GRAY ELISHA

FAMILIAR TALKS ON SCIENCE: WORLD-BUILDING AND LIFE; EARTH, AIR AND WATER.

Elisha Gray

Familiar Talks on Science: World-Building and Life; Earth, Air and Water.

Familiar Talks on Science: World-Building and Life; Earth, Air and Water.:

Содержание

Elisha Gray
Familiar Talks on Science: World-Building and Life; Earth, Air and Water

INTRODUCTION

Dear Reader: Please look through this "Introduction" before beginning with the regular chapters. It is always well to know the object, aim, and mode of treatment of a book before reading it, so as to be able to look at it from the author's view-point.

First: A word about the title – "Nature's Miracles." Some may claim that it is unscientific to speak of the operations of nature as "miracles." But the point of the title lies in the paradox of finding so many wonderful things – as wonderful as any miracle that was ever recorded – subservient to the rule of law.

"But," you say, "a miracle does not come under any rule of law."

Ah! are you sure of that? It is true that we may not understand the law that the so-called miracle comes under, but the Author of all natural law does. We do not pretend to dispute but that the Power that made nature's laws can change them if He sees fit; but we cannot believe that He will ever see fit. It would destroy all order and harmony, all advancement in science and knowledge of God's works, not to be able to rely implicitly upon the laws of nature as consistent and continuous.

In putting out these little volumes, it is not to be understood that the subjects treated will be more than touched upon, at the most salient points. To do much more would require volumes of immense size, and life would be too short for me to write or for you to read them.

Again: these volumes are "familiar talks." The Author wishes to sit down with you – so to speak – and not hold you at arm's length.

It will be his aim to use the language of common life and to avoid all technical names so far as possible, or, when they are necessary, to explain their meaning. The object is to reach the thousands of readers who have not and cannot have the advantages of a scientific education, but who can by this means get at least a rudimentary idea of some of the natural laws with which they are coming in contact every hour, and through which the inner man has constant communication with the outer world. It may be, too, that many young students will be helped by these plain general views of topics which their text-books will give them in detail.

A knowledge of the real things in the objective world about us and the laws that govern them in their inter-relations is of practical value to every man, whatever his calling may be. Not only will it be of value practically, but it will also be a constant source of interest and pleasure. Man is so constituted that he must have something to be interested in, and if he has no resources within himself he looks elsewhere, and often to his hurt, mentally, morally, or otherwise. If he could have an interest awakened in him for the study and contemplation of the natural world he would then have a book to read that is always open, always fresh, always new. He is dealing with facts and not theory, except as he uses theory for getting at facts.

A man who is all theory is like "a rudderless ship on a shoreless sea." All he really knows is that he is afloat, and if he lands at all it is likely to be in an insane asylum. The mind, in order to keep its balance, must have the solid foundation of real things. Theories and speculations may be indulged in with safety only so long as they are based on facts that we can go back to at all times and know that we are on solid ground.

It is the desire and aim of all good men to make their nation a truly great people, with a civilization the highest possible. The character of all kinds of growth is largely determined by the character of the material upon which it feeds. The study of natural law can never be harmful, but is always beneficial, for the student is then working in harmony with law. It is the violation of law that makes all the trouble in the world – whether physical, moral, or social. When we speak of natural law we do not confine ourselves to what is commonly known as chemistry and physics, and the laws that govern the material world, but include as well the laws of our own being, as intellectual and spiritual units. For all law, physical, intellectual, and spiritual, is in a sense natural.

All departments of science are simply branches of one great science, and all phases of human activity are touched by it. The preacher is a better preacher, the doctor a better doctor, the lawyer a better lawyer, the editor a better editor, the business man a better merchant, and the mechanic a better workman, if they follow scientific methods. Indeed, any man will be a better husband, father, and citizen, if he has some trustworthy knowledge of the laws under which this great universe, down to his own little part of it, lives, moves, and has its being.

EARTH

CHAPTER I
WORLD-BUILDING AND LIFE

"In the beginning God created the heaven and the earth. And the earth was without form, and void."

Whatever our speculations may be in regard to a "beginning," and when it was, it is written in the rocks, that, like the animals and plants upon its surface, the earth itself grew; that for countless ages, measured by years that no man can number, the earth has been gradually assuming its present form and composition, and that the processes of growth and decay are active every hour.

The science that deals with the formations and stratifications that are found on the earth and under the earth, and all the forces that have been and are now active in their formation, is called Geology (earth science). It is a science about which little is known by the average individual, and yet it is one of transcendent interest, from the study of which the lover of nature can obtain a vast amount of profit and pleasure. When the uncultured man sees a stone in the road it tells him no story other than the fact that he sees a stone and that it would better be removed; and all the satisfaction he gets out of it is in the thought that he has saved some unlucky wagon wheel from being wrenched or broken. The scientist looking at the same stone perhaps will stop, and with a hammer break it open, when the newly exposed faces of the rock will have written upon them a history that is as real to him as the printed page. He is carried back to a far-off time, where he sees the processes and forces at work that have formed this stone and made it what it is, not only in its outward form, but in its constitution, down to its molecules and atoms. (The word "atom" is used in chemistry to mean the smallest particle of an elementary substance that will combine with the atoms of another substance to form new compounds of matter. And molecules are made up of atoms.) The scientist looking at this stone sees in it not only that mechanical and chemical agencies have cooperated in the work of its formation, but that animal life itself may have been the chief agency in bringing the materials together and giving form to the peculiar architecture employed in its formation. If it is a piece of limestone this latter statement will be eminently true.

Here is a powerful motive for the study of physical science. It is not to be expected, nor is it possible, that every individual can be a scientist in the strict sense of the word, but it is possible for everyone of ordinary intelligence to become familiar with the salient facts of science, if only a small portion of the time that is now devoted to the reading of literature that is rather harmful than helpful be spent in studying the phenomena and works of nature.

The acquirement of such knowledge would furnish every individual with a constant source of instructive amusement that would never lose its interest. He would not be dependent every hour upon people and things outside of himself; because he would carry about with him inexhaustible sources of instruction and pleasure that would furnish him continual and helpful diversion and save him from a thousand morbid tendencies that are always ready to seize upon an unemployed mind. There are many men and women in the insane asylum to-day for the simple reason that they have not made intelligent use of the mental powers that nature has endowed them with.

Sermons are not always preached from pulpits. They are written in the rocks and on the flowers of the field and the trees of the forest.

Let us then look a little at the underground foundation of all this beautiful earth. And before attempting that, the question may arise in some minds how we know what is so deep down under the surface. Fortunately this is a question very easily answered. At some period after the rocks were formed the crust of the earth was broken by volcanic eruptions at various places and times, and turned up, as in the formation of mountains, so that the edges of the various stratifications of the rocks, from those near the surface down to the lowest rocks, are exposed to view. Another means of knowing what the various formations are has been by borings of deep wells. These borings, however, are only confirmatory of what was well known before through the upheavals that are plentiful in all parts of the world. There is abundant evidence that all of the rocks and all of the strata of every name and nature (except perhaps igneous rocks) were originally laid down in water. This is evidenced not only by the stratifications themselves, but by the evidences of sea-life everywhere present in the earth's crust. Before the upheavals in the earth's crust began, the whole surface of the globe was a great ocean of hot water. The substances of which the rocks were formed were undoubtedly held in suspension in the air and in the water, and by a gradual process were deposited in the bottom of the ocean in layers, forming rocks of various kinds, according to the nature of the substance deposited. Gradually the crust of the earth was built up until it acquired a certain thickness; when, either from shrinkage under the crust a great void was formed until it could not sustain its own weight, or the pressure caused by confined gases and molten matter produced an upheaval which broke the crust of the earth outward, causing great wrinkles that we call mountain ranges. Undoubtedly both forces were active in producing these results. When the gases and molten matter had escaped through the rifts in the rocks caused by the upheaval there must have been great voids formed that were filled up by the shrinkage of the earth, causing much irregularity in its surface.

In some places there were enormous elevations, and in others correspondingly deep depressions. The water that before was evenly distributed over the surface of the globe, after the upheavals ran off into the lower levels, filling up the great valleys, forming the seas, and leaving about one-third of the land surface uncovered. It must not be supposed, however, that the appearance of the land was caused by one grand movement or upheaval, but that it has been going on in successive stages through long ages of time. This is clearly evidenced by the rock formations. The deposition of rock strata is still active in the bottoms of the oceans, although not to the same degree as in former times. When the upheaval took place the old stratifications were thrown out of level, but the new ones that were then formed remained in a level position until they were in their turn disturbed by some subsequent upheaval.

The laws of gravitation would tend to precipitate the matter held in suspension by the water straight down to the bottom, toward the center of the earth, so that the plane of these stratifications would tend to be parallel to the surface of the water, that is horizontal, until disturbed. Then they would be tilted in many directions. Hence it will be easily seen why the seams in the rocks, especially in and near mountainous regions, do not lie in a horizontal position after an upheaval, but are found standing at all angles, up to a perpendicular.

Viewed from this standpoint, the solid portion of the old world has gone all to pieces. Wherever there is a chain of mountains it marks a breakage in the earth's crust, and these mountains are not all on the land, but extend under the seas so deeply that they are unable to lift their heads above the surface of the water. The earth is no longer round, except in general outline, but broken up into all sorts of shapes that give the varied conditions of landscape that we find whichever way we turn.

There are but few volcanoes that are active in this age, while in former times they extended for thousands of miles. We still have occasional earthquakes, but undoubtedly they are very slight as compared with those that shook the earth millions of years ago.

If, now, we study the constitution of the earth's crust so far as it has yet been penetrated, we find it divided up into periods called Primary, Secondary, and Tertiary. The primary period reaches down to the line where the lowest forms of animal fossils begin to be found. This is called the "Paleozoic" period, which means the period of "ancient life." From here let us first go downward. Immediately under this lies a stratum of "Metamorphic" rocks. To metamorphose is to change; and metamorphic rocks are those which have been changed by heat or pressure from their original formation. This class of rocks lie on top of what are called "Igneous" rocks, which means that they have been formed by or subjected to heat. All lava-formed rocks are igneous. They are unstratified, – not in layers or strata, but in a formless mass, – and in this they differ from water-formed rocks.

If there is a molten center to the earth these igneous rocks are undoubtedly the offspring of this great internal furnace. The metamorphic rocks were primarily igneous and are changed somewhat in their structure by the lapse of time. For instance, marble is a metamorphic limestone. The difference between common limestone and marble is in its molecular structure – the way in which its smallest particles are put together. They are both carbonates of lime. But the marble is made up of little crystals and will take a polish, while ordinary uncrystallized limestone will not. The igneous rocks are chiefly granite; and granite is formed of orthoclase-feldspar, mica, and quartz. (The word "orthoclase" means straight fracture, and the orthoclase-feldspar has two lines of cleavage at right angles to each other.) This is the ordinary composition of granite, but there are a great many variations, chiefly as to color and proportions of the ingredients named.

The igneous rocks, then, are the lowest of all; then come the metamorphic rocks; and as before stated, on top of metamorphic rock begins the first evidence of life in its lowest form. The Paleozoic (ancient life) or Primary period is made up of a number of subdivisions. The first and oldest division is called the "Silurian" age, which is underlaid by the metamorphic rocks and overlaid by the rocks of the Devonian period. It is called Silurian, from the name of a kind of fish, fossils of which are found in the rocks of this age, which are distinguished for the absence of land-plant fossils and vertebrate animals.

In the Silurian strata are found limestones, slate, flagstones, shales, etc. On top of the Silurian begins the "Devonian" age, in which is found the old red sandstone, as well as limestone and slate; and here begin to be found the fossils of land-plants.

On top of the Devonian lies the "Carboniferous" series, which complete the series of the primary period. In the lower part of this stratum is found carboniferous limestone, which is overlaid by a kind of stone called millstone grit, and on top of this lie the true carboniferous strata or coal-bearing measures. In the coal strata are found the first reptile fossils.

On top of the coal measures begins the Secondary period, or "Mesozoic" (middle life). This period is distinguished for the great development of reptiles, and is called the "age of reptiles." In this age occur the first traces of mammals, and birds, and fishes with bony skeletons. Among plants we find here the first evidence of palms. The formation is chiefly chalk, sandstones, clays, limestone, etc. We now come to the last or "Tertiary" period, which brings us to the top earth. This is chiefly formed of sedimentary rocks – those which have been formed by the settling of sediment, in water.

While we are forced to these general conclusions in regard to the building of the world, and to its subsequent distortion by the series of upheavals that have occurred from time to time, and to the successive "ages" of the layers of rock foundation of its crust, there are many mysteries that remain unsolved and many questions will present themselves to the mind of the reader. One of these questions is, Where was the water and where was the earthy matter before its precipitation? Matter, including water, can exist in the gaseous form, and we only need to assume that there was a core of intense heat, to understand how all the material that we find on the earth and in the earth could have been held in suspension in the gaseous state until the cooling process had reached a stage where the various combinations and recombinations could take place in the great laboratory of nature. If we study the constitution of the sun (and with the modern appliances we are able to do so), we find that it is made up of some and perhaps all of the same materials that are found here on earth. If there is no water existing, in the sun, as water, there are the gases present which would produce it if the conditions were right. And, for all we know, that flaming mass of burning gases may some time go through the same kind of cooling and building up in solids that our earth has experienced.

We thus have what may be called an outline sketch of the process of World-building.

CHAPTER II
LIMESTONE

A large part of the structure of the earth's crust is formed of a substance called limestone. Ordinary limestone is a compound of common lime and carbon dioxide, a gas that is found mixed with the air to a very small degree. Carbon dioxide will be better known by the older people as carbonic acid. It is a gas that is given off whenever wood and coal are burned, or any substance containing carbon. It is composed of one atom of carbon to two of oxygen. Every ton of coal that is burned sends off three and two-thirds tons of this gas. The increase in weight comes from the fact that every atom of carbon unites with two of oxygen, which it takes from the air, and the oxygen is heavier than the carbon.

In comparing the relative weights of atoms (the smallest combinable particle of a solid, liquid, or gas) we use the hydrogen atom as the unit of comparison and call it "one," because it is the lightest of all atoms. The carbon atom is twelve times heavier than the hydrogen atom, and the oxygen atom is sixteen times heavier. Hence it will be seen readily how a ton of coal will form two and two-thirds times its weight of carbonic dioxide. Lime, having a strong affinity or attraction for this gas, has absorbed it from the air and water, forming what is known as carbonate of lime – which is the ordinary limestone. Chalk and the various marbles are also carbonates of lime. Limestone strata in the crust of the earth are found in all the periods of the earth's formation. All forms of sea shells that were once the homes of animal life are constructed of this compound; and in the later formations of limestone, in the Secondary and Tertiary periods, we find this rock to be made up almost entirely of marine shells, some of them microscopic in size. The earlier or older formations of limestone that are found deeper down in the earth's crust are less mingled with these marine shells. This comes from the fact that the first deposition of limestone strata occurred before the later forms of sea life had developed. Whatever signs of life are found in these lower stratifications are of the very lowest order. It is not to be understood that animal life is a necessary factor in the formation of limestone, but it has been an incidental feature which no doubt has been the chief means of gathering up from the water this compound and precipitating it into the great limestone strata that are everywhere found.

Carbonate of lime is found in solution in nearly, if not quite, all of the mineral waters, and is also found in the water of the ocean. In earlier times it must have been held in solution in much greater quantities than at present. The myriads of sea animals that existed, and that still exist, gathered from the water this substance, which formed their shells, and served as a house in which they lived. New germs were continually forming new shells, while the older ones ceased to live as animals, and their houses in which they lived were precipitated to the bottom of the ocean, where they were bound together as limestone rock. These sea animals no doubt caused a much more rapid formation of limestone than would or could have been the case without their existence.

One can thus readily see what an important factor animal life has been in the process of world-building. This process is still going on, but probably not to the same extent as in former ages, because it is not likely that there is so much carbonate of lime held in solution as there was before these great limestone beds were formed. Limestone, however, is easily disintegrated by the action of water. We find the spring water impregnated with it as well as that of the small streams and rivers. Pure water is a powerful solvent. When the rains fall upon the earth the water percolates through it and through the limestone strata, which gradually wears away the limestone and carries it back to the ocean, so that the process of tearing down and building up is continually going on. The great caves that are found everywhere in the limestone regions were formed by the action of water. The great Mammoth Cave of Kentucky, which is said to have 200 miles of underground passages, has been entirely worn out by the action of running water.

Some years ago the writer visited this cave and had an opportunity to study the wonderful eroding or gnawing-out effect of water on limestone. At some period earlier in the history of the earth there was evidently an underground river or large stream of water that found its way through the crevices of the rocks, and gradually wore out a great bed for itself, which was fed by lateral streams pouring into the main branch, each one of which lateral branches cut its own channel. A plan view of the Mammoth Cave presents a picture not unlike that of a great river with numerous branches emptying into it, all of them showing the windings such as we see in a river and its feeders upon the surface of the earth. There are three sets of these channels, one above the other, and we do not find the water till we get to the bottom of the third underground story, so to speak. There is one place in this system of underground channels where the dripping from the roof of the upper channels has cut a great well hole many feet in diameter perpendicularly down through the whole system to a great depth. The sides of this great well hole are fluted into grooves caused by the constant downflow of the water. Although the amount of water flowing down through this well hole is very small, it is continually at work. Like interest on money, it never rests, each minute that passes has eaten away some of the great rock.

In other portions of the cave the dripping of the water is so gradual that the carbonate of lime hardens and forms what are called stalactites, that hang like icicles from the roof of the cave. Sometimes the water runs down so slowly upon these stalactites that it evaporates as fast as it appears, leaving behind its little load of carbonate of lime. If, however, there is a drip, there are formations built also from the lime in the dropping water on the floor of the cave, and these are called stalagmites. In time the stalactites and the stalagmites will meet, forming a great column reaching from floor to ceiling. Some of these formations, when they are free from foreign substances, are very beautiful. They are also very hard, giving off a metallic musical tone when struck by any hard substance.

We have already stated that limestone is a compound of ordinary lime and carbon dioxide, forming a carbonate of lime. This statement does not give a complete analysis of all the elements entering into limestone. In the first place lime itself is a compound formed of two elementary substances, calcium and oxygen. The lime molecule is composed of one atom of calcium and one of oxygen. Neither calcium nor lime is found pure in nature. Inasmuch as carbon dioxide is composed of one atom of carbon and two of oxygen, and lime is composed of one atom of calcium and one of oxygen, when we have the two combined the molecule of carbonate of lime, or, as it is technically called, calcic carbonate, is composed of one atom of calcium, one of carbon and three of oxygen, (lime plus carbon dioxide).

As before stated, lime is not found un-combined with other substances in nature. And as it is of great economic importance, it will be profitable to know how it is formed. Lime is produced from ordinary limestone by burning it in kilns where it is subjected to a heat of a certain temperature for a number of hours. The heat drives off the carbon dioxide, which, as we have seen, has taken away from each molecule of the compound all of the carbon and two atoms of the oxygen, while all of the calcium is retained with one atom of oxygen, leaving ordinary lime. Lime, then, is simply oxide of calcium.

As all know, it is used almost exclusively for making mortar for building purposes. In order to do this we have to put it through the process of "slacking," by pouring water upon it, and here another chemical change takes place. The water unites with the lime, when immediately the heat that was expended in throwing off the carbon dioxide and was stored in the lime as energy is now given up again in the form of heat. When a considerable bulk of lime is slacked very rapidly the heat that is given off is so great that it will produce combustion. Here is a beautiful illustration of what has been erroneously called "latent heat." It is "heat stored as potential energy," that is released by the combination of lime with water. Slackened lime, then, is called calcic hydrate.

Very little of the limestone that we find is absolutely pure. It is considered good when it does not contain over five or six per cent. of foreign substance. When more than this is present the lime is considered poor, and when it reaches fifteen per cent. or more of impurities it assumes the property of hardening under water and is called cement.

Carbonate of lime is found in several other forms; for instance, the various kinds of marble and chalk are carbonates of lime. The composition of marble and chalk is exactly the same as that of limestone. The difference is chiefly one of molecular rather than chemical structure. Marble is what chemists would call an allotropic or changed form of limestone; and, as before stated, the difference seems to consist in the fact that the marble assumes a crystalline arrangement of its atoms and will therefore take a high polish, which is not true of ordinary limestone. Marble varies greatly in coloring and texture, all of which differences are explainable under the one head of molecular arrangement. Nearly pure carbon exists in three distinct forms – the diamond, graphite, and charcoal. As is the case with marble, these differences in the different forms of carbon are not chemical, but molecular differences. The substances are the same, but their infinitesimal particles are differently arranged.

Carbonate of lime – as it exists in its various forms, as limestone, from which lime and cement are made, and marble, which is such an important element in the arts – is a substance of great importance to man. We have already noted some of the processes that nature uses in gathering up these substances from the ocean by the employment of various forms of animal life. Here is another. Whoever has visited the Bermudas has seen an island wholly formed of what is called coral rock. Coral is a structure produced by a peculiar form of sea animal that gathers up the calcareous or lime-like matter floating in the sea water, and builds a house of it in which to live during the little lifetime that is allotted to him. When he dies his children do not occupy the old home, but build a new one, which is a superstructure planted upon the old one as a foundation. This process of growth sometimes takes the form of a tree or plant, and coral trees grow upon trees and plants upon plants, until a structure is erected having its foundation upon the bottom of the ocean, that finally reaches up until it rises above the surface of the water; and here – after through years the water has brought sea-weed and drift to decay and form soil, and the birds have brought seeds and fertilization, and vegetable life is prospering – another animal called man builds his home upon it. The material that the coral is formed of is substantially the same as that we find in the minute shells of the limestone rocks.

The great chalk cliffs that are found on the coasts of the English channel are the work of a sea animal microscopic in size. At one time it was a question among scientists how these chalk cliffs were formed, but when the microscope was invented this mystery, as well as many others, was solved. The chemical components of chalk are precisely the same as those of limestone. The microscope shows that chalk is almost wholly a product of very small organized shells. The animals who are the architects of the chalk cliffs are called "foraminifera" – bearing shells perforated with little holes. The chief difference between chalk and limestone seems to be in the size of the shells of which they are respectively made up and in the manner of the bonding of these shells together. The shells in a lump of chalk are held much more loosely than those in a lump of limestone. These intrepid workers are still actively changing the structure of the bottoms of seas and oceans, and forming new islands, which in turn become the substructure that supports new life, animal and vegetable. And when we consider the great part performed by these microscopic architects and builders it is not a misnomer to speak of the building of a world.

CHAPTER III
COAL

Some time, long ago, some man made the discovery that what we now call coal would burn and produce light and warmth. Who he was or how long ago he lived we do not know, but as all earthly things have a beginning, we know that such a man did live and that the discovery that coal would burn was made. Coal, in the sense that we use the word here, is not mentioned in the Scriptures. According to some authorities, coal was used in England as early as the ninth century. It is recorded that in 1259 King Henry III. granted a privilege to certain parties to mine coal at Newcastle. It is further stated that seven years after this time coal became an article of export. In 1306 coal was so generally used in London that a petition was sent to parliament to have the use of it suppressed on the ground that it was a nuisance. Coal was used in Belgium, however, about 1200. There is a tradition that a blacksmith first used it in Liège as fuel. It was first used for manufacturing purposes about 1713.

Coal is found laid down in great veins, varying in thickness, in various parts of the world in the upper strata of the Paleozoic period. The age in which it was formed is called by geologists the Carboniferous (coal-bearing) age.

Before going on to account for the deposits of coal, let us stop a moment and consider what it is. Chemists tell us that coal is chiefly constructed of carbon, compounded with oxygen, hydrogen, and nitrogen. There are many varieties, but all may be classified under two general headings – bituminous and anthracite. Bituminous coal contains a large amount of a tarry substance, a kind of mineral pitch or bitumen, which burns with a brilliant flame and a black sooty smoke, exceedingly rich in carbon. Anthracite coal is hard and stone-like in its texture, burning with scarcely any flame and no smoke. It produces a fire of intense heat when it is once ignited. There is another form of coal called cannel coal, which is a corruption of "candle coal," so called because a piece of this kind of coal when ignited will burn like a match or pine knot and give light like a candle. This is the richest of all the coal deposits in gases that are set free by heat, and for this reason is extensively used in the manufacture of what is commonly called coal gas. England produces a large amount of cannel coal, as well as another variety of bituminous coal, which latter, however, does not burn with such a black smoke as the coal found in the Ohio valley and the Western States of America. East of the Alleghany Mountains there is a region of anthracite coal that is very extensively worked and finds great favor in all parts of the country as fuel for domestic heating, especially on account of its great cleanliness.

All of the coal beds have a common origin, and the difference in the quality of coal found in different parts of the country is due to many circumstances, some of which have never been explained. There is indisputable proof, however, that all coal beds are of vegetable origin. Geologists tell us that these coal beds were formed during an age before the earth had cooled down to the temperature that it has at the present time – an age when vegetation was forced by the internal heat of the earth instead of having to receive all its warmth from the sun's rays as we do now. Some of our readers are familiar with what is commonly termed a hotbed. A hotbed is made by putting soil on top of substances that will ferment and create heat underneath the soil. This heat from beneath will force vegetation and cause a much larger growth than there will be if left to the sun's rays alone. During the carboniferous age the earth was a great hotbed.

The fossils of trees and plants, as well as reptiles, that we find in the great coal measures of the world, show that they were of large tropical growth, and this is shown not only in the temperate zone, but in the zone farther north. For ages and ages this rank growth of vegetation grew up and fell down until a great layer of vegetable matter was formed, which at a later time was covered over by other stratifications of earth material, so that these great layers of vegetable formation were hermetically sealed and pressed down by an enormous weight that increased as time went on. The formation of coal may be studied even at this day (for it is now going on) by visiting and examining the great peat beds that are found in various parts of the world. It is well known that peat is used as a fuel by many people, especially the peasantry of the old countries. If peat is pressed to a sufficient degree of hardness it burns in a manner not unlike some forms of coal. Peat is a vegetable formation and has been formed by the rank growth of various kinds of vegetation in swampy places. Of course, it lacks the purity of the coal that was formed during the carboniferous age, because of the much slower growth of vegetation now than during that time, and the opportunity that peat bogs offer for an intermixture of earthy with the vegetable matter. The fact that we find the imprint of trees and ferns and other vegetable growth of tropical varieties, as well as the fossils of reptiles, imbedded in the coal measures, proves that at one time this stratum was at the land surface of the earth. We also find that all of the formations of the Secondary and Tertiary periods are on top of the coal – and this shows that after the age of rank vegetable growth there was a sinking of the earth in many places far down into the ocean – so that vast layers of rock formed on top of these beds of vegetable matter. In England great chalk beds crop out in cliffs on the southern coast, and, as we have seen, these chalk rocks are largely made up of the shells of marine animals. London stands on a chalk bed, from six hundred to eight hundred feet thick. Indeed, England has been poetically called Albion, White-land, from this appearance of her coast.

All of the great chalk beds were formed ages after the coal beds, as the latter are found in the upper strata of the Paleozoic period.

A study of these strata will show that there are many layers of coal strata varying in thickness and separated by layers of shale and sandstone. How the shale and sandstone layers are formed will be the subject of a future chapter.

From the position that the coal measures occupy, being entirely under the Secondary and Tertiary formations, it will be observed that they are very old. If we should examine a piece of ordinary bituminous coal we should find that there are lines of cleavage in it parallel to each other, and that it is an easy matter to separate the lump on these lines. If we examine the outcrop of a coal bed we will find that these lines of cleavage are horizontal. This indicates that the great bulk of vegetable matter of which the coal formation is made up has been subjected to tremendous pressure during a long period of time. If we further examine the structure of a body of coal we find the impressions of limbs and branches as well as the leaves of trees and various kinds of plants. We shall further find that these impressions lie in a plant in the same direction as the line of cleavage. This is a point to be remembered, as it helps to explain the nature and structure of other formations than those of coal. Not only are leaves and branches of vegetable matter found, but fossils of reptiles, such as live on the land. Sometimes there is found the fossil of a great tree trunk standing in an erect position, with its roots running down into the rock below the coal bed, while the trunk extends upward entirely through the coal and high up into the other strata. All of these facts lead us to the firm conclusion that when the trees were grown that formed these beds they were above the surface of the ocean. This, taken in connection with the fact that the vegetable fossils that are found indicate a tropical growth of great size, drives us to the conclusion that the climate at the time these coal measures were formed was much warmer than it is now.

As already remarked, this extra warmth came from the earth itself before it had cooled down to its present temperature, rather than from the heat of the sun. There is nothing inconsistent in the thought that the sun may have been warmer in a former age than now. We may conceive that the earliest coal formations took place when the land stood above the surface of the water, and that the conditions were favorable for a rapid and luxuriant growth of vegetation; after this had gone on for a very long period of time, by some convulsion of nature the land surface was submerged under the ocean, when other mineral substances were deposited on top of this layer of vegetable growth, which hardened into a rock formation. At a later period the earth was again elevated above the surface of the water and the same process of growth and decay was repeated. These oscillations of the earth up and down occurred at enormously long intervals, until all of the various coal strata with their intermediate formations were completed. After this we must suppose that the whole was submerged to a great depth and for a very long period of time, because of the great number and various kinds of rock formations laid down by water that lie on top of the coal measures. This tremendous weight, as it was gradually builded up, subjected these vegetable strata to an inconceivable pressure. In some places this pressure was much greater than in others, which undoubtedly is one of the reasons why we find such differences in the structure and quality of coal. There were no doubt many other reasons for differences, one of them being the character of the vegetable growth out of which they were formed. Again, in some parts of the world these coal strata may have been subjected to a considerable degree of heat, which would change the structure of the formation, and in some cases drive off the volatile gases. One can easily imagine that heat was thus a factor in the formation of what is known as anthracite coal, so much less gaseous than the bituminous kinds. The anthracite beds seem to be denser and of a more homogeneous character. The lines of cleavage are not as prominent, but there are the same evidences of vegetable origin that we find in the bituminous formations.

It will be seen from what has gone before that coal was first wood. But wood is a product of sunshine. Thus the sun was the architect and builder of the trees and plants that were finally hermetically sealed under the great earth strata. The sun gathered up the material and set the forces in play which made the chemical combinations of the various elements in nature that enter into vegetable growth.

After the lapse of untold ages of time these great beds of stored-up sun-energy were discovered by man and their contents are dragged out to the earth's surface, to warm our houses, to drive the machinery of our factories, to send the locomotives flying across the continents and the steamships over the oceans. So important has this article become that if any one nation could control the output it would be able to paralyze all the navies and the manufacturing of the world.

If the coal of the world should become exhausted we should be confronted with a great problem. Fortunately for us, this is a problem that will have to be solved by the people of some future age, as the growth of wood will scarcely keep pace with the consumption of fuel. By that time the genius of man will have devised an economical means of storing the energy of the sunbeams directly for purposes of heat, light, and power.

CHAPTER IV
SLATE AND SHALE

Slate is one of the great commercial products of the world. As far back as the year 1877 the output of slate was not less than 1,000,000 tons per annum. The chief use to which slate is put is for covering buildings, and for this purpose it is better than any other known material. It is also used in the construction of billiard tables and for writing-slates; these latter uses are very insignificant as compared to its use in architecture. Slate, like building-stone and limestone, is quarried from the earth's crust and is found in the strata close above the Metamorphic rocks, near the beginning of what is called the Primary, or Paleozoic period. As compared with the coal formations it is very, very old.

There are different substances called slate that are not slate in the scientific use of that word. In general all stone formations are called slates that split up into thin layers. But the true slate is a special material which is formed by special processes of nature. The difference between slate and shale, for instance, is not one of ingredients, but of the process by which the ingredients are put together. All of the sedimentary rocks are formed by a deposit of sediment from the water on the bottom of the ocean. At one period the floods have brought down a certain kind of material in greater profusion than at others, and this is deposited in thin layers, and as it hardens there will be seams in it and the stratifications will be differently colored, the color depending upon the deposit at any particular time.

A bed of shale, like a bed of coal, has lines of cleavage in it, and if it is examined under a microscope it will be found that the sedimentary particles, like the twigs and leaves in the coal veins, lie with their longest dimensions in line with the plane of cleavage. Shale in color looks like slate, and an analysis of the material of which it is formed shows that shale and slate are both made from the same. There is, however, a structural difference between the two which is very peculiar and very interesting. The slate is ordinarily a denser material and the lines of cleavage are often at right angles with those that we find in ordinary shale.

A slab of shale will be of a uniform color on any one line of cleavage. The color may change at the next line, and generally does, to a slight extent. It is easy to see, then, if we could change the lines of cleavage in the shale, so as to run at right angles with their present lines, the face of a slab would show bands of different colors or shadings, such as we often see in slate. If you take a piece of clay that has been thoroughly mixed, and subject it to a very great pressure, and then examine the piece that has been submitted to pressure under a microscope and compare it with a piece of the clay after it has been thoroughly mixed, but has not been submitted to pressure, you will find that the two are very different in structure. The pressed clay will show that the particles of which it is made up have all turned, so that their longest dimensions are in a line at right angles with the direction of pressure. Here is an interesting fact that we must remember. And it is in this that we find the reason for the structural difference between shale and slate. The lines of cleavage in shale are not formed necessarily by pressure, but because in the disposition of the material of which it was formed the particles naturally laid themselves down so that their longest dimensions were on a horizontal line.

Ages after, when other rock and other formations had been laid down on top of the bed of deposited mud, the upheavals of the earth have so changed the lines of pressure upon this material and the pressure is so great that a rearrangement of the particles of which the slate is made up has taken place, so that their longest dimensions now are in a direction that crosses the stratifications as originally laid down.

The effect of this is twofold. First, the material is compressed into a denser, closer form, and then, the lines of cleavage are changed, or to express it in more common language, the grain has been changed. So that when it splits up it runs crosswise of the original layers as the water deposited them, and this produces the different shadings so often seen in different slate. Shale splits in line with its layers; slate splits across that line.

Let us go back a moment to our experiment with the lump of clay. If we examined the mixture before submitted to pressure we should find that the oblong particles of which it was made up would stand in all directions, hit or miss, and if we should dry this lump of clay it would have no special lines of cleavage.

But the moment we have submitted it to a certain amount of pressure we find that lines of cleavage have been established, and that the particles have been rearranged so that their longest dimensions are all in one direction, which coincides with the cleavage lines. If we should now take this same piece of clay and subject it to a pressure at right angles to that of the first experiment we should find that the lines of cleavage had also changed and that the particles had all been rearranged. Apply the principle to the formation of slate, and we can understand how it happens that what we call the grain runs crosswise of the deposits that were made at different times. It is not a chemical, but purely a mechanical difference. Or, to express it differently – the difference is a structural one produced by mechanical causes.

The origin of cleavage in slate has been the subject of much speculation and investigation, but like many other problems it was solved through the invention and application of the microscope. Thin layers of slate have been made, the same as with limestone and chalk, so thin that the light would readily pass through it and that an examination of the particles could be readily made, showing their arrangement under varied conditions. Science is indebted to the microscope for the solution of very many problems that for ages before had puzzled philosophers.

CHAPTER V
SALT

It may seem curious to the reader that we should care to discuss a subject seemingly so simple as common salt. But it is a very usual thing for us to live and move in the presence of things that are very common to our everyday experience, and yet know scarcely anything about them, beyond the fact that they in some way serve our purpose.

Salt is one of the commonest articles used in the preparation of our food. It has been questioned by some people whether salt was a real necessity as an animal food, or whether the taste for it is merely an acquired one. All peoples in all ages seem to have used salt, and reference to it is made in the earliest histories. Travelers tell us that savage tribes, wherever they exist, are as much addicted to the use of salt as civilized people. One of the early African travelers, Mungo Park, tells us that the children of central Africa will suck a piece of rock salt with the same avidity and seeming satisfaction as the ordinary civilized child will a lump of sugar.

All animals seem to require salt, and it is claimed by those who have tried the experiment that after one has refrained from the use of salt for a certain length of time the craving for it becomes exceedingly painful. It is most likely that the taste for salt is a natural craving. In any event, whether it is a natural or an artificial taste, it has become an article of the greatest importance in the preparation of food, as well as on account of its use in the arts. Salt is a compound of chlorine and sodium. In chemical language it is called sodium chloride. The symbol is NaCl, which means that a molecule of salt is composed of one atom of sodium and one of chlorine. Chlorine is an exceedingly poisonous gas.

Formerly the chemist when he wished to obtain sodium extracted it from common salt and discharged the chlorine gas into the air. It was found that in establishments where the manufacture of sodium was conducted on a large scale the destructive properties of the chlorine discharged into the air was such that all vegetation was killed for some distance around the manufactory. This came to be such a nuisance that the manufacturers were either compelled to stop business or in some way take care of the chlorine. This is done at the present day by uniting the chlorine gas with common lime, forming a chloride of lime, which is used for bleaching and purifying purposes.

Salt is found in great quantities as a natural product under the name of rock salt. It is found in some parts of the world in great veins over 100 feet in thickness. In some cases the rock salt is mined, when it has to be purified for commercial purposes. The common mode of obtaining salt, however, is by pumping the solution from these great beds where it is mingled with water – salt water; the water is then evaporated, and when it reaches a certain stage of evaporation the salt crystallizes and falls to the bottom.

Different substances crystallize in different forms. The crystallization of water when it freezes, as we shall see hereafter, arranges its molecules in such a form as to make a lump of ice of given dimensions lighter than the same dimensions of water would be. Salt in crystallizing does not follow the same law; the salt crystal is in the shape of a cube and is denser in its crystalline form than in solution, hence it is heavier and falls to the bottom.

It is said that there is a deposit of rock salt in Galicia, Austria, covering an area of 10,000 square miles. There are also very large deposits in England, the mining of which has become a great industry. There are also great beds of salt in various parts of the United States, notably near Syracuse, N. Y., where large salt deposits were exposed in an old river bed formed in preglacial times. The common mode of preparing salt for domestic purposes is by the process of evaporation from brine that has been pumped from salt wells. The quality of the salt is determined largely by the temperature at the time of evaporating the water from it. Ordinary coarse salt, such as is used for preserving meat or fish, is made at a temperature of about 110 degrees; what is known as common salt is made at a temperature of about 175 degrees; while common fine or table salt is made at a temperature of 220 degrees. Thus it will be seen that the process of granulation with reference to its fineness is determined by the rapidity of evaporation. Salt is one of the principal agents in preserving all kinds of meats against putrefaction. It will also preserve wood against dry rot. Vessel builders make use of this fact to preserve the timbers used in the construction of the vessels.

Salt at the present day is very cheap, but at the beginning of the present century it was worth from $60 to $70 per ton. The methods of decomposing salt to obtain its constituents, which are used in various other compounds, are very simple to-day as compared with the processes that prevailed in the days before the advent of electricity in large volume, such as is produced by the power of Niagara Falls. It is curious to note that a substance so useful and so harmless as common salt should be made out of two such refractory and dangerous elements as chlorine and sodium. Both of these elements, standing by themselves, seem to be out of harmony with nature, but when combined there are few substances that serve a better purpose.

These great salt beds that are found to exist in England and America and other parts of the world were undoubtedly deposited from the water of the ocean at some stage in the formation of the earth's crust. It is well known that sea water is exceedingly saline; 300 gallons of sea water will produce a bushel of salt. Undoubtedly beds of salt are also formed by inland lakes, such as the Great Salt Lake in Utah. Only about 2.7 per cent. of ocean water is salt, while the water of the Great Salt Lake of Utah contains about 17 per cent. When there is so much salt in water that it is called a saturated solution, salt crystals will form and drop to the bottom, which process will in time build up under a large body of salt water a great bed of rock salt.

The water in all rivers and springs contains salt to a certain degree, and where it runs into a basin like that of a lake with no outlet, through the process of evaporation pure water is being constantly carried off, leaving the salt behind. It is easy to see that if this process is kept up long enough the water will become in time a saturated solution, when crystallization sets in and precipitation follows, accounting for the deposits of rock salt.

AIR

CHAPTER VI
THE ATMOSPHERE

Meteorology is a science that at one time included astronomy, but now it is restricted to the weather, seasons, and all phenomena that are manifested in the atmosphere in its relation to heat, electricity, and moisture, as well as the laws that govern the ever-varying conditions of the circumambient air of our globe. The air is made up chiefly of oxygen and nitrogen, in the proportions of about twenty-one parts of oxygen and seventy-nine parts nitrogen by volume, and by weight about twenty-three parts oxygen and seventy-seven of nitrogen. These gases exist in the air as free gases and not chemically combined. The air is simply a mixture of these two gases.

There is a difference between a mixture and a compound. In a mixture there is no chemical change in the molecules of the substances mixed. In a compound there has been a rearrangement of the atoms, new molecules are formed, and a new substance is the result.

About 99-1/2 per cent. of air is oxygen and nitrogen and one-half per cent. is chiefly carbon dioxide. Carbon dioxide is a product of combustion, decay, and animal exhalation. It is poison to the animal, but food for the vegetable. However, the proportion in the air is so small that its baneful influence upon animal life is reduced to a minimum. The nitrogen is an inert, odorless gas, and its use in the air seems to be to dilute it, so that man and animals can breathe it. If all the nitrogen were extracted from the air and only the oxygen left to breathe, all animal life would be stimulated to death in a short time. The presence of the nitrogen prevents too much oxygen from being taken into the system at once. I suppose men and animals might have been so organized that they could breathe pure oxygen without being hurt, but they were not, for some reason, made that way.

Air contains more or less moisture in the form of vapor; this subject, however, will be discussed more fully under the head of evaporation. The air at sea-level weighs fifteen pounds to the square inch, and if the whole envelope of air were homogeneous – the same in character – it would reach only about five miles high. But as it becomes gradually rarefied as we ascend, it probably extends in a very thin state to a height of eighty or ninety miles; at least, at that height we should find a more perfect vacuum than can be produced by artificial means. The weight of all the air on the globe would be 11-2/3 trillion pounds if no deduction had to be made for space filled by mountains and land above sea-level. As it is, the whole bulk weighs something less than the above figures.

As we have said, the air envelopes the globe to a height at sea-level of eighty or ninety miles, gradually thinning out into the ether that fills all interstellar space. We live and move on the bottom of a great ocean of air. The birds fly in it just as the fish swim in the ocean of water. Both are transparent and both have weight. Water in the condensed state is heavier than the air and will seek the lowest places, but when vaporized, as in the process of evaporation, it is lighter than air and floats upward. In the vapor state it is transparent like steam. If you study a steam jet you will notice that for a short distance after it issues from the boiler it is transparent, but soon it condenses into cloud.

If we could see inside of a boiler in which steam had been generated, all the space not occupied with water would seem to be vacant, since steam before it is condensed is as transparent as the air. We will, however, speak of this subject more fully under the head of evaporation and cloud formation. It is not enough that we have the air in which we live and move, with all of its properties, as we have described: something more is needed which is absolutely essential both to animal and vegetable life – and this essential is motion. If the air remained perfectly still with no lateral movement or upward and downward currents of any kind, we should have a perfectly constant condition of things subjected only to such gradual changes as the advancing and receding seasons would produce owing to the change in the angle of the sun's rays. No cloud would ever form, no rain would ever fall, and no wind would ever blow. It is of the highest importance not only that the wind shall blow, but that comparatively sudden changes of temperature take place in the atmosphere, in order that vegetation as well as animal life may exist upon the surface of the globe. The only place where animal life could exist would be in the great bodies of water, and it is even doubtful if water could remain habitable unless there were means provided for constant circulation – motion.

The mobility of the atmosphere is such that the least influence that changes its balance will put it in motion. While we can account in a general way for atmospheric movements, there are many problems relating to the details that are unsolved. We find that even the "weather man" makes mistakes in his prognostications; so true is this that it is never safe to plan a picnic for to-morrow based upon the predictions of to-day. The chief difficulty in the way of solving the great problems relating to the sudden changes in the weather and temperature lies in the fact that two-thirds or more of the earth's surface is covered with water; thus making it impossible to establish stations for observation that would be evenly distributed all over the earth's surface. Enough is known, however, to make the study of meteorology a most wonderfully interesting subject.

We have already stated that air is composed of a mixture of oxygen and nitrogen chiefly, with a small amount of carbon dioxide. So far as the life and health of the animal is concerned we could get along without this latter substance, but it seems to be a necessity in the growth of vegetation. There are other things in the air which, while they are unnecessary for breathing purposes, it will be well for us to understand, as some of them are things to be avoided rather than inhaled.

As before mentioned, air contains moisture, which is a very variable quantity. In a cold day in winter it is not more than one-thousandth part, while in a warm day in summer it may equal one-fortieth of the quantity of air in a given space. There is also a small amount of ammonia, perhaps not over one-sixty-millionth. Oxygen also exists in the air in very small quantities in another form called ozone. One way to produce ozone is by passing an electric spark through air. Anyone who has operated a Holtz machine has noticed a peculiar smell attending the disruptive discharges, which is the odor of ozone. It is what chemists call an allotropic form of oxygen, just as the diamond, graphite, and charcoal are all different forms of carbon, and yet the chemical differences are scarcely traceable. It is more stimulating to breathe than oxygen and is probably produced by lightning discharges.

As has been before stated, the oxygen of the air is consumed by all processes of combustion, and in this we include the breathing of men and animals and the decay of vegetable matter, as well as the more active combustion arising from fires. A grown person consumes something over 400 gallons of oxygen per day, and it is estimated that all the fires on the earth consume in a century as much oxygen as is contained in the air over an area of seventy miles square. All of these processes are throwing into the air carbon dioxide (carbonic acid), which, however, is offset by the power of vegetation to absorb it, where the carbon is retained and forms a part of the woody fiber and pure oxygen is given back into the air. By this process the normal conditions of the air are maintained.

One decimeter (nearly 4 inches) square of green leaves will decompose in one hour seven cubic centimeters of carbon dioxide, if the sun is shining on them; in the shade the same area will absorb about three in the same time.

There is another substance in the form of vegetable germs in the air called bacteria. At one time these were supposed to be low forms of animal life, but it is now determined that they are the lowest forms of vegetable germs. Bacteria is the general or generic name for a large class of germs, many of them disease germs. By analysis of the air in different locations and in different parts of the country it has been determined that on the ocean and on the mountain tops these germs average only one to each cubic yard of air. In the streets of the average city there are 3000 of them to the cubic yard, while in other places where there is sickness, as in a hospital ward, there may be as many as 80,000 to the cubic yard. These facts go to prove what has long been well known, that the air of a city furnishes many more fruitful sources for disease than that of the country. Some forms of bacterial germs are not considered harmful, and they probably perform even a useful service in the economy of nature. Within certain limits, other things being equal, the higher one's dwelling is located above the common level the purer will be the air. This rule, however, has its limits, as the oxygen of the air is heavier than the nitrogen, so that the air at very great altitudes has not the same proportion of oxygen to nitrogen that it has at a lower level. An analysis that was made some years ago of the air on the west shore of Lake Michigan, especially that section where the bluffs are high, shows that it compares favorably with that of any other portion of the United States.

In view of the foregoing, it is of the highest importance to the sanitary condition of any city, town, or village that it be not too compactly built. If more than a certain number of people occupy a given area, it is absolutely impossible to preserve perfect sanitary conditions. And there ought to be a State law, especially for all suburban towns, which are the homes and sleeping places for large numbers of business men who spend their days in the foul air of the city, stipulating that the houses shall be not less than a certain distance apart. Oxygen is the great purifier of the blood, and if one does not get enough of it he suffers even though he breathes no impurities. The power to resist the effects of bad air is much greater when one is awake and active than when asleep, and this is why it is more important to sleep in pure air than to be in it during our waking hours. It is best, however, to be in good air all of the time. By pure air I do not mean pure oxygen, but the right mixture of the two gases that make air. Too much of a good thing is often worse than not enough. Pure food to eat, pure water to drink, and pure air to breathe would soon be the financial ruin of a large class of doctors.

CHAPTER VII
AIR TEMPERATURE

The most recent definition of heat is that it is a mode of motion; not movement of a mass of substance, but movement of its ultimate particles. It has been determined by experiment that the ability of any substance to absorb heat depends upon the number of atoms it contains, rather than its bulk or its weight.

It has also been stated that the atmosphere at sea-level weighs about fifteen pounds to the square inch, which means that a column of air one inch square extending from sea-level upward to the extreme limit of the atmosphere weighs fifteen pounds. The density of the air decreases as we ascend. Each successive layer, as we ascend, is more and more expanded, and consequently has a less and less number of air molecules in a given space. Therefore the capacity of the air for holding heat decreases as we go higher.

We deduce from these facts that the higher we go the colder it becomes; and this we find to be the case. Whoever has ascended a high mountain has had no difficulty in determining two things. One is that the air is very much colder than at sea-level, and the other that it is very much lighter in weight. We find it difficult, when we first reach the summit, to take enough of oxygen into our lungs to carry on the natural operations of the bodily functions. To overcome this difficulty, if we remain at this altitude for a considerable time, we shall find that our lungs have expanded, so as to make up in quantity what is lacking in quality.

If a man lives for a long time at an altitude of 10,000 feet he will find that his lungs are so expanded that he experiences some difficulty when he comes down to sea-level. And the reverse is true with one whose lungs are adapted to the conditions we find at sea-level, when he ascends to a higher altitude. There is a constant endeavor on the part of nature to adapt both animal and vegetable life to the surroundings. While no exact formula has been established as to the rate of decrement of temperature as we ascend, we may say that it decreases about one degree in every 300 or 400 feet of ascent. There is no exact way of arriving at this, as in ascending a mountain the temperature will be more or less affected by local conditions. If we go up in a balloon we have to depend upon the barometer as a means of measuring altitude, which, owing to the varying atmospheric conditions, is not a reliable mode of measurement. It is easily understood that a cubic foot of air at sea-level will contain a great many more atoms than a cubic foot of air will at the top of a high mountain; or, to state it in another way, a cubic foot of air at sea-level will occupy much more than a cubic foot of space 10,000 feet higher up. Suppose, then, that the amount of heat held in a cubic foot of air at sea-level remained the same, as related to the number of atoms. In its ascent we shall find that at a high altitude the same number of atoms that were held at sea-level in a cubic foot have been distributed over a so much larger space that the sensible heat is greatly diminished or diluted, so to speak. It was an old notion that heat would hide itself away in fluids under a name called by scientists latent heat. This theory has been exploded, however, by modern investigation.

If we place some substance that will inflame at a low temperature in the bottom of what is called a fire syringe (which is nothing but a cylinder bored out smoothly, with a piston head nicely fitted to it, so that it will be air-tight) and then suddenly condense the air in the syringe by shoving the plunger to the bottom, we can inflame the substance which has been placed in the bottom of the cylinder. In this operation the heat that was distributed through the whole body of air, that was contained in the cylinder before it was compressed, is now condensed into a small space. If we withdraw the plunger immediately, before the heat has been taken up by the walls of the syringe, we shall find the air of the same temperature as before the plunger was thrust down. This, however, does not take into account any heat that was generated by friction.

Let us further illustrate the phenomenon by another experiment. If we suddenly compress a cubic foot of air at ordinary pressure into a cubic inch of space, that cubic inch will be very hot because it contains all the heat that was distributed through the entire cubic foot before the compression took place. Now let it remain compressed until the heat has radiated from it, as it soon will, and the air becomes of the same temperature as the surrounding air. What ought to happen if then we should suddenly allow this cubic inch of air to expand to its normal pressure, when it will occupy a cubic foot of space?

Inasmuch as we allowed the heat to escape from it when in the condensed form, when it expands it will be very cold, because the heat of the cubic inch, now reduced to the normal temperature of the surrounding air, is distributed over a cubic foot of space.

This is precisely what takes place when heated air at the surface of the earth (which is condensed to a certain extent) rises to the higher regions of the atmosphere. There is a gradual expansion as it ascends, and consequently a gradual cooling, because a given amount of heat is being constantly distributed over a greater amount of space. At an altitude of forty-five miles it will have expanded about 25,000 times, which will bring the temperature down to between 200 and 300 degrees below zero.

When we get beyond the limits of the atmosphere we get into the region of absolute cold, because heat is atomic motion, and there can be no atomic motion where there are no atoms.

We have now traced the atmosphere up to the point where it shades off into the ether that is supposed to fill all interplanetary space. As Dryden says:

> There fields of light and liquid ether flow,
> Purg'd from the pond'rous dregs of earth below.

By interplanetary space we mean all space between the planets not occupied by sensible material. It is the same as interatomic space, or the space between atoms, except in degree, as the same substance that fills interplanetary space also fills interatomic space, so that all the atoms of matter float in it and are held together from flying off into space by the attraction of cohesion. What this ether is, has been the subject of much speculation among philosophers, without, however, arriving at any definite conclusion, further than that it is a substance possessing almost infinite elasticity, and whose ultimate particles, if particles there be, are so small that no sensible substance can be made sufficiently dense to resist it or confine it. It is easy to see that a substance possessing such qualities cannot be weighed or in any way made appreciable to our senses. But from the fact that radiant energy can be transmitted through it, with vibrations amounting to billions per second, we know that it must be a substance with elastic qualities that approach the infinite. Assuming that the ether is a substance, the question arises how is it related to other forms of substance? This is a question more easily asked than answered. The longer one dwells upon the subject, however, the more one is impressed with the thought that after all the ether may be the one element out of which all other elements come.

Chemistry tells us that there are between sixty and seventy ultimate elements. This is true at least as a basis for chemical science. Chemical analysis has never been able to make gold anything but gold, or oxygen anything but oxygen, and so on through the whole catalogue of elements. It may be, however, that the play of forces under and beyond those that seem to be active in all chemical processes and relations, are able to produce certain affections of the ether, the result of which in the one case is an atom of gold and in the other an atom of oxygen, etc., to the end of the list. In this case all of the so-called elements may have their origin in one fundamental element that we call the ether. I am aware that we are wading in deep water here, but sometimes we love to get into deep water just to try our swimming powers. The above is a suggestion of a theory called "the vortex theory," that is taking root in the minds of many philosophers to-day, and yet there is almost nothing of known facts to base such a theory upon, and nearly all we can say about it is that it seems plausible, when viewed through the eye of imagination.

Конец ознакомительного фрагмента.