the work of denudation must have been different during the different ages of the past, can not be doubted. There were periods when a very high temperature prevailed all over the earth, from the poles to the equator, causing a heavy rainfall, and lending the water a greater dissolving power, circumstances which must have produced greater denudation. Then, again, other periods set in, when the temperature of our globe was very low, when the excessive heat of former ages was replaced by excessive cold. Frost is a very powerful agent in the destruction of rocks. The hardest material which admits water into its pores will be crumbled to dust by this destructive force. Here, again, denudation must have been very large. Between these extremes in temperature, our planet experienced some moderate climate which had not such a destructive influence upon the solid material of our earth's crust.

STRATA AND LAYERS.—These two terms are generally used as synonymous, but some geologists make a distinction between them. They use the term layer for each single member of stratified rock, and apply the term strata to beds of the same material. Thus, if a section shows in its lower half limestone, and in its upper half sandstone, it contains only two strata, though it may show a great many layers.

Layers and strata vary in thickness from an inch, and less, to many feet. Very thin layers are called laminæ, and for thin strata, the term seams is used. If all the strata had remained undisturbed in their original position, all would be nearly horizontal, and parallel to each other; but the many upheavals and depressions to which our earth's crust has been subjected, have disturbed their original horizontal and parallel arrangement, and we now find them occupying every imaginable position in relation to each other. Wherever two sets of strata or layers are nearly parallel to each other, it proves that the older set was not disturbed in its original position before the younger or later one was deposited upon it; but whenever the upper strata rests on the edges of those below, these latter have been disturbed before the formation of the upper ones took place. In the first case, where the parallelism of the strata is maintained, they are said to be conformable; but whenever the planes of the upper layers rest on the edges of the lower ones, they are called unconformable. Conformability of strata indicates a period of rest, whilst unconformability is a certain proof of disturbance. Any movement in the earth's crust must produce some changes in its layers or strata, resulting either in a bending or breaking of the same, whereby fissures, folds and faults are originated. Fissures are rents caused by breakage, without any displacement of the rock on either side of the fracture, below or above their former level; but, whenever the masses on one side or the other have changed their positions, either by elevation or depression, the rent becomes a fault. According to the great difference in the magnitude of the forces producing the faults, the size of the latter must also differ greatly. We find them measuring from an inch and less, to many hundred feet. Faults are of great inconvenience to miners, especially where they appear of considerable size. Folds of strata are the result of their bending without breaking; they differ in size from a few feet to many miles, and form, very often, extensive valleys and mountains. Strata are very seldom found perfectly horizontal; they may be so for a short distance, but, extending over a larger area, they will always show a certain amount of curvature. These curves bending inward—that is, with their convexity toward the center of earth—are forming troughs; bending outward, they form arches. A line running, in a series of strata, through the highest point of their arches, is called their anticlinal axis, and the line running through the lowest point of their troughs is known as their synclinal axis. If no denudation had interfered, we would always find the anticlinal axis to correspond with elevations, and the synclinal with valleys; but, since, by the influence of weather and water the figuration of our earth's surface has greatly changed, we often meet with anticlinal valleys and synclinal hills. The correct location of these lines is often of great importance to the geologist in surveying a certain district or country, which he can easily accomplish if he bears in mind that his proceeding from older upon younger strata leads him towards the synclinal; and *vice versa,* if he proceeds from younger upon older formation he approaches an anticlinal.

Two other important features of the stratified rocks are their dip and strike. Upon these, to a great extent, depends the peculiar topography of the earth's surface.

Dip is the amount of the deflection of strata from the horizontal or level line; it is measured by, or expressed in, degrees. If a layer has a dip of forty-five degrees, it is bent downward, and forms with the horizontal surface an angle of forty-five degrees. Wherever the dip increases to an angle of ninety degrees, the strata stand on their edges in a vertical position. Strike is the horizontal line drawn at right-angles to the direction of the dip. Rocks with a southern or northern dip, will have an eastern or western strike. As long as the dip of certain strata runs in the same direction, their strike is indicated by a straight line; but as soon as the dip changes its direction, the strike will assume the shape of either a broken or curved line. Rocks with great dip produce a broken undulating country, and in accordance with the curved or straight lines of the strike, we find the hills and valleys respectively winding or rectilineal.

P ALÆONTOLOGY.

Palæontology treats of the animals and plants which inhabited our planet during former periods, and may, therefore, be properly styled the natural history of by-gone ages. From zoology and botany, it differs only in so far as its objects belong mostly to an extinct fauna and flora, the remains or traces of which are imbedded in the rocks and soils of the earth's crust. Palæontology forms a science of itself; but on account of its intimate connection, with geology, it is generally considered as only a branch of the latter. The objects with which palæontology deals are known under the name of "fossils," a term designating bodies "dug out of the ground," and which was formerly applied to metals and rocks, as well as to organic remains. At present the word fossil is used in a more restricted sense, applying only to such geological objects from which science may deduce information about the organic life of the past. These objects mainly consist in remains of animals and plants, such as shells, teeth and bones; or stems, leaves and fruits; but they also include the burrows and tracks of annelids, the footprints of saurians and other animals, and even the droppings of fishes and reptiles, which are known under the name of coprolites. Some geologists class among the fossils even objects produced by man, such as arrow-heads, spear-heads and canoes found in the gravel and clay beds of our fields and river shores; but, inasmuch as they properly belong to archaeology, they can not be counted among the fossils.

The real nature of fossils was known more than five hundred years before the Christian era, by Xenophanes. He observed the fossil remains in the quarries of Syracuse, consisting of marine shells and fish-bones. He recognized them as the remains of real animals, that had lived there at the bottom of the sea, where they were imbedded in mud, which afterwards hardened into the rocks then inclosing them. He also laid down the general proposition, that the geographical features of our earth are not constant, but that, where land now is, sea has been, and where sea now is, land has been. Afterwards this clear conception of the real nature of fossils appears to have been lost, until the end of the seventeenth century, when Nicholas Steno, Professor of anatomy in Florence, though a Dane by birth, gave them again a correct explanation, and revived the theory of Xenophanes.

Before Steno, during the fourteenth, fifteenth, sixteenth and seventeenth centuries, fossils were regarded as mere figured stones, portions of mineral matter which have assumed the forms of leaves and shells and bones, just as those portions of mineral matter which we call crystals, take on the form of regular geometrical bodies. Others considered them the products of the germs of animals and of the seeds of plants, which have; as it were, lost their way, in the bowels of the earth, and achieved only an imperfect and abortive development. These opinions appear to us ridiculous, and we are inclined to sneer at our ancestors for entertaining such ideas about a matter which is now so clear and simple. People who believed in spontaneous generation, could have no difficulty in taking fossils for sports of nature, and we know that spontaneous generation was generally believed in up to the present century; and, even to-day, thousands of people, laying claim to a fair education, still adhere to that belief These erroneous ideas about the nature of fossils were, long after Steno's correct interpretation, maintained among common people, but men of science became more and more convinced of the correctness of

Xenophanes' theory. To-day, every person who has gained an insight into palæontology, knows that the fossils found in most of the sedimentary rocks are originated by animal or vegetable remains, which became imbedded in the mud at the bottom of the sea, during former ages. In speaking of fossils, we generally describe them as remains of animals and of plants, which is not in accordance with the facts, at least not for the majority of them, inasmuch as, in the larger number, not a particle of organic matter is preserved, and only the form of the imbedded body retained. The original animal or vegetable substances dissolved and became replaced by calcareous, siliceous and other minerals. The remains, therefore, underwent an active transformation into stone, or became, as we call it, petrified. Fossils thus transformed or changed, are classed together under the name of petrifactions.

This term is very often used as a synonym for fossils, but erroneously; because not every fossil has passed through a petrifying process, while there are many belonging to younger formations, that have, outside of form and structure, retained also the color and organic matter of the original remains. Every petrifaction is a fossil, but not every fossil is a petrifaction. The process by which the transformation of organic remains into mineral bodies is produced, is of a chemical nature, and depends upon conditions not yet fully understood.

We must distinguish between petrifactions and incrustations, although the latter are often classed among the former. Incrustations are generally produced in springs, whose waters are charged with a considerable amount of calcareous matter, which settles upon immersed bodies, like flowers and branches, or shells and bones, inclosing them with a mineral coat or crust, but never permeating them, as is done in the case of petrifaction. By breaking such incrustations we find, either the inclosed bodies unchanged, or, if they have disappeared, the place formerly occupied by them a hollow mould.

Another transformation of animal matter is by many erroneously classed among petrifactions. We sometimes notice in public papers reports of cases where human bodies, resurrected after some years of interment, have been found, not only well preserved in form, but so hard and stiff, and so much increased in weight, as to appear completely changed into stone. Such cases are looked upon by a great many people as a kind of miracle, while, really, they are nothing more than the result of a chemical process by which the animal fat has been converted into a sort of wax. Transformations of this kind occur only in bodies buried in wet places, where they are completely submerged by underground water charged with antiseptic ingredients. As soon as these bodies are removed from their original resting place, they commence to decompose, a fact clearly showing that they never underwent the process of petrifaction. The wax-like material into which the fat is converted is called adipocere. It was first discovered by the French scientist Fourcroy, in the year 1787, during the removal of the cemetery of the Innocents, in Paris.

USE OF FOSSILS.

Collectors of geological and palæontological specimens are often objects of wonder and curiosity to people who notice them closely examining rock-piles and clay-banks. What are those fellows doing there? What are they hunting for? These questions are asked, without exception, by almost every person passing by, and if the men of science show the things they are looking for, and explain their origin and meaning, they may consider themselves very fortunate if, in ninety-nine out of a hundred cases, they are not looked upon as fit recruits for a lunatic asylum. The ignorance prevailing among the mass of the people, about objects of natural science, and especially of geology and palæontology, is appalling. Such ignorance might be excused among the lower classes, who had neither time nor opportunity to acquire knowledge, but to find it, even at the end of the nineteenth century, among the majority of persons who lay claim to a fair and liberal education, is very humiliating, and proves the inefficiency of our schools, at least in that direction.

Fossils are picked up, by people in general and by curiosity hunters in particular, because they look so "pretty" or so "strange," as the expression may be; but that these pretty and strange-looking things are of the greatest importance to science, and of immense service to industry, is, so far, known only to very few, outside of the scientific world. Fossils are the letters with which Nature has written the earth's history, in a language intelligible to every student of natural science, whatever nationality he may claim. They faithfully report to us the different processes and changes through which our globe has passed, from its beginning as a solid body to the present day. In them, the animal and vegetable kingdoms of by-gone ages arise from their tombs, and present themselves to the investigation of science. They furnish the indisputable proof that the organized world commenced with its lowest forms, and developed gradually into its higher types. Mantell, an English geologist, says of them: "Fossils have been eloquently and appropriately termed medals of creation, for, as an accomplished numismatist, even when the inscription of an ancient and unknown coin is illegible, can, from the half obliterated effigy and from the style of art, determine with precision, the people by whom, and the period when it was struck; so, in like manner, the geologist can decipher these natural memorials, interpret the hieroglyphics with which they are inscribed, and, from apparently most insignificant relics, trace the history of beings, of whom no other records are extant, and ascertain the forms and habits of unknown types of organization, whose races were swept from the face of the earth long before the appearance of man and his contemporaries." The fact that fossils show the gradual development of organic life from its lowest to its highest types, affords to science the means of determining the relative age of the different strata in which they are imbedded; rocks, for instance, embracing remains and traces of fishes, must be younger than others in which only fossils of shells and corals are contained; or, again, strata only imbedding seaweeds and other low forms of the vegetable kingdom, must be older than those in which leaves and fruits of the trees of our present forests are found. Fossils tell us by their character, and by their mode of preservation, whether they have lived at the bottom of the ocean, in fresh water lakes or rivers, or on the dry land. If they lived in the seas, they also inform us whether these were quiet or stormy, deep or shallow. By the data deduced from fossils, geologists are able, to-day, to write the geographies of former geological epochs, and to mark out on maps the exact distribution of land and water prevailing on our globe during those periods. What the compass is to the navigator, guiding him across the pathless ocean into the intended port, are the fossils to the geologist in his scientific investigations, and in his explorations for economical and industrial purposes. They not only tell him the history of the earth, and of its former inhabitants, they also show him the fields where the gold and diamond hunter may find those brilliant treasures with which our daughters like to heighten and brighten their natural charms. They indicate the places where to dig successfully for the briny water which furnishes our table with the most indispensable spice, or for the valuable oil illuminating our houses and parlors. They also locate the mines from which we extract that invaluable mineral which not only affords us comfort at home, but also speeds our travels across the oceans and the plains.

Fossi1s are the letters in the geological alphabet. To read the latter you must know the former. Without their thorough understanding, no successful study of geology is possible.

GEOLOGICAL PERIODS.

During the infancy of the geological science, it was generally believed that different periods had existed in former ages, which were separated by sharply defined division lines, and that each period possessed its own creation; which meant that all the different species of animals and plants of a certain period were created and destroyed during that period, and that, for the succeeding epoch, an entirely new creation had to take place. This belief in the total destruction of all existing life at the end of the different geological periods, called cataclysm, originated from the fact that different groups of strata contain different groups of fossils, and was upheld by the belief in a priori creation of each species. Corresponding with those periods, the stratified rocks were divided into different formations.

The rapid progress of the geological science has expunged the division lines between the periods, and has upset the theory of cataclysm. The existence of different groups of fossils in different strata can not be denied; but a more careful examination of the fossils has already shown, and hereafter will show more conclusively, that the existing differences are not the result of new creations, but are produced by the gradual modifications occurring in species exposed to changes in their surroundings during the course of many centuries. The theory of evolution, now generally accepted by all men of science, has destroyed the theory of cataclysm, as well as the belief in an a priori creation of each single species. The division of the geological time into periods, and of the stratified rocks into formations, though based upon erroneous suppositions, has proved to be of great convenience to geologists, and is, therefore, maintained. The dividing lines, however, are not fixed by nature, but may be shifted by arbitration. The whole geological time, from its beginning to the present day, is divided into four great divisions called ages. These are as follows:

1. AZOIC AGE, embracing the time from the beginning of the earth as a solid body to the appearance of life in the shape of either animals or plants.

2. PALÆOZIC AGE, beginning witl} the appearance of organic forms, and terminating with the close of the coal formation.

3. MESOZOIC AGE, beginning at the end of the coal formation, and closing at the appearance of mammals.

4. CENOZOIC AGE, embracing the balance of time up to the present day.

Corresponding with this division of time, we divide all the rocks into the four groups of azoic, palæozoic, mesozoic and cenozoic rocks, according to the age in which their respective formation took place. The first group of rocks is of little or no interest to the palæontologist, inasmuch as it does not contain any traces of life; still, what we to-day consider azoic, or bare of life, may, to-morrow, disclose forms of undoubted organic character. Not many years ago all the metamorphic rocks were considered azoic; but since Canadian geologists have discovered the Eozoan canadense, and have also established the fact that numerous traces of coal and graphite are to be found in these rocks, the existence of some kind of life during the formation of that group can not be doubted any longer. As soon as the presence of life during the formation of those rocks, which heretofore were classed among the azoic, is definitely settled, those rocks have either to be removed to the palæozoic group, or, as Professor Dawson, of Canada, has proposed, a new group, to be called the Eozoic, has to be established for their reception.

All the different metamorphic rocks constitute together the Archaean formation, which is subdivided into the Laurentian and Huronian groups. The Laurentian group forms the base of the whole geological column of sedimentary rocks. It derives its name either from the St. Lawrence river or from the Laurentian mountains in Canada, where it is exposed over an extensive area. In the United States we find it cropping out in New York, where it forms the Adirondack mountains; also in Michigan and Tennessee, and in a few other States. Its thickness in Canada is estimated to be about six miles, or more than 30,000 feet. About the middle of its column are the strata containing the Eozoan canadense, the real nature of which is still involved in some doubt. However, it appears that a majority of geologists have accepted it as the fossil remains of a Rhizopod, and consider it as the commencing point of animal life.

The Huronian group has received its name from Lake Huron, in the vicinity of which it is largely developed and exposed. It overlies the rocks of the previous group in a manner proving its later origin. The dividing line between these two Archaean groups is not sharply drawn. The absence of fossils in these rocks compels us to base their distinction altogether upon their lithological characters, which, alone, seldom affords a safe criterion for the determination of groups. The thickness of the Huronian group in Canada is estimated to exceed 10,000 feet. None of these Archaean rocks are exposed in the State of Kentucky, though their presence at great depth can not be doubted.

The rocks formed during the Palæozic age are divided into three formations: the Silurian, the Devonian and the Carboniferous.

SILURIAN FORMATION.—This formation was first established by Sir R. T. Murchison, the celebrated English geologist. He named it after the ancient Silures, the former inhabitants of that portion of Britain where he first studied this class of rocks. Murchison divided this formation into the Upper and Lower Silurian, a subdivision generally accepted by the geologists of Europe and America, and which answers fully for most purposes. The Lower Silurian formation is the most important on account of its large extent in thickness, as well as in area. It is subdivided into the following groups, which are given in ascending order.

1. St. John's Group; 2. Potsdam Group; 3. Calciferous Group; 4. Quebec Group; 5. Chazy Group; 6. Birdseye Limestone; 7. Black River Group 8. Trenton Group; 9. Utica Slate; 10. Hudson River Group. Some of these groups, as will be seen, are named after localities where they are prominently exposed, while others have received their name from the peculiar character of the rocks which they embrace. Of all these different groups, the Trenton

and the Hudson River groups are of main importance to Kentucky geologists. These two cover extensive areas of our State, and show in some places considerable thickness. The balance are either wanting in Kentucky altogether, or exposed in only very few and very limited spots.

The Hudson River Group is generally known as the Cincinnati Group, on account of its excellent exposure at and around Cincinnati. In Kentucky, the blue limestone of the Trenton forms the surface-rock of that rich and world-renowned district known as the "Blue-grass Country," and is, there, the source of the most productive soil of the United States. In consequence of the rapid decomposition of this rock, when exposed to the influence of sunshine and rain, it keeps the soil in an everlasting virginity, a soil which, a thousand years from to-day, will produce as well as it does at present, pro- vided all other conditions remain the same. The Upper Silurian is divided into the following groups:

1. The Oneida Conglomerate; 2. The Medina Sandstone; 3. The Clinton Group; 4. The Niagara Group; 5. The Onondaga Salt Group; 6. The Lower Helderberg Group. Of these subdivisions of the Upper Silurian, only the Clinton and the Niagara groups deserve especial notice as Kentucky formations. The Clinton Group is only found in few and isolated places, and never attains a thickness of any consideration. The Niagara Group embraces the same kind of rocks which form the bed of the Niagara river at its world-renowned falls, whence it derives its name. In Kentucky it neither covers extensive areas nor attains great thickness; but it furnishes, in some places, excellent building stone. Near Louisville, we find it well exposed in the quarries east of the city, providing Louisville with most of the limestone required for building purposes. Here the Niagara rocks are very rich in fossils, which are mostly well preserved, and have furnished a great deal of the material now in the valuable collections of several Louisville geologists, and which enables science to acquire an extensive knowledge of the fauna of the Niagara period.

DEVONIAN FORMATION.—This formation is named by Murchison after Devonshire, in England, where it is prominently represented in the surface-rocks. Here in America we have subdivided it in the following groups:

1. Oriskany Sandstone; 2. Upper Helderberg Group; 3. Hamilton Group; Portage Group; 5. Chemung Group; and 6. Catskill Group.

The Oriskany sandstone is placed here at the base of the Devonian column, whilst others consider it as the youngest member of the Silurian groups. It is extremely difficult to decide which of the two places assigned by different geologists to the Oriskany sandstone, is the proper and correct one. If, in accordance with the opinion of the older geologists, the Silurian period had been closed by a cataclysm, extinguishing all life of the Silurian time, Nature itself would have drawn a dividing line between Silurian and Devonian formations which could not be misunderstood by anybody; but no cataclysm ever took place; on the contrary, the transformation of the Silurian fauna and flora into their Devonian forms was accomplished by slow and gradual modifications, a process which did not produce partition lines, the establishment of which is thus left to arbitration. The proper way to find out the correct position of the Oriskany sandstone, is to carefully examine its fossils; if these show a nearer relationship to those of the Devonian than to the Silurian, the questionable group belongs to the younger formation; but if the relationship is closer to the Silurian forms, said group should be transferred to the Silurian column. In our own State, we find the Devonian formation represented only by the upper Helderberg and Hamilton groups, which are so blended together that it is entirely impossible to separate them from each other. Fossils characteristic of either of these groups are found from bottom to top of the whole Devonian columns in Kentucky. The Devonian formation does not cover a very extensive field in our State, still it is of great importance for economic, as well as for scientific purposes. It furnishes to the builder rock, cement and lime; to the farmer, a healthy and productive soil; and to the geologist, those precious specimens of fossil corals, crinoids and shells, which nowhere on the whole globe can be found in such abundance of specimens and species, and in such excellent state of preservation, as at Louisville and its vicinity. The widely known Falls of the Ohio River are not only known here in this country as an obstruction to navigation, but they are known to geologists of the whole civilized world as the great store-house where the Devonian world has collected the choicest specimens of its animal kingdom.

The Upper Helderberg group is often called the Corniferous limestone, or the Corniferous group, on account of the great mass of hornstone which it contains. This hornstone is found in great abundance in all of our Devonian strata, and it would, therefore, be advisable to designate the whole Devonian column in Kentucky as the Corniferous group.

CARBONIFEROUS FORMATION.—This formation is divided into Subcarboniferous and Coal Measures; both are still covering a large territory in Kentucky, though it appears that their former original extent has been greatly reduced by denudation. At present we have two large coal fields in our State; the eastern, which forms a part of the Appalachian coal region, and the western, belonging to the Illinois coal fields. Both these districts, it appears, were formerly united, though they are at present separated from each other by a broad strip of land whose surface-rocks belong either to the Devonian or to the Silurian. That the Carboniferous strata originally covered this dividing strip can scarcely be doubted, when we find the many knobs by which it is covered capped with the Carboniferous formation. Those knobs can not be the products of volcanic action. The undisturbed horizontality of their layers proves them to be the result of denudation. The denuding influence of heat, frost and rain appears to be too insignificant to have produced such an amount of excavation as would have been necessary to cut down many square miles of land from their former to their present level—a difference in some places amounting to several hundred feet. However, we must always bear in mind that geological agencies are enabled to do their enormous work, not so much by their magnitude, but mainly by their perseverance throughout the endless spaces of geological times.

Of the Subcarboniferous we distinguish the following five subdivisions: Kinderhook, Burlington, Keokuk, St. Louis and Chester groups. It is doubtful whether the Kinderhook group is really different from the Chemung group, and, even if a difference exists, it remains questionable where to place it properly, whether with the Devonian or the Subcarboniferous; its fossils show a nearer relationship to the Devonian fauna than to that of the superimposed strata of the Subcarboniferous. In Kentucky we find only the three younger formations, viz.; the Keokuk, the St. Louis and the Chester, which form a kind of border around the coal fields. The St. Louis limestone gives a peculiar feature to the country of which it forms the surface-rock. In its strata we find the many, often very extensive caverns, and the surface covered over with numerous funnel-shaped sink-holes. All the formations and groups so far enumerated, originated during the Palæozoic Period; they alone are of interest to Kentucky, inasmuch as they embrace all the surface-rocks of our State.

MESOZOIC AGE.—This produced the following three groups: Triassic, Jurassic and Cretaceous. None of these are represented in our State, though they cover vast areas of our continent, especially the Triassic and Cretaceous, whilst the Jurassic is only recognized in the Rocky Mountains and on its western slope.

CENOZOIC AGE.—During this age, which reaches to the present time, the Tertiary formation was called into existence. In it we find the earliest representatives of the different genera and species of animals and plants which today inhabit our planet. The subdivisions of the Tertiary are Eocene, Miocene and Pliocene.

Of living or recent species, the Eocene contains 3 to 4 per cent.; the Miocene from 18 to 20 per cent., and the Pliocene from 35 to 95 per cent., according to Lyell's definition of these different groups.

In the localities where Lyell studied these different rocks, there was a clear line of demarkation between the groups as he organized them, and in each group he found the above stated percentage of recent species; but other localities of Tertiary rocks showed more than 4 and less than 18 per cent., and others again more than 20 and less than 35 per cent. of living species among their fossils. The question there and then arose, to which of the groups such strata should be attached? This question is solved by placing them in those groups with which their fossils show the nearest relationship.

MOLLUSCA.

Mollusca form one of the great animal sub-kingdoms; their name is derived from the Latin word "Mollis," meaning soft, on account of the soft consistency of their body. This name was given to them by the French savant, Cuvier. This sub-kingdom embraces the Mollusca proper and the Molluscoids. The latter include the Polyzoa or Bryozoa and the Ascidians. The Ascidians having no shell, but instead only a kind of leathery sack, are not, so far, found in a fossil condition. The Bryozoa were formerly classed with the Corals on account of the resemblance of their calcareous support with those forms, but a closer study of the animals themselves proves their nearer relationship with the Mollusca. Inasmuch as the following monograph only treats of the fossil remains of the Mollusca proper, I deem it sufficient to limit my description to the latter.

The soft condition of the animals of this class makes it necessary to provide them with a protection in some shape or form. This is given them either by a calcareous envelope called their shell, or by a leathery sack or mantle surrounding the body. This mantle is possessed by every Mollusca, whether it is provided with a shell or not; but the mantle of those without shell is more leathery and better adapted for protection than the mantle of the shell-bearers. The shells are either of one, two or several pieces, and are accordingly called; univalves, bivalves and multivalves. The common garden snail belongs to the first, the river mussel to the second, and the Chitons to the last group. Some of the Mollusca have a regular head furnished with eyes, tentacles, and a mouth with jaws and teeth. This class is called Encephala. The balance, having no head, are known as Acephala. The first group is divided into Cephalopoda, Gasteropoda and Pteropoda; the second into Brachiopoda and Lamellibranchiata.

CEPHALOPODA, meaning head-footed, so named because their arms or feet are arranged around their mouth. To this class belong the Nautilus, the Argonaut and the cuttle-fish of the present fauna, and the Ammonites, Cereatites and Belemnites of former ages. The bodies of most of them are symmetrical, that is, both halves of their bodies are identical in parts and size; their locomotion is produced either by the muscular feet surrounding their mouths, or by two fins attached to the sides of their body, or, again, by the forcible expulsion of water through a tube, called the siphon. There are two orders of Cephalopods: Dibranchiata and Tetrabranchiata, the first possessing two and the second four branchiae.

The first order includes the cuttle-fishes; they are all naked, with the exception of the Argonaut. Their soft body is supported by an internal shell. Plate I, figure 12, shows the complete animal of the Sepia officinalis; and Plate I, figure 16, is a Belemnite, or the internal shell of one of the dibranchiate Cephalopods. Most all the species of this order are provided with an ink-bag; the contents of which they discharge when pursued by their enemies. Of the second order, the Tetrabranchiata, only very few species are living at the present time. Plate I, figure 24, shows the Nautilus pompilius, the main representative of the tetrabranchiate Cephalopods of the present seas. The oceans of former ages were swarming with species of this order, fossil forms of which are figured on Plate I, figures 1, 2, 18 and 19. Their shells are internally divided into cells or chambers (see Plate I, figures 1 and 24), by a series of partitions called the septa (see Plate I, figure 24*b*), connected by a tube called the siphon or siphuncle, shown by c, Plate I, figure 24. Only the last chamber, called the body-chamber, is occupied by the animal, while the others are empty and serve as air-chambers. In fossil specimens very often the outer shell is removed, and the edges of the septa are seen (Plate I, figures 18 and 19), which are called sutures. Their form serves to distinguish different genera; they are curved in Nautilus and Orthoceras, zigzag in Goniotites, or foliaceous in Ammonite.

The siphuncle is also of great importance in determining genera; its shape and location have to be noticed by the student of Palæontology. Its shape is so variable that it is impossible to give here a sufficient explanation of the same, whilst its siphuncle may be located either in the center of the shell or in its dorsal or ventral lines, or even on either of its sides. The opening of the body-chamber is called its aperture, which, in different species and genera, assume different shapes, and is generally closed by a calcareous plate, called the operculum.

GASTEROPODA.—This class includes land and water-snails, which are either naked or provided with a shell. They received their name because their locomotion is accomplished by the lower part of their body, which is provided with strong muscles, and, by its contractions and expansions, serves them as a foot. (See Plate I, figure 13.) Their shells are generally univalve, either spiral or tubular, but a few are multivalve, the Chitons (see Plate I, figure 11). In the spiral shells we have to notice the following parts: see Plate I, figure

2, a, the apex; C, c and d, sutures; a to f, the spire; g, the aperture. In figure 14 of the same plate, "a" is the posterior canal, "C" the anterior canal, and "d" the outer lip of the aperture. Each full turn of the spiral is called a whorl. The axis (see Plate I, figure 23), ("a"), around which the whorls are coiled, is either solid or it is hollow, as may be seen in Plate I, figure 10. In this case the shell is called perforated or umbellicated. Nearly all the shells are dextral, or right-handed; others are sinistral, or left-handed; see Plate I, figures 14 and 15. The first is dextral, the second sinistral. In a few species the shell is regularly sinistral; for instance, in Clausilia, while among those with dextral spires, sometimes sinistral aberrations are found. The last turn of the shell is called the body-whorl, and the aperture is generally closed by an operculum.

The aperture is either entire, as in Plate I, figures 10 and 21, or drawn out or produced into a canal, see Plate I, figures 14 and 15. Species having shells with an entire aperture, are generally vegetable feeders, whilst, on the other hand, the siphonated shells belong to carnivorous families. The Gasteropoda are found all over the world on land, in rivers and fresh-water lakes, and in the different oceans. Their fossil representatives run through all the different geological strata, from the lowest Silurian up to recent formation of the Pliocene.

PTEROPODA.— (Wing-footed.) Their locomotion is accomplished by means of a pair of large fins attached to the sides of their head (see Plate I, figure 4). Their shells are univalve, but of very different forms. Plate I, figure 5, shows the fossil shell of one genera of Pteropoda, a Conularia. Animals of this class are very abundant in all our oceans, and furnish food for a good many inhabitants of the sea. In former ages they lived in all the oceans from the Silurian age to those just preceding the now existing ones.

BRACHIOPODA.—The Brachiopoda are bivalve shell-fish, which differ from the ordinary mussels, cockles, etc., in being always equal sided, but never quite equal-valve. Their forms are symmetrical, and so commonly resemble antique lamps that they were called lampades, or lamp shells, by the old naturalists. The hole which, in a lamp, admits the wick, serves, in the shell, for the passage of the pedicle by which it is attached to submarine objects. The valves of the Brachiopoda are respectively dorsal and ventral. The ventral valve is usually the larger, and has a prominent beak, by which it is attached or through which the organ of adhesion, the pedicle, passes. The valves are articulated by two curved teeth in the ventral valve, which are received by sockets of the dorsal valve; some genera and species are not provided with such hinges. In both the articulated and unarticulated Brachiopods, the valves are opened and closed by strong muscles, whose places of attachment are seen in

Plate I, figure 25. Among the fossil shells of even the older Palæozoic strata, we find sometimes Brachiopod shells so well preserved that even the valves may be opened as far as the teeth and sockets of the hinge will allow. Most of the shells of Brachiopods have a peculiar structure, consisting of flattened prisms of considerable length, arranged parallel to each other with great regularity, and obliquely to the surfaces of the shell, which is also perforated by canals (see Plate I, figure 22). This great class of Mollusca has derived its name from the two long ciliated arms developed from the sides of the mouth, with which each animal is provided as means to create currents which bring to it its food. These arms (Plate I, figure 9) were considered by former naturalists as instruments of locomotion; but it is now ascertained that they, outside of their first mentioned purpose, serve mainly as breathing organs; the erroneous name Brachiopoda (arm-footed), should, therefore, be corrected into Brachionabranchia (arm-breathers). Most of the Brachiopoda are provided with an internal skeleton, consisting of two spiral processes in the Spiriferidæ (see Plate I, figures 7 and 8), whilst in others, the Terebratula and Thecidia, this skeleton takes the form of a loop, as seen in Plate I, figures 6 and 26. This skeleton serves as a support for the brachial membrane. The prominent parts of the Brachiopod shell are the following: Dorsal valve, the upper one, which is usually the smaller, ventral valve, the lower one, which is generally the larger. The beak is that portion of the valve which terminates above the hinge-line in a sharp point or in a perforation (as seen in Plate I, figure 25 "a”). This perforation is called the foramen. The most convex portion of the valve near the beak is known as the umbo. Most of the shells have below the beak a triangular opening, which, in valves without hinge line, is closed by a separate body, consisting of either one or two pieces, the deltidium. In shells with a hinge area, as the Spirifera and Cyrtina, said area is divided in two by the triangular opening, which is partly or entirely closed by the growth of the shell. This is known as the pseudo-deltidium. In some shells the outline of the valve forms on both sides of the hinge a straight line, the hinge line, which may be as long as the greatest breadth of the shell, or may be so short as scarcely to be noticeable. The area which sometimes exists between hinge-line and beak is the hinge -area, best developed in the shells of Cyrtina. The hinge-area may be straight or curved, and is always divided by the pseudodeltidium.

The valves of a shell are either both convex, or one convex and the other plane, or one convex and the other concave. In some shells, as in Spirifera, the ventral valve has a strong depression extending and enlarging from the beak to the front, dividing the valve into two equal halves. This depression is known as the mesial sinus. Corresponding with this mesial sinus is an elevation in the dorsal valve, extending and enlarging also from beak to front, and, called the mesial fold. Cardinal area is a synonym for hinge-area, and cardinal extremities are the extreme points of the hinge-line. Of all the Mollusca, the Brachiopoda enjoy the greatest range both of climate and depth and time; they are found in tropical and polar seas. The living species prefer the deep waters to shallow lakes, though some of them are found even here. Of the population of the seas of former ages, they formed a very large part. Their fossil remains are found in almost every strata of the whole geological column. They are not only very abundant, but also well preserved, and form the principal treasures of many palæontological collections.

LAMELLIBRANCHIATA.—The Mollusca of this class are familiar to everyone; they are represented by the oysters, mussels and cockles. The animal is without head, and the shell is bivalve. The valves are attached to the sides of the animal. We have, therefore, in this class, a right and left valve. Plate I, figures 3 and 20, show the left valves. In figure 17, the upper valve is a right one, and the lower a left one. The mouth of the animal is generally directed towards the shorter slope of the shell. The hinge is on the back of the animal and formed by teeth and sockets, together with an elastic ligament. The shells are closed by powerful adductor muscles, but open when the animal relaxes the muscles, or when it is dead. We distinguish in the shells of this class the dorsal, ventral, anterior, and posterior margins. The dorsal margin contains the hinge, whilst the ventral margin is opposite to this. The anterior margin forms the end of the shell on the shorter slope, and the posterior margin the end of the longer slope.

Plate I, figure 3, is the left valve of Cytherea dione, separate from Cytherea, with the following prominent parts: h, the hinge ligament; d, the umbo; f, the lunule; c, cardinal tooth; tt, lateral teeth; a, anterior adductor muscle; a, posterior adductor muscle; p, pallial impression; s, sinus, occupied by retractor of the siphons. The line designated as pallial impression, which in many shells is prominently marked, indicates the place where the mantle is attached to the shell. The presence of a bay or sinus (s), in the line of the pallial impression, proves "the animal to have possessed retractile siphons. All the Mollusca belonging to this class live in the water, in rivers, lakes and oceans. They are abundant at the present time, and have been so in all the seas of former ages. Their fossil remains are often extremely well preserved, and add greatly to the beauty of many Palæozoic collections.

Within the here described five classes, the different Mollusca are divided into families, genera and species. The naturalists of former centuries were able to give a more precise definition of these terms. They believed that each species was *a priori* created, and thus by sharply defined lines of distinction, separated from all the other forms, and only related to some of these by accidental similarity in certain features. Inasmuch as relation between organic beings depends upon their origin from common ancestors, no real relation could exist outside of a species among the animals and plants, if the former belief in the stability of species had remained. The erroneous views of the old school were based upon observations among the more highly developed animals and plants, where the division lines between the species are more pronounced.

Had the scientists of olden times directed their investigation to the lower organisms, they would soon have met with difficulties, and in many cases even with impossibilities, to accomplish a specific differentiation. The evolution theory has upset the views of the old school. It does not believe in a separate original creation for every species, but, according to it, new ones are produced by gradual modifications of old forms. Changes in organisms may be either temporary, that is, dying out with the same specimen in which they first occur, or they may be constant, when they reappear in all the succeeding generations. Only these constant alterations will lead towards new species, and in order to do this, they must intensify in every succeeding specimen, until they become so characteristic as to afford an easy and sure distinction between the original and the new species. It is obvious that this procedure in the creation of species will leave some specimens in a doubtful position; their modifications may separate them from the old forms and still be insufficient to place them among the new ones. These forms are connecting links, and serve to establish a general relationship in larger groups of organism; but they cause considerable trouble as far as classification is concerned.

It is impossible to state the exact amount of similarity required between two animals or two plants, which will place them both either in the same family, the same genus, or the same species. In recent years a real mania has sprung up among some naturalists to manufacture as many genera and species as possible. By such proceedings science is not benefited, but only becomes incumbered with synonyms, of which, sooner or later, it has to be purged. Such a cleaning process will be necessary in Palæontology. This science, which has lately passed its childhood, and which handled material, the character of which was little known, has certainly established species and genera which will require revision. We find, for instance, of some fossil shells specimens showing the outside shell with all the markings well preserved, and again, others in the condition of internal casts, with all the shell exfoliated between such specimens exist differences rendering it impossible to recognize their intimate relation without closer investigation. That the first geologists, noticing these two different forms, described them as different species, is quit natural; but as soon as material of this kind increased, some forms were found, showing partly the internal cast and partly the exterior shell, combining the two fossils which were so far considered as different species. Again, we have certain species in which the extreme forms are so different from each other that anyone finding only these two extremes, would be fully justified in describing them as different species, but increased material furnishes intermediate forms connecting those extremes into one species.

Before closing these introductory remarks, I will copy from an English writer some observations which show the beneficial influence of the cultivation of natural sciences upon the minds and morals of the people, words which should be well remembered by every parent looking to the welfare of his child; by every teacher aiming by his labors to ennoble the mind and character of his students; and by every trustee of schools endeavoring to elevate those institutions to real nurseries of the highest type of civilization. He remarks: "It is fearfully true, that nine-tenths of the immorality which pervades the better classes of society, originate from the want of an interesting occupation to fill up their vacant time; and as the study of natural sciences is as attractive as it is beneficial, it must necessarily exert a moral and even religious influence upon the young and inquiring mind. The youth who is fond of scientific pursuits will not enter into revelry, for frivolous or vicious excitement will have no fascinations for him. The overflowing cup, the unmeaning or dishonest game, will not entice him. If anyone doubts the beneficial influence of these studies on the morals and character, I would ask him to point out the immoral young man who is devotedly attached to any branch of natural science. I never knew such an one, and if there are any, they are rare exceptions; and the loud clamors which are always raised against the man of science who errs, prove how rarely the study of the works of nature fails to exert an ennobling effect upon a well regulated mind. Fortunate, indeed, are the youth of either sex, who early imbibe a taste for natural knowledge, and whose predilections are not thwarted by injudicious friends."

These remarks, based upon indisputable facts, show that the value of the natural sciences ought not to be estimated only by their financial result, which is, unfortunately, the only scale with which most people nowadays measure, but also, and more deservedly so, by their ennobling influence upon the hearts and brains of the human race.