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LECTURES

UPON

NATURAL HISTORY,

GEOLOGY, CHEMISTRY, THE APPLICATION OF STEAM,

AND INTERESTING DISCOVERIES IN THE ARTS.

'The man
Whom nature's works can charm, with God himself
Holds converse.' AKENSIDE.
Felix, qui rerum potuit cognoscere causas. VIRGIL.

BY TIMOTHY FLINT.

BOSTON:
LILLY, WAIT, COLMAN, AND HOLDEN.
CINCINNATI: E. H. FLINT.
1833.

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PREFACE.

In so extensive a field as this work opens, offering a condensed view of the prevalent systems and leading facts in science, it cannot be expected, that I should presume to offer claims to general originality. The text book, which I have chiefly followed, is a French work, 'Lettres a Sophie,' in 4 volumes 12mo, 9th edition, 1825, Paris; by Aimé Martin; and what is taken from that work is rather compilation and paraphrase, than exact translation. I have wholly omitted more than half the matter, a considerable part of which is in French verse, scarcely translatable into our language. Many of the opinions and doctrines of the author have yielded to more recent experiment and observation. I have been neither an incurious, nor indolent observer of nature myself; and, in pursuing his themes, I have interposed my own correlative remarks, wherever I thought I could offer additional illustration; and for the style and manner, I alone am answerable. The author of these letters himself compiled from Bacon, Descartes, Newton, Herschell, Lavoisier, Buffon, Fontenelle, Linneus, Spallanzani, St Pierre, Chateaubriand, Patrin, and numerous naturalists, voyagers and travellers. This work contains a synopsis of their best thoughts upon their favorite subjects. I will add in this connection, that, where I have not been able to find any corresponding names in English for the French names of animals and plants, I have given the scientific Latin names. The circumstance of becoming interested in the history of an animal or a plant, with an unknown name, may induce the student to repair to a dictionary of natural history; and he may thus be unconsciously led to more thorough and scientific acquaintance with the subject.

I have thrown the scientific axioms and doctrines, connected with the point in discussion into a tabular form, not with a view to a show of learning, which I would have gladly avoided; but that the reader may see in one view, the leading propositions, which books of physics and natural history propose to develop, and demonstrate, or illustrate in detail. In selecting these doctrines, I have consulted the most recent and approved authorities, among which I may mention Fischer's Elements of Philosophy, and his works upon Physics. In compiling the Geological part, I have chiefly kept Bakewell and Buckland in view; and I have ventured upon some further observations, the result of my own surveys of our country. For the letters on the application of steam, so far as the principles of the power and the mode of the application are concerned, I have found my authorities in Dr Lardner's small, popular work upon that subject. The lectures on Political Economy were based on Blake's Conversations on that subject. It would be useless to cite all the sources, to which I have repaired for information, to furnish a sketch of the history of the more interesting inventions.

These lectures turn upon those points of science and natural history, which are the most common and interesting topics of discussion in Lyceums, and of conversation in the more intellectual circles of society. But a small proportion of our young men, and none of our young ladies receive a complete academic education. They will all wish to possess general views of those doctrines of philosophy, and those sciences, which have been hitherto chiefly studied in universities and institutions, the professors of which are exclusively devoted to teaching the sciences. It is not presumed, that the instruction of this book can be offered, as a substitute for such a course of sustained and profound study. Its aim is, to present, in the most attractive form, enough of the philosophy and general principles of science, to furnish materials for thought and conversation upon the subjects discussed. Many of the graduates of our colleges are not remarkable for their broad and clear views on these points. I would hope, that they might derive profit from perusing it; either in gaining new information, or being refreshed in the recollection of their old studies. These sketches, I flatter myself, may excite sufficient interest and curiosity in those readers, for whom they are chiefly intended, to induce them to examine works, which treat upon these themes scientifically and at large. If there be a work of similar character, fitted for these intentions, in reference to the numerous and important classes, which I have named, brief, simple, clear, without diagrams and algebraic demonstrations, calculated, by the intrinsic interest of the theme, and the manner in which it is discussed, to seize upon the thoughts and memory of the reader, and give him possession of those great and leading principles of nature, which the studious in all time have labored to investigate, I am ignorant of the fact. My aim has been to furnish such a book.

To these inducements, I may add, that this work turns upon studies, which have been dear to me, since I possessed the power of thought. The universe, thus examined, assumes a new aspect. If Galen was reclaimed from atheism, by examining the wonderful adaptation and harmony of the constituent parts of the human body in concurring to produce life, motion and thought, what must be the convictions of the student of nature, who finds the whole universe every where as replete with these harmonies, as the human system? In enunciating the views of this work, where the term *nature* is used, I would be understood to mean *Providence* or God. In the heavens and the earth, in man that thinks, and the insect that creeps, I have found every thing labelled with the single, grand, all comprehending term — God.

To the students, particularly the female students in our higher seminaries, this work is affectionately inscribed.

It invites you to study nature in the fields, meadows and forests, on the mountain side, along the shores of streams or of the sea, and in the realms of space above you, through which the stars roll their everlasting courses. By holding forth to you the flowers of science, it would tempt you not to satisfy yourselves with their perfume and barren beauty, but with industry and energy to cultivate and gather the matured fruits of the harvest. With the fondness of one of their own children, I have loved the wild woods, the forest-skirted streams, the snow-clad mountains with their secluded dells, the plains and meadows, where plants and flowers spring without a name from the botanist, and without the permission or the aid of man. I ranged these haunts in my vernal day with untiring footsteps, satisfied to see, feel, and enjoy them without investigating final causes, or the object of the luxuriance and beauty before me. But, as I find myself in 'the sear and yellow leaf' of autumn, every thing in life has changed its aspect; and I am compelled either to relinquish, in satiety and weariness, those haunts and pursuits, which the habits of years have rendered dear, or to seek in them new and more elevated sources of enjoyment. I have found what I sought. I have reperused the open volume of nature, page by page, searching with the elder poets, the sweet Mantuan, and the sweeter psalmist of

Israel, with Christian philosophers, and all true lovers of nature, for the harmonies of this beautiful universe; for traces of the finger of God; for proofs, that divine love and wisdom are equally discernible in the great and the minute of creation. I have looked upwards into the unfathomable depths of space with the astronomer, and have listened with him to the eternal concord of the celestial melodies; and the innumerable lamps of the sky have lighted me onward through the etherial plains to the throne of the Eternal.

I have returned to contemplate nature with the physiologist, like another Columbus, discovering a new world with the solar microscope. He shows me oceans with their leviathans, forests with their winged inhabitants, empires and kingdoms with their numberless dwellers, where the naked eye sees but a drop of water, a little mouldiness, or the blue down of a plum. The truth radiates from these new realms of nature, that creative love is also there.

Where all seems to the undistinguishing gaze inextricable disorder, I discover perfect arrangement, I find that the sands, the ocean-pebbles, the forest-trees, the beasts of the field, the fowls of heaven, the insects that fly or crawl, all have their ranks and orders, which industrious research, may class into families, and inscribe with their generic names.

Be my walks in nature amid light or darkness, in sunshine or storm, 'in the waste desert or the city full,' a radiance, as of the greater light of the sky, has enabled me to find God every where in love and wisdom, still more than in power.

Even in the sterner aspects of nature, in storms, inundation, earthquake, and volcanic eruption, in the universal deluge, or the purifying baptism of fire, which has left in the past no traces of animated existence, but crystallizations in granite, or organic remains imbedded in the secondary strata of stone, I have discovered a purpose to remould the earth and prepare a new and fairer abode for man, in which may dwell purer reason and more exalted righteousness. I have become satisfied, that the seeming disorders and imperfections of nature are such, only because of the weakness of our intellectual vision; and that even death itself is a remedy and a blessing.

As I have beheld nature with these eyes, my heart has burned within me with the desire, that others may derive the same pleasure from the love and study of her works.

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LECTURES

ON

NATURAL PHILOSOPHY.

LECTURE I.

THE NATURAL LAWS.

The laws of the universe, as they relate to men, may be divided into three classes — physical, organic, and moral. The first class comprises the unchangeable properties of inanimate matter; the second, the phenomena of organized and sentient life; and the third, the laws of beings capable of moral action, that is, conformity or want of conformity to a known and prescribed rule.

These laws, as far as our faculties can trace them by reason and inference, have prevailed without variation from the beginning. They are found to be unchangeably the same in every part of our world. Astronomy teaches us, that the physical laws are the same to the utmost extent of the solar system. Certain movements of the heavenly bodies were thought to be exceptions or aberrations, which, it was supposed, were continually increasing, and might finally destroy our system. More enlightened and exact observation has ascertained, that these seeming aberrations are real harmonies, and additional demonstrations of the uniform and universal action of the physical laws.

The organic and moral laws, to the extent of our sphere of observation, are equally uniform, unchanging, and identical. May we not conclude, that the whole universe, with its everlasting order, and all the laws that govern it, are transcripts of the divine immutability and perfection; that they have been the same in all time, and in all space, and will continue the same through all the lapse of ages before us?

Without the utmost folly and impiety, we cannot imagine that these laws will change to meet our arrogant expectations and wishes. We are moral beings, capable, in various ways, of becoming acquainted with them, and of yielding conformity or resistance to them. All our suffering here and forever, must result from their infringement; and our happiness, from knowing and obeying them. To study them, so as to understand them to the extent of our power, in order to adore the infinite wisdom and goodness of the lawgiver, and with undeviating uniformity to obey them, is true philosophy, and our best wisdom. Health, sound reason, the highest perfection of our intellectual and moral nature, and our present and eternal well-being, are the rewards of this knowledge and obedience.

The attainment of knowledge and truth of every description, tends not only to make us wise, but good and happy. The study of nature leads directly to this result, by unfolding at every step of our progress, new harmonies, new adaptations of the system of the universe, in whole and in part, to the position and comfort of all animated existence; and by showing the physical conformity of the constitution and place of every living thing to the laws of nature. The beauty and fitness of the universe to all that has life, radiate alike from the earth and the heavens, from a molecule of matter and the world. Every new fact in the study of nature, when rightly interpreted, becomes a new evidence of the intelligence and benevolence of a first cause. But this range is too vast for the shortness of life, and the feebleness of human vision. There are a thousand provinces in the empire of philosophy. Let us not bewilder ourselves, by attempting an undistinguishing survey of the whole. The practical astronomer, instead of gazing upon the whole galaxy, intensely contemplates a single star. Leaving to more adventurous aspirants in the temple of nature, the appropriate investigations of the metaphysician, the physiologist, the divine, and moralist, in studying and expounding the organic and moral laws in their bearing upon man; my humble object is to point out some of the more striking harmonies of nature in physics, chemistry, natural history, geology, and those powers of nature, which have given birth to the arts.

But though my aim be comparatively humble, in the immensity of my subject, I know not where to commence. Whether with Humboldt we look down from Antisana of the Andes, upon the earth at our feet, and observe and class the facts of natural philosophy and geology; or with Herschell go forth in the stillness of night, under the star-sprinkled canopy, and contemplate world beyond world, and system beyond system, revolving in their eternal circles in the depths of space, with the same unvarying harmony from age to age; or, exhausted with straining our narrow ken to such vast contemplations, repose with the botanist in the mountain glen, and class the tribes of trees, shrubs, plants, and flowers; or mark, with the naturalist, the races that soar, or walk, or crawl, or swim; every discovery we can make, all the facts we can class, if our minds are rightly constituted, will result in gratitude and love to the divine Being, and in enlightened and thankful obedience to his laws.

I will attempt to show you the glory of God in his works. We will scale the summits of the mountains to study the sources of the streams. We will behold the storms in the rudiments of their formation, and the elements of the thunder that bursts below us. Sometimes, sitting on the shores of the sea, and listening to the ceaseless dash of the surge, we will investigate the cause of the everlasting flux and reflux of its tides. Sometimes, with the voyager, we will make a transit over its vast abyss, and survey the wonders of foreign climes. Penetrating the mysteries, which the earth conceals in her bosom, we will contemplate her crystals, gems, diamonds, and gold, in their primitive particles. We will demand of the volcanoes the cause of their central and inextinguishable fires, and the terrific spectacle of their explosions. When the thunder-storm is past, we will sit down with the cottager on the threshold of his peaceful dwelling, inhaling the freshness of renovated nature, and listening to the distant thunder and the renewed songs in the dripping groves, while we gaze in admiration at the splendid bow, which so gloriously spans the heavens from forest to forest, stretched over the dark cloud that has gone by. While we analyze the gorgeous illusion, and learn that it is no more than sun-beams painted upon mist, we will learn the moral lesson to undeceive ourselves in regard to most of the mockeries of the external show of human existence.

Before I commence an exposition of the most obvious laws of the physical universe, and their application to my subject, I shall abridge a sketch of the voluminous works, that present the details of the ancient systems of physics.

The most striking feature of all these doctrines of the philosophy of the olden time is, that they were not so much the study, or the science of nature, as the opinions and theories of the philosophers. Philosophy was not supposed to consist so much in observation of facts, as in speculation upon systems. Every master bore a standard inscribed with the name of his school, and the disciple stood pledged to the system of his master. In physics, no point seemed to them more important than one, which has been a most prolific theme with modern philosophers — the question, how the world was made, and of what elements it was composed? Thales created the world from water. Pherecides held it easier to compose it of earth. Anaximines found air sufficient for the purpose; while Zeno availed himself of the four elements united. It was almost as difficult to people the world as to make it. Other sages followed them, kindling prodigious theoretical subterranean fires, in which grand workshop, they fabricated metals, stones, and earths. The disciples of Aristotle considered air, earth, water, and fire, as the four elements, out of which every thing was composed;

and with these elements, properly moulded and organized, and attempered by the central heat, they held it possible to cover the earth with plants, and people it with men.

If we consult their opinions, in respect to the celestial phenomena, we shall be no less surprised. The sun, which Carsini ascertained to be a million times larger than the earth, Heraclitus affirmed to be no more than a foot in diameter. Even Anaxagoras, a more enlightened astronomer, did not believe it to be larger than Peloponessus. This sublime orb, the rays of which Newton has analyzed, according to Thales, was only an inflamed vapour; or, in the judgment of Anaxagoras and Democritus, an ignited mass of rock. Before we spend a smile upon these systems of the ancient sages, let us observe the obstacles, which truth has had to surmount in modern times. Let us not forget the reception given to the true system of the universe, as declared by Galileo, the discovery of printing, the circulation of the blood, and, in fact, most of the great discoveries. It is only two or three centuries since physics has become a science of facts, instead of opinions. Torricelli, in ascertaining the weight of the air, and Bacon, in indicating the avenue to almost all the modern discoveries, prepared the way for Newton and Lavoisier. The chief burden of these letters will be the development of some of the views and demonstrations of these great men.

I here present you a tabular view of the chief doctrines and propositions of that branch of physics, which relates to matter and its properties. Large treatises of philosophy have been written upon each one of these propositions. Most of them have been either illustrated or demonstrated, by diagrams and mathematical reasoning, which my plan precludes. Let not the apparent intricacy and hardness of the terms, in which these propositions are declared, alarm or revolt you. It was necessary to conciseness, and to avoid the tedious circumlocution of explanatory verbiage, to include doctrines which involve a vast amount of inferences and details, in abstract terms and the most compact form. If you commit them to memory, you will always have at hand the chief facts, about which the science of physics is conversant. If hereafter disposed fully to investigate the subject, not only in the principles, but in the illustrations and demonstrations of voluminous books of philosophy, you will find the advantage of carrying to those works the distinct remembrance of these propositions.

A body is a material substance. All bodies possess extension, form, bulk, divisibility, impenetrability, mobility, gravity, porosity, compressibility, and elasticity. Bodies are solid, as stone; liquid, as water; æriform or gaseous, as air. Many bodies, as water, mercury, and the easily fusible metals, can assume each of these forms, and return, by reversing their transitions, to their original state. There are bodies, which are not seen, except in the form of solids — as the infusible metals and the simple earths.*

Bodies have a determinate form in consequence of cohesion and aggregation. The aggregation of bodies is chiefly effected by heat and chemical combination. When two intimately combine, the one often imparts its aggregation to the other. Again the aggregation of the compound is often different from the simples that composed it. *Examples.* — Salt liquifies in water; water becomes an elastic fluid in air. Two gases, muriatic acid gas, and ammoniacal gas, form solid muriate of ammonia. The hydrogen and oxygen gases united, form water.

The changes in the states of the aggregation of bodies probably depend upon the opposition of two forces, one attractive, the other repulsive. The first is an inherent property of matter; the second is produced by caloric. When the attractive force exceeds the repulsive, the body is solid. When both are in equilibrium, liquid; when the repulsive exceeds the attractive, æriform.

Most bodies are composed of heterogeneous substances, as culinary salt, of muriatic acid and soda. Those

* In indicating temperature, reference is had to Fahrenheit's thermometer. Water exists in the form of a *solid* at any temperature below 32 degrees; above that, it is *liquid;* till it reaches 212 degrees, when it becomes *æriform* or *gaseous.*

substances, which compose another, are called its constituent principles, to distinguish them from the simple, integrant particles of a homogeneous body.

There are reckoned over fifty bodies, undecomposable by any analysis yet known. This number is continually varying with the varying results of chemical experiment. Most of the substances, formerly considered elements, as air, earth, and water, have been decomposed. Even potash and soda, until very recently considered simple substances, have been found to be metallic oxydes.

The mixture of two substances results from a mutual attraction, or tendency to penetrate into the interstices, or spaces, which exist between their particles. This tendency is called their affinity. We know nothing of matter, but its properties. There are, however, two prevalent theories to explain its intrinsic nature. The first, called the *atomic* theory, prevails in France. According to this theory, matter is composed of indivisible, impenetrable particles, called atoms. These atoms are kept apart by attractive and repulsive forces, and porosity results, as a necessary property. There is more void space than matter, in every body. The varieties of bodies result from a material difference in these atoms, or in their form, magnitude, position, and distance.

The *dynamic* theory considers matter as filling the space occupies. According to this, porosity is an incidental property; but compressibility and dilatability essential properties. The state of the body depends upon its attractive and repulsive forces. Change their ratios, and its volume changes. There are certain primitive substances, the varirious combinations of which produce all bodies. This is the theory of Germany. Neither is susceptible of proof. That philosophy, which admits nothing as certain, but what has passed the test of experiment, is called the *inductive* philosophy, and is the true mode of philosophizing.

Motion is change of place, and is rectilinear, or curvilinear, varied, accelerated, or retarded. The space passed over in a given time, by a body in uniform motion, is called its velocity. In uniform motion, the space described is as the time. In compound motion, if a body receive an equal compound force acting in rectangular directions, the body will describe the diagonal, in the time that is requisite to describe either of the sides, with the simple force acting in either direction. This is a difficult law of motion to illustrate, except by presenting a diagram; but it is the most important doctrine of rectilinear moving forces. By this law, any number of motions may be compounded into one; or a single motion may be decomposed into any number of constituent motions.

The moving force of animated beings is communicated by volition; of inanimate bodies by impulse. A body at rest, without impulse, remains at rest. A body in motion continues to move in a right line, until the motion is changed or arrested by some extrinsic moving force. This indifference of matter to motion or rest is called the force of *inertia*. A *force* is measured by the product of the *mass* multiplied into the *velocity* of the moving body. The action and reaction of two bodies upon each other are always reciprocal and equal. In other words, if two moving bodies meet, the motion, which the one gains by impulse, the other loses.

But the law of matter, which far surpasses all others in its important relations to physics, and in the magnitude of the discoveries to which the knowledge of it has led, is the *gravity* of attraction. It acts at vast distances, sustains the worlds in space, and determines the extent and form of their orbit round their suns. It is this, which unites, in one vast whole, all the bodies, of which the planetary system is composed, imparting perpetual order and harmony to their motions. If the Creator were for a moment to suspend this universal power, all nature would return to chaos.

Gravity is the reciprocal attraction existing between all the bodies in nature, operating in the direct proportion of their masses, and in the inverse proportion of the squares of their distances. The measure of this is called weight; and, in homogeneous bodies, is as their bulks. Specific gravity is the proportion of the absolute weight of one body to another, not homogeneous. The weight of pure water is the common standard of this proportion.

In a vacuum, all bodies fall with the same velocity. The intensity of gravity is a little less at the equator, than the poles of the earth, proving, that the earth is not an exact sphere, but flattened at the poles. It is also a little less on high mountains, than on plains.

The force, which holds the different parts of solid bodies together, is called *cohesion*. It is capable of being indefinitely varied by mechanical and chemical means. The most general law is, that it is diminished by heat, and increased by cold. Pure hammered iron possesses it in a remarkable degree. The attraction existing between homogeneous bodies is called *affinity*. There are three sorts of attraction acting upon all bodies—gravity, cohesion, and affinity. Bodies, which, when compressed, tend to recover their primitive figure, are called *elastic* bodies.

To understand the *equilibrium* of bodies, suppose a pair of scales. When equal weights are placed in opposite scales, they are said to be in equilibrium. The point in a body, which, being sustained, will preserve it in equilibrium, is called its centre of gravity.

Falling bodies have a uniformly accelerated motion. The general law of descent is, that the spaces described are as the squares of the velocities. The measure of this motion is called the accelerating force. The velocity of a body projected upwards, diminishes in precisely the same ratio as it increases in its descent. Thus, knowing the velocity, with which a body is projected, we can determine the height to which it will attain. These propositions are only strictly true, when the ascent and descent is in a vacuum. In actual projectiles, the resistance of the air, and the bulk of the body in relation to its gravity, must be taken into the calculation. Bodies impelled in any direction oblique to the perpendicular, describe a *parabolic* curve, the laws of which curve are demonstrated in *conic sections*. The science of gunnery is chiefly taught by these laws. The parabolic curve is magnificently shown by the blazing fusee of a bomb discharged from a mortar in a dark night.

When a force draws a body *towards* a centre, while the body has received from another force an impulse *from* the centre, the motion produced is called *central motion*. These forces, in relation to the earth and the other planets to the sun, have generally been called *centripetal* and *centrifugal*. They are explained by the laws of curvilinear motion, and are not easily intelligible, except by diagrams and demonstrations appertaining to astronomy. These are the laws, which determine the motions and orbits of the heavenly bodies.

Such are the chief of the most prevalent doctrines of modern physics. Are we certain, that they contain only truth? They have been sustained, it is true, by the greatest names that science can boast; and have been fortified by analogy and geometrical reasoning. We cannot but recollect, however, that there was not one of the ancient errors in philosophy, but what found numerous and zealous partizans. The physics of Aristotle were held in such veneration for centuries, that it was regarded a criminal heresy to controvert them. The systems of Epicurus, Archelaus, Democritus, Anaxagoras, and Xenophanes, obtained in their turn the most brilliant success. What we now hold unquestionable error, our fathers considered equally indisputable truth. St Pierre said to Rousseau, 'there are a hundred forms in which to present nature.' 'Yes,' replied Rousseau, 'and perhaps none of them the true one.'

We have not a doubt, that most of the preceding propositions are simple truth; for they are founded, not like the systems of the ancients, upon theory, but upon experience and demonstration. But enough of perplexity and uncertainty appertains to all the deductions of human reason, to inspire us with that modesty and docility, which have always been the prominent characteristics of the most patient and successful searchers after truth. Embassadors from Europe informed the king of Siam, that water in their country, during the winter, became so solid, that men could walk, and carriages be driven upon it. Believing them to be false, he ordered his Talapoins to make a series of experiments to verify or disprove the information. In that burning climate, with their defective chemical knowledge, (for ice could now be artificially formed there,) the experiment entirely failed; and the king and his Talapoins adjudged, that water was essentially fluid. One of these philosophers soon after, happening to cross the high mountains of Ava adjoining his country, found ice on their summits, and affirmed, on his return, that water is a fusible chrystal. The king could hardly fail to learn a lesson of modesty, and more docility to the laws of moral evidence.

LECTURE II.

NEWTON. LIGHT. LAVOISIER.

The most illustrious name in the history of modern science is Newton. He is most generally known, as the philosopher, who convinced the age that gravity is an essential and universal property of bodies, and that it is the principle of attraction, which sustains the worlds in space. He was equally profound, as a mathematician and an astronomer. Heshowed, perhaps, as great research in a walk, in which he is scarcely known, except to the learned. It is questionable, whether he deserves most fame as the measurer of worlds and the discoverer of their sustaining principle, or as having first decomposed light, and astonished the world by demonstrating that it is composed of seven primitive colours; and that the sun, its source, is the grand painter of the universe.

Let us follow him into his darkened chamber. He receives a pencil of light upon his prism. In passing through the prism it is decomposed, and offers the spectacle of a rainbow. All the colouring, which embellishes nature, was explained in a moment.

He discovered that bodies have the property of decomposing light, of reflecting one or many tints, and absorbing others, by which they appear in different colours. The blue of indigo is not an inherent property in the fecula of the plant, until after it has received by fermentation a property to reflect that colour and absorb the other rays. Before Newton, the cause of this phenomenon had been scarcely dreamed. Little had it been suspected, that a solar ray, which appears a dazzling white, is really a compound of all the colours of the bow. He showed us that light is the colouring matter, of which nature avails herself to paint the firmament, the clouds, the green earth, the forests and flowers, and all the infinite and delightful varieties of light and shade, which imparts to the universe its highest charm.

Light is the most striking, sensible phenomenon of the universe. It opens to us the most exalted and exquisite pleasures, and furnishes the means of our most valuable knowledge. I may therefore promise myself your interest so far, as to induce you to follow me through a tabular view of the chief phenomena of vision. The subject in its details is intricate, often abstruse, and only to be apprehended by demonstrations. A few only of the more striking and obvious laws of vision, are all that my plan allows me to offer you.

Some of the ancients deemed that the medium of vision was transmitted from the eye to the object. Newton supposed it to proceed from the object to the eye. Descartes and Euler believed in an exceedingly subtle fluid, the motions of which produce vision in the same manner, as the vibrations of the air produce sound. These are hypotheses to explain, what in this life we shall probably never understand. We only know, that, but for vision, light would have existed for us in vain; and that, but for light, the faculty of vision would have been to no purpose. Both these adaptations are proofs of a divine arrangement for our benefit. We open our eyes, and the majesty and beauty of the creation enter. The theory can go no further than to declare the fact.

If light be matter, as we are in some sense obliged to consider it, it is matter so unlike any other, of which our senses take cognizance, that we are compelled to employ, in treating of its laws, very different calculations from those which we apply to the laws of all other matter. That some of its rays are absorbed by bodies, and given out again, we know by observation. It penetrates all bodies, and offers no impediment to the transit of any other body. Chemistry promises more precise knowledge of its nature than physics. It is every where connected with heat, the most important chemical agent in nature. In combustion, in electro-chemical experiments, and in the properties of many bodies, there are chemical changes, which can be operated only by the action of light. The beneficent influence of light upon the living universe, no one can fail to have observed. It may well be questioned, if it be not the germ and prolific principle of all organized life.

Bodies through which the light passes freely, are called transparent. Those, which retain the light, are named opaque. That light is transmitted through the air in right lines is beautifully illustrated in a dark room, into which the light is admitted through a small aperture. The illuminated particles of dust are seen arranged in right lines. Rays entering a medium, more rare or dense, are refracted according to fixed laws; that is, are deflected more or less from their rectilinear direction. The science, which treats of the phenomena and laws of this refraction, is called *dioptrics.* Rays falling upon the polished surface of an opaque body are reflected in a determinate direction; and the science which shows the laws and phenomena of this effect upon light is called *catoptrics.*

Of opaque bodies, whose surfaces are not polished, some send off nearly all the light they receive. These are white. Others reflect little or none. These are black. All bodies of the intermediate colours produce some chemical modification of the luminous matter, which causes their appropriate tints. Hence we infer, that color is not a property inherent in bodies, but in the light transmitted from them.

The transmission of light is with about the velocity of 200,000 miles in a second. Light loses its intensity by diffusion; and this intensity is inversely proportional to the square of the distance.

The eye, the wonderful organ of vision, is a small globular body fitted with different coatings and humours adapted to the different purposes of sight; and placed in a cavity, in which it moves freely, to take in the different objects of the hemisphere.

The exterior coating is a white, opaque, horny substance called sclerotica. The front part of this coating, which is perfectly transparent, is called the cornea. Within the sclerotica is the dark coloured coat, called the choroid. Behind the cornea the choroid is detached, and divided into two parts, one of which is in the shape of a ring, and forms the circular opening, called the pupil. The membrane, which forms this ring, is called the iris, on account of the variety of its colours. Behind the iris is a transparent body, shaped like a lens, dividing the interior of the eye into the anterior and posterior chambers. The lens shaped body is called the crystalline. The anterior chamber contains a transparent liquor, like water, called the aqueous humour. The posterior chamber is filled with a gelatinous substance, which is also transparent, and is called the vitreous humour. A line, which passes through the pupil, perpendicular to the two faces of the crystalline, is called the axis of the eye. When the axis varies from this line it produces squinting. Persons, who see well close at hand, are called *myopes*, or near sighted. Those, who see clearly at a distance, are called *presbytes*, or long-sighted.

It is an often vexed question, why it happens, that we see objects erect, when the painting of the image on the retina is inverted? This question turns upon a point, as little capable of solution, as the question, how the mind perceives objects? The image is probably presented erect to the mind by some inexplicable power of the imagination.

Plane mirrors reflect the objects that fall upon them. Glass mirrors are the well known instruments employed for the common purposes of vision. But for exact optical experiments polished metallic mirrors should be used.

The axis of a concave mirror being directed towards the sun concentrates its rays to a focal point, producing intense heat. This is called a *burning mirror*. When we present the axis of a convex mirror towards the sun, it does not concentrate, it disperses the rays, and lessens the object reflected from its surface.

When a luminous ray passes obliquely into a transparent medium, it is refracted, that is, deflected *towards* the perpendicular, when the ray passes from a rare to a denser medium; and *from* it, when the ray passes from a dense into a rarer medium. When a ray passes from one medium into another, the sine of the incidence of the ray and of its refraction are in a constant ratio to each other.

The most important optical instruments are *lenses* of different forms and dimensions, to answer different intentions. The common convex lens, or burning glass, converges the sun's rays to a focal point; and its effects are as remarkable, in producing intensity of heat, as the concave mirror. Common spectacles are generally glasses of this character. A lens of this description, whose focal distance is less than half an inch, is called a *microscope*. There are microscopes, that magnify an object more than half a million times. The solar microscope is most commonly used for the purposes of microscopic observation, having the advantage of enabling a number of persons to see the object at the same moment.

In the camera obscura the images of distant objects are formed by a converging glass thrown upon some surface. These images can be reflected upward or downward by a plane mirror, placed at some distance behind the glass at an angle of 45°; so that the images may be represented upon a horizontal plane. This is a most important instrument for a landscape painter, as the landscapes are represented with great beauty, and in perfect accuracy of proportion.

The camera lucida consists of a quadrangular base, before which is placed a convex lens of considerable extent.

Behind this in the base is a plane mirror, placed at an angle of 45°, which reflects towards the cover the images of distant objects. This is also much used by landscape painters.

By means of two large convex glasses, placed at a little distance from each other, and by passing pictures before them painted upon glass, all the beautiful experiments, at once so fascinating and inexplicable to untaught beholders, such, for example, as the phantasmagoria and spectral appearances, of the magic lantern are produced.

A tube fitted with lenses, for the purpose of viewing objects at a great distance, is called a telescope. Herschell's telescope possesses a very great magnifying power. The telescope of Dolland is called *acromatic*, or colorless, because it exhibits the object without any of the prismatic colors. The making of telescopes, capable of answering all astronomical purposes with entire accuracy, is a work of great difficulty, principally owing to the different refracting powers of the various lenses employed, and to the want of perfect uniformity in the substance of any glass, that has been yet made.

While Newton was settling the courses of the stars, and decomposing light, Buffon laid open the wonders of the irrational animate creation, and placed the living universe in review before our eyes. The superb courser, kindling at the sound of the trumpet, and arching his neck 'clothed with thunder,' the lion, the tyrant monarch of the burning African plains, the tiger, ranging over the arid sands, thirsting for blood, the fleet stag, the beavers constructing their city with mathematical precision, and the profoundest knowledge of hydraulics, in the peaceful waters, the soaring eagle, the splendid humming bird, all live in his graphic descriptions. Living nature seemed to pass before him, as before our first father, to be classed, and named. As he gave the names, he developed the instincts and dispositions of the animals, and taught us, if I may so say, their moral character. The eloquent painter of nature aspired to show us, how the system of the universe was reared. According to him the Creator hurled an immense comet upon the sun, which struck off a glittering and red hot spark from that planet, which, in process of time, became our globe. He supposes it whirling in space, in which it kindled an immense conflagration, for three thousand years. Such a proportion of the waters, the while, were reduced to vapor, as to cause the dry land of the continents to appear. To people the world with its variety of living beings, he has recourse to a theory of organic molecules, not unlike the atomic philosophy of Epicurus. His imposing eloquence has indeed thrown an attractive brilliancy over his visionary system. But no effort is necessary to crush his colossal image of imaginations, like that of Dura, partly of gold and partly of clay. His philosophic reveries have already passed into oblivion. His zoology, on the contrary, will live forever. He faithfully observed living nature, and has produced in his writing those strong and faithful pictures, which cannot be mistaken.

The illustrious Swedish naturalist Linneus came after him, emulating his march. Patient, industrious, and highly endowed, he has classed the plants and flowers from the cedar of the mountains to the hydrangea of the brook.

A man equally illustrious in his own walk arose after them. Lavoisier devoted himself to the investigation of matters, simple and unimportant in appearance, which had been overlooked by preceding philosophers. He became the founder of chemistry in such a sense, as almost to create a new science, which science seems almost endowed with the power to create. He decomposed, and recomposed water and air; and the age was taught to recognize new elements in substances, which had hitherto been considered simple and elementary. The maker of porcelain came to him for his earths, the painter for his colors, the physician for his remedies, and the warrior for his steel. All the other sciences drew resources from the new fountains which he opened. He created mineralogy in France, reformed geology, and penetrating the earth, taught us many of the secrets, that nature had hitherto concealed in her bosom. To his researches we owe much of the exactness of our knowledge respecting our food, dress and arts; our gold, silver and iron, of gunpowder and the mineral medicines.

It would be difficult to find limits to the utility of his discoveries. Contemplating the wonderful labours of this great man, of Sir Humphry Davy, and a host of chemists, who have followed in their steps, we might imagine, that this new science was exhausted.

But it is only a little portion of the surface of our sphere, about which we have any knowledge. Of its depths and centre we remain wholly ignorant. A few scattered rays of the light of truth, which glimmer here and there in the general darkness, have been discovered. The true philosophers, like fugitive points, collect, and diffuse, from time to time, a little light. To inspire the learned with modesty, it is a fact worthy of remark, that the most important discoveries have been made by persons, who laid no claims to the reputation of learning. The discovery of gunpowder was not made by professed chemists, but by a poor monk. The hint for the first perspective glasses was not given by opticians, but by children in their sports. The discovery of America was not due to the proud priests and geographers of the king of Spain, but to an obscure Genoese pilot, who sought a western route to the East Indies and the spice islands. The discoverer of Herschell's new planetary satellites, and a vast number of the celestial phenomena, was not an astronomer by original profession, but a musician of the royal guards of the British king. The discoverer of the identity of lightning and electricity, the illustrious Franklin, commenced his career not in academic shades, or under the shelter of great names, but in the obscure garret of a printer. The name of Jenner would have been lost in obscurity, but for the immortal discovery of the vaccine disease; and Fulton has left no heritage to his posterity, but honorable poverty, and the renown of having first successfully applied steam to the driving of vessels upon rivers. That would be a useful book, which should indicate all the discoveries, made by chance or by the unlearned.

LECTURE III.

NATURE SENTIENT. HABITS OF PLANTS.

THE hypothesis of Pythagoras was, that every thing in nature is sentient. From the recognized law of attraction, that every particle of matter in creation is attracted towards every other particle, to the doctrine, that every thing in nature is sentient, the transition is easy and natural. Orpheus and Homer had sung what Pythagoras taught. In their ear the living universe was constantly engaged in one grand and unceasing concert; and wisdom and philosophy were but the study of the music of the spheres. The elder poets have transmitted this doctrine in the splendid allegories of their poetry, which, unintelligible without this key, are easily unfolded by it.

The movement of plants to follow the course of the sun, the singular formation of stalagmites, and stalactites in caves, the magnetic power of the needle, the wonderful vegetation of some metals, and innumerable phenomena of apparent sensation in plants, the discovery of a new living universe concealed in the minuter parts of visible nature, and made known by the microscope, — all these facts of modern investigation might have given some countenance to the ancient philosophers, in affirming, that nothing in nature is without sensation. In their view all creation was animated, and every portion of it peopled with nymphs and gods. For them, wood nymphs, crowned with violets, embellished and gave life to the sylvan scenery. Oreads, clad with moss, reposed in the cool grottos of the mountains. Dryads consorted together in the groves. Echo repeated 'I love thee' to each of her lovers. Aurora, spring, the hours, every thing was alive, and invested by imagination with celestial beauty.

Let us survey some of the facts, which Pythagoras would have adduced in support of the hypothesis, that every thing has sensation, and is endowed with the faculty of love. Admit it, and we are instructed, why the *equisetum* and the *lythrum* never quit their streams, or the *majoram* its arid rocks; why the *heath* is faithful to its hills, the *hyoscyamus* to its desolate places, and the *lily* of the valley to its woods. You will know why the apple tree delights to grow only in cultivated plains, and the pine upon the sides of the wind beaten hills. You will discover, why the *reseda* and *helianthus* turn round towards the sun; why the *sensitive plant* shuns the hand of man, as if conscious, that man is every where a destroyer. If you study the plants, that grow on the borders of streams, you will be surprised to note the number of flowers that never quit them. Among them you will be struck with the *circe*, which contemplates itself in the fountain, in which it bathes its delicate feet; the *scrofularia* with its little shells of velvet, the *mints* with their delightful perfume, and the beautiful '*forget me not*,' which arises on the shore of the water, and reflects in it the azure of its flowers. All are acquainted with the touching metamorphosis of which the ancients supposed it the subject. The popular name, which it has received from a modern fact, is scarcely less impressive. Two youthful lovers walked on the banks of the Danube, the evening before their intended marriage. A beautiful flower of this plant with its celestial blue floated on that mighty stream. The young lady admired its brilliancy, and expressed regret, that such a lovely flower should sink in the waves. The lover at the word threw himself into the stream, seized the flowering stem, and, from some sudden illness, sunk under the wave: as he rose, exerting a last effort, he threw the flower on the shore, exclaimed ' forget me not,' and sunk forever.

If we ascend from plants to insects we shall find that nature has also treated them with maternal tenderness. The *ephemera* is born, passes a life of a minute's duration, and dies. The moment has been all consecrated to love; and, perhaps, according to its laws of sensation, that life may have seemed as long as that of the ante-diluvians. The *termites* find their cradle a nuptial couch and a tomb. But their brief and secluded existence is passed in love. A *caterpillar* envelopes itself in a tissue of silk; for it is destined to experience an aerial transformation, in which alone it can perpetuate its kind. It bursts its silken envelope, to awaken with splendidly painted wings, with which it flutters from flower to flower, to live on aroma and love. The larger animals feel the impulses of the same passion, and fill the forests with their cries of joy. The birds have each their song of tenderness; and the nightingale pours the strain of love, imbued, in its true nature, with a touch of sadness.

The whole picture of creation is a grouping of harmonies, affinities, sensations, affections. We shall see, that even the vegetable, recently considered as remote from sensation as the mould from which it sprang, and into which it resolves at its decay, is distinguished by affinity, sex and movements, analogous to those of sensation and maternity. It was from similar views of nature, that Pherecides affirmed, that the Divinity became pure and unmixed love, when he created the worlds. May it not have been, that the contemplation of the reciprocal attraction, which every thing in nature exercises towards every other thing, considered as an innate principle of love, that led Newton to the secret of the universe? Love is every where, penetrates every thing, and imparts life to all that lives. The other passions were distributed unequally, for they are not indispensable to the perpetuity of life. Some people have been seen wholly devoid of apparent ambition; others without fear; others without avarice; but none without love.

If the passions which agitate us were to dispute the empire of the world, Ambition might say, 'I have invented war, and tithed the human race for my bloody hecatombs.' Avarice, 'I have raised the metals from their deep beds, and have united the two worlds in the golden chain of commerce.' Gluttony, 'I preside over vintages and harvests, fisheries and the chase.' Interest, 'I have blinded the eyes, hardened the hearts, and seared the affections of men.' Hatred, 'I have made men tremble, and inspired the malignant desire of revenge.'

Love would say, 'I was before all these. I was the eternal source of all life, the exhaustless fountain of all joy. I kindled the bridal torch, and prepared the nuptial couch. I sang the first songs. For my habitation the arts reared their palaces. I gathered the flowers of all climes into gardens. My smile imparts fecundity to nature, and thrills the maternal bosom. Riches without me are nothing. With me poverty is happy. I raised the first altars to the divinity, and the first statues to men. I perpetuate the remembrance of whatever is amiable or good. I am the divine reason, and human reason resists me not. I subjugate wrath, soften ferocity, and quench revenge. I am the charm of the senses, the delight of souls, and an inspiration from on high.' Thus sung the ancient poets in view of the diffusive principle of love, and the indications of benevolence visible in every province of the creation.

Some modern philosophers have transcended even these views of the extent of love, as the prolific source of being. Some years since, Durand delivered at Paris a course of lectures upon mineralogy. He affirmed, that he was able mathematically to demonstrate, that stones were endowed with sensibility. To sustain his theory, he relied chiefly upon what he called the love of matter for the sun. He gave the following as an example. Take a solution of salt. Expose the vessel which contains it in such a manner as that one half the surface shall be in the sun, and the other half in the shade. In a little time you will see superb crystals in the enlightened part, and none in the portion deprived of the sun's rays. This singular phenomenon proves, that light enters into the composition of crystals. Diamonds are only found in those portions of the world, where the intense and almost continually cloudless action of the sun imparts the degree of heat and brilliancy, which determines their peculiar crystallization. These bright gems, so eagerly sought by power and beauty, according to this theory, are a kind of consolidated light;

and the opaque elements from which they are formed, on a principle of love for the solar rays, imbibe the germ of their formation from the influence of a planet placed many millions of leagues from them. The philosopher carried his thoughts still farther. Remarking that the highest mountains are placed under the equator, he attributed their creation to the light of the sun. According to him there is there on a vast scale the same process by which crystals form in the solution of salt, and Antisana, and Chimborazo, and Himala are formed of crystallized light! If these portions of the globe had been in shade, these sublime piles had never been reared.

Whatever may be thought of the system of Durand, it has awakened a great number of new observations. The highest mountains of the globe are granite. Granite is an outline of crystal, an imperfect crystallization. If Durand reasoned justly, light a little more brilliant, heat a little more vivid, and all these mountains had been diamond. In this way a trifling experiment upon a solution of salt, indicated by chance, suggested new principles in a theory of creation, which supposes it gradually becoming a crystallization.

The supposed sensibility of nature has been the foundation of a system, still more eccentric than this. A certain class of philosophers have seriously insisted, that the earth is an animated body. The Parisian cotemporaries of Patrin will not soon forget the beautiful physiological lectures he pronounced in that capital, touching the organization of this immense animal. According to him, the gases, which incessantly circulate in his huge bosom, form metals, minerals, and vegetation, nearly as blood supplies life by circulating in the veins. I do not know, whether he ascribed thought to the vast creature. He only affirmed that it was sensitive, not as a man, but as a world.

The compound microscope shows us whole nations, as I shall hereafter have occasion to remark, constituting the delicate blue on the surface of a plum. Vinegar is seen to be peopled with a kind of huge alligators. A drop of water shows its myriads, possessing organization and life. If these animals could use microscopes, they would probably discover on each other, animals as much minuter than themselves as they are smaller than men. The tartar on human teeth is said to be an aggregation of animalculæ. Perhaps the bases of the salts, metals, and earths, are animals. The different forms, and the slow or brisk movements of component animalculæ, may give their peculiar and specific effect to medicines, in acting upon the human stomach. From the same vegetable soil, and side by side, one class of animals, mounting in the circulations of the rose, may give its brilliant colour and delicious perfume; and another, ascending the capillaries of the poppy, may impart the sleep-inspiring opium. This vast animal, the world, in this case, would be no other than a living creature made up of creatures descending from it by regular gradation to the molecules of life, that impart flavour to the nutmeg and fragrance to the rose.

LECTURE IV.

BOTANY.—BOTANICAL SENSATION.

When the sciences are taught profoundly, and in their details, it is customary to observe the strictest order. Wishing to impress you with some of the striking facts and general views of science, I shall discuss subjects only in the order in which they present themselves to my thoughts, as most likely to arouse and sustain your attention. I descend from considering the great world, to note some of the harmonies of a few of its humble and beautiful embellishments, the plants and flowers; previous to which, I request your attention to some general sketches and first principles of that charming science—botany.

This is a term derived from a Greek word, and imports the history of the vegetable kingdom. The object of this science is, to disclose the different parts of plants, to compare them, and judge of their resemblance or conformity, to be able to discriminate the points in which they differ. The number of plants embraced by botany is immense. Sherrard is said to have been acquainted with 16,000. Adanson carried the number to 20,000. Commerson boasts of having made a collection of more than 25,000. Linneus and his followers number more than 30,000. Turner, Morrison, Ray, Tournefort, Jussieu, and Linneus, are the most learned and celebrated botanical writers of the old world; and Nuttall, Bigelow, and Eliot, have gained reputation among the botanical writers of the United States.

But Linneus, a Swedish naturalist of the last century, has been placed, almost by general consent, at the head of this science. The first sketch of his *System of Nature* was published in 1735. His *Species of Plants* appeared in 1753, and most of his important works, particularly his *Philosophical Botany* and his *Genera of Plants*, about the same time. The sexual distinction of plants had been previously known; but he was the first, who made it the basis of a new system. His arrangement is confessedly artificial, though no one was more sensible of the necessity of an order, founded solely in the natural affinities of plants. Bernard de Jussieu made the first successful attempt to introduce a natural order in botany. His outline was carried to much greater perfection by Lawrence de Jussieu, his nephew. The order is founded on the number of cotyledons of the seed, on the insertion of the stamens, in respect to the pistil, whether immediately on the receptacle, the calyx, or the pistil itself, or mediately by means of the corolla similarly situated; and so on, from the essential to the non-essential, from the more important to the less important parts, in a descending progress to those that are the most variable, and of the least value.

The system of Linneus, which is generally followed, is founded upon the fructification of plants. The classes, orders, and genera, are taken entirely from this circumstance. In the greater part of plants, the parts of fructification may be readily discerned by the naked eye, or the assistance of a common microscope. Not a few are either too minute to be observed, or at least have not been discovered. Most commonly the stamens and pistils are inclosed in the same envelope, or are contiguous. In some they are contained in separate flowers, or placed at a distance from each other. The characters of the classes are taken exclusively from the stamens; those of the orders, from the stamens or pistils, most generally from the latter.

His classes amount to twenty-four. The first eleven classes, excepting the fourth and sixth, are named from their stamens by a compound of a Greek term, which signifies male, or husband, with the Greek numerals from one to twelve. I add in this place, that all these terms are formed from Greek compounds. The first class contains — 1. monandria, or flowers with one stamen; 2. diandria, of two; 3. triandria, three; 4. tetrandria, four; 5. pentandria, five; 6. hexandria, six; and so of the rest, which are heptandria, octandria, enneandria, decandria, dodecandria, with twelve stamens. 12. Icosandria, flowers about twenty, attached to the calyx, or sometimes in part to the corolla. 13. Polyandria, flowers most commonly with more than twenty; stamens attached to the receptacle. The fourteenth and fifteenth classes have always two stamens shorter than the rest. Their names are taken from the number of those which are longer, compounded with a word, implying power or dignity; as 14. didynamia, flowers with two longer stamens; 15. tetradynamia, flowers with four longer stamens. The next three classes are determined by the union of the filaments, or lower parts of the stamen, into one or more bundles or neighbourhoods. Their names are derived from a word, which imports brother, compounded with the numerals one, two, many. 16. Monadelphia, filaments united into one brotherhood. 17. Diadelphia, filaments forming two brotherhoods. 18. Polyadelphia, filaments forming more than two brotherhoods. In the nineteenth class, the anthers or superior parts of the stamen are united, and compose a hollow cylinder, through which the style of the pistil passes. It is called syngenesia, to denote the union of the parts, which possess the faculty of rendering the pistil fertile. 19. Syngenesia, anthers united. The twentieth class is called gynandria, which imports male and female. It is distinguished by the attachment of the stamens to the pistil itself; and not, as in other flowers, either to the receptacle, calyx, or corolla. 20. Gynandria, stamens on the pistil. The twenty-first and twenty-second classes, consist of plants which have the stamens and pistils in separate flowers, growing from the same or different roots. Their names are derived from a term, which imports a house, compounded with the numerals one and two. 21. Monœcia, stameniferous and pistiliferous, flowers on the same plant. 22. Diœcia, stameniferous and pistiliferous, flowers on different plants. The twenty-third class has been formed for such plants, as have some flowers with both stamens and pistils. It is called polygamia, from terms which import a diversity in the mode of connexion between the stamens and pistils. 23. Polygamia, different connexions on the same plant.

The twenty-fourth and last class, comprehends all the plants which have inconspicuous flowers, and of which the fructification is, in a great measure, unknown. It is derived from two words, which import private marriage. 24. Cryptogamia, flowers inconspicuous. The palmi form an appended class, whose fructification has not hitherto been described.

Next follow the botanical orders. The orders of the first thirteen classes are founded entirely on the number of the pistils; and are numbered, as the classes, by the Greek numerals compounded with a Greek term, importing wife, as monogynia, digynia, &c. The styles are to be counted from the base, and not from the upper part. When the styles are wanting, the number of stigmas determines the order. In the classes didynamia and tetradynamia, none of the genera have more than one style; the characters of the orders are, therefore, taken from the pericarp. The class didynamia has two orders. The first is distinguished by its naked seeds, inclosed, till ripe, in the permanent calyx, instead of a pericarp. Its name, gymnospermia, imports naked seed. The second has its seeds in a pericarp, and its name, angiospermia, imports a seed vessel. The class tetradynamia has also two orders, distinguished by the form of the pericarp; the first called siliculosa, from silicula, a little pod; the second siliquosa, importing pod. In the classes monadelphia, diadelphia, and polyadelphia, the orders are denominated from the number of the stamens, triandria, pentandria, &c. In the class syngenesia, the orders are more complex. They are six in number. The first five are distinguished by the epithet polygamia, intimating that the flowers are compound, and consist of numerous florets, or little flowers seated on a common receptacle. In the first order, polygamia æqualis, all the florets are equally possessed of stamens and pistils. In the second, polygamia, superflua, the florets of the disk, or central part of the compound flower, have both stamens and pistils Those of the ray or circumference, have only pistils; but the latter, as well as the former, produce fertile seeds. In the third, polygamia frustranea, the florets of the disk have both stamens and pistils; those of the ray, neither one nor the other, or only abortive pistils. In the fourth, polygamia necessaria, the florets of the disk have efficient stamens, but abortive pistils; those of the ray, fertile pistils, impregnated by the stamens of the disk. In the fifth, each floret has its own calyx in addition to that which surrounds the common receptacle, and forms the whole into one compound flower. The sixth differs from the rest in only having simple flowers referred to this class on account of the union of the anthers. It has been lately abolished by the general consent of botanists; and the plants formerly included in it, have been referred to the class pentandria. In the class monœcia and diœcia, the orders have the same names as the preceding classes, and are distinguished by the number of the stamens; or by the union either of the filaments, or of the anthers; or by the attachment of the stamens to the pistil. The orders of the twenty-third class, are denominated from the number of the houses or plants, on which the several kinds of flowers are found. In the order monœcia, there are some flowers with stamens and pistils; and others, that have only stamens, or only pistils on the same plant. In the order diœcia, they are perfect, and only stameniferous; and have only pistiliferous flowers on two distinct individual plants. In the order triœcia, the different kinds of flowers are distributed among three distinct individual plants. The class cryptogamia is divided into four great families. 1. Filices, or ferns. 2. Musci, or mosses. 3. Algæ, which signifies sea-weeds; but it includes several numerous terrestrial genera, which ought to constitute a distinct order. 4. Fungi. When the order to which a plant belongs is ascertained, its genus is next investigated. The genera are universally taken from some part of the fructification. They are too numerous to be given, except in a work exclusively devoted to botanical science.

The sensible qualities of plants furnish distinct characteristics. The most obvious of these are their colors, odors, and tastes. Their less obvious, but more important characters are their medicinal properties, or their utility in colouring and the arts. The most common terms of the anatomy of plants is the epidermis, or thin cuticle, which invests the whole plant. The cellular or reticular substance which appears after the epidermis is stripped off. The liber, the inner or true bark. The alburnum, a ring of imperfect wood between the liber and the true wood. The lignum, or true wood, consisting of concentric rings. The pith, a spongy substance in the centre of the plant. The medullary productions, or filaments, proceed from the pith, and cross the stem in a radiate direction, as far as the cellular substance. The medullary appendices, filaments placed between the medullary productions, and reaching no farther than the wood. The tracheæ or air vessels, the sap vessels, and the vessels which secrete the peculiar juices of the plant.

The most important parts of plants are the following. The stamen is the male organ, by which the plants are fecundated, or fructified. It is most frequently in the form of a thread surmounted by a kind of button filled with a subtle dust. The pistil is the female organ, concurring to the same result of fructification. The dust, that is the instrument of this fructification, is called pollen. The pistil has three parts. The superior part is named stigma; the middle part style, and the lower part, or receptacle of the seeds, ovary. The sexual system is one of the best established facts of natural history, and the foundation of the Linnean classification. Upon many plants, the flowers in the part, where these organs are situated, manifest sensibility. The corolla is the most apparent and striking part of the flower, and is so named from the beauty of its colors and shades. The calyx, or cup of the flower, is the extremity of the peduncle, which opens, and envelopes all the other parts of the flower.

The preceding table, if committed to memory, will enable you, with the assistance of a microscope, to botanize, aided by the invaluable advantage of being able to class whatever flowering plants you meet. It is an immense advantage, and the point in which science shows its preeminent superiority. The 30,000 plants, by this arrangement, are all classed in families and species, and, by referring to the representative head of the family, some of the more obvious characteristics of all the members are seen at a glance. No faculty of our nature so directly allies us with superior intelligences, as this of being able to generalize and classify.

Returning from a tabular view of the divisions of botany, which, I hope, its intrinsic utility will redeem in your eyes from the charge of being a tedious detail, I return to contemplate some striking vegetable phenomena. which, still more than these sexual organs, indicate something like sensibility in plants.

The naturalist Bonet pleasantly exclaimed, in a botanical discussion turning on the question of the sensibility of plants, 'It is not so easy, as you imagine, to distinguish a rose tree from a cat.' Let us contemplate some of the characteristics, which excited such extraordinary doubts. The upper surface of the leaves is slippery and varnished. It serves as a roof for the inferior surface, which is turned towards the earth, and where nature has placed a multitude of little mouths to inspire the humidity which nourishes the tree. Turn the under surface of the leaves upwards, and you will soon see the leaves commence a return movement, gently twisting, yet with a kind of effort, on their peduncle, as on a pivot. At the end of a few hours, you will find, that they have resumed their first position. The varnished surface will have become anew the roof of the leaf; and the little mouths, once more turned toward the earth, will be again inhaling the ascending moisture.

Astonished, says Aimé Martin, at these movements, which unfold a kind of sensibility, I transplanted a rose tree from one part of my garden to another, and continued to observe it. To the right of the new position the soil was dry, hard and sterile; to the left moist, rich and tender. The roots at first radiated alike to the right and left. But I soon discovered, that the roots, which had advanced to the right, bent back towards the fertile and mellow earth, as if divining, that their companions at the left had found better pasture. To prevent their intercepting nourishment, intended for other plants, I dug a ditch to prevent the further advance of the roots. Arrived at the ditch they plunged perpendicularly below its bottom, ran onward beneath it, ascended, and advanced anew towards the point, where they had discovered the rich soil. I stood astonished, and almost expected to hear my rose tree complain of my injuries. I recollected the voices, which softened the heart of Tancred in the enchanted forest, and the groans of the myrtle, which expostulated with Eneas on the shores of Thrace. Should the stately and noble trees of our country thus cry out against every rude Vandal, who cut them down without necessity, what an appalling shout would issue from our groves!

We have all remarked with surprise the habits of the vegetables deposited in our cellars through the winter months. On the return of the vernal warmth, we ventilate the cellars by removing the windows. The vegetables will throw out long and succulent shoots with the rapidity of the growth of mushrooms, and perfectly blanched. These shoots will all turn round, and radiate towards the light; and the points of the stems, upon which the smallest light falls, will become green. Turn them gently away from the windows at night, and in the morning, they will be found bent back, and again paying their homage to the sun.

The most careless inspection of plants and flowers offers numerous phenomena equally striking. Great numbers of them foresee heat, winds and rains The calendula arvensis, or field calendar, unfolds, when the sky is serene, and announces a storm by folding up its leaves. On the contrary, the Sanchus Sibiricus closes itself during the night; and gives you a presage of assurance, that the next day will be fair.

There are vegetables, which present still more striking indications of sensibility. I was one day, says Aimé Martin, sitting under the shade of those acacias, called mimosa eburnea, whose thorns are as white as ivory. On a sudden I saw the deep shade in movement, and giving place to a flickering light let in upon me. The foliage seemed at once to have withered. A dark cloud passing over head caused the phenomenon. When the cloud was past, and the sky had become serene, the foliage became reanimated, and resumed its freshness. This acacia flourishes in the burning climate of India. My first solution of the cause of the sudden withering of the leaves was, that the habit of the tree was only to give shade in the clear light of the sun; and that by a kind of foresight, it refused its shade to the earth, when it was not needed. On more exact observation I became convinced, that the foresight announced a still more admirable intention. The leaves are so tender, that when the rains fall upon them, they would be pressed down, and torn by the thorns under them, had they not this forecast to fold themselves, and to lie the one upon the other, like tiles on a roof, for mutual defence.

Other flowers are sensible to the slightest variations of the atmosphere. Each movement has its specific object, and every hour fulfils some of them. To meet this object, the flowers open, or close; and from this pleasing spectacle of the sleeping or waking of the flowers, Linneus conceived the charming idea of a clock of Flora. Claude Lorraine, the first of landscape painters, always wandering in the fields to catch the aspects of nature in all her varieties, contrived a similar clock. Long before either of these great observers, the laborers in the fields had divined the hours of the day by casting their eyes on the meadows, and noting the inexplicable harmony, which exists between a delicate flower, and those distant and majestic planets, which measure the flight of time. With these views the peasants of Auvergne and Languedoc train to the sides of their cottages a species of carlina to answer for a barometer. When the flowers open, it presages a pleasant day; when they wither it is a sure indication of approaching rain.

But some of the most important movements of vegetable nature are still more mysterious, the accomplishment of which the flower cup modestly conceals in its bosom. Nature is always modest; and yet I may not reveal to you all the secrets, which transpire, at what Linneus gallantly named 'the espousals of the plants.' One analogy of the world of animal life is preserved; and the male flowers, as the stronger and bolder sex, are drawn by the impulses of nature to pay court to the feebler and more delicate female. The male stamina, with their gaily painted hats, bow round the female pistil, as beaus about their belle. Each in turn is permitted to come in contact with the fair; and as the contact takes place, the golden pollen is shaken upon the pistil; and the stamen retires to give place to the next, that offers the same homage. The mystery of fructification is accomplished, and the flower cup is fecundated.

Nothing is more charming than this diffusion in the fructification of our maize, the most beautiful vegetation, which any country can offer. When the southwest breeze whispers, and a slight humidity inspires a voluptuous languor, in riding by these noble fields of maize, the pollen floats along the forest-spikes, like a delicious shower of aroma, with a fragrance more delightful, than ever breezed from the spicy fields of 'Araby the blest.' Then the different kinds of maize growing near each other are intermixed upon the same ear. What is called the silk of the ear conveys this pollen to the kernel and fructifies it. Where there is not a silken thread to convey the pollen to the kernel, it will be found wanting.

It is the most interesting fact of vegetable nature, that this dust, shed by the stamen upon the pistil, is a necessary condition of the fecundation of plants, in virtue of which they produce those seeds or eggs, which reproduce their kind. There are stamina, which cannot reach half the height of their beloved pistil. Nature varies her arrangements so as not to be defeated in her object. These Lilliputians strive in vain to reach their gigantic Venus. As they cannot reach her, she condescendingly comes down to them. In this way the imperial crown, the ancoly and the campanula hang down upon their stems. This position, so graceful in the flower, is a foresight of nature. The pollen of the stamen comes in contact with the stigma of the pistil, by falling upon it. As soon as the mystery is accomplished, and the flower is fecundated, the peduncle which sustains the flower, turns up again towards the sky. Its bower of love was concealed; but it shows the cradle of its children.

Whenever you see flowers, gently inclining their bells towards the turf, you may infer that the stamens which they inclose, are shorter than the pistil. There are plants, the habits of whose loves are still more amusing. They are the wedded dames, who, in compassion to their little husbands, slightly bend their elastic persons, contemplate them for a moment, and afterwards raise themselves erect, still bearing the marks of their yielding weakness. Such are the loves of the nigella, the passiflora, and the epilobium angustifolium, the pistils of which incline upon the stamina.

I know not how these inexplicable phenomena strike you. At least you will perceive, that there is some little more ground than you had first imagined for saying, that it is not so easy to distinguish a plant from an animal, as some would suppose. I have not referred to the narratives of travellers, which speak of plants that are mistaken for animals, and animals for plants; nor to the known gradation by which the two kingdoms so approach each other, as to render it impossible to say, where the one terminates and the other commences. These varied movements, in conformity to the wants of the leaves and roots, the sensibility of the stamina and the pistils, these loves and fecundations, these sleeping and waking hours confound all our reasonings. I could collect volumes, all having the same purport with these facts, which show that the hypothesis of Pythagoras, that nothing in nature is insensible, is not so absurd as at first sight most would deem it.

Cavillers may ask, why nature strews these beautiful ornaments so abundantly in the wild desert, in remote forests, on uninhabited isles, where no human footstep is impressed, where no human eye sees? I have seen the splendid nymphea nelumbo, spreading a cup of prodigious size and of the purest and most brilliant white on the surface of the pestilential lakes, in the dark and inundated forests of the Arkansas. Poisonous insects swarmed about them in countless millions. The huge moccasin snake basked upon their broad leaves, and the unwieldy alligator pursued its sports in the deep waters beneath them. Who knows, but the carrion vultures that wheel their drony flight above them, that these monsters of the fens, that these millions of insect tribes hostile to men, who live where man cannot live, take pleasure in beholding the splendid wonders of those dreary fens? If these glorious flowers have sensibility, form their unions, rear their families, and feel their solitary joys unwitnessed by man, cannot we discover new reasons for placing flowers in the desert?

LECTURE V.

INSECTS.

Might not the ancients imagine that every thing in nature was sentient, when they saw the sensitive plant shrinking from the hand that approached it? I took note, says Bonnet, of one of these plants, which seemed to form the link between the animal and vegetable kingdom. A little beyond this sensitive plant, in a kind of cup, I saw a small body like a flower. As I attempted to touch it, the thing retreated and disappeared. When I retired, it came out of its cup, and again unfolded itself. I soon discovered another similar body, but larger and not inclosed in a cup. It was taken up by a little stem, the lower extremity of which was attached to the sensitive plant. I divided the animal lengthwise, into two parts. The one, that remained attached to the plant, pushed out a form like that which I had seen entire. The little branches became agitated, and propelled their extremities to some distance. The small animal passed them, and gently touched one of their number. The branch seemed to twist itself around the insect, and raised it towards the upper extremity of its stem. An aperture enlarged itself to receive the animal. It entered into a long cavity contained in the stem. It was there dissolved, and digested before my eyes; and, a moment afterwards, I saw the residue thrown out of the same opening. This singular production detached itself from the plant, and began to creep. The little branches performed the functions of arms and afterwards of legs.

From all these circumstances, I could not fail to discover, that what I considered at first a parasitic plant, was in fact a true animal. I turned to remark the portion I had cut off. I discovered with surprise, that it had increased, and became an animal like the other.

My surprise was not diminished, when I saw these two animals transform themselves into little tufted trees. From the outside of the trunks, which had been the bodies of the animals, proceeded many branches. These branches shot forth smaller ones, which prolonged their extremities by a certain tremulous motion. The trunk remained attached to something, which supported it. This wonderful assemblage formed but a single body; and the nourishment, taken by one part, was successively communicated to all the rest. Finally, the whole assemblage decomposed itself, and each branch separated, to assume an independent and individual existence.

I repeated this operation a great number of times upon the same subject; and thus gave birth to a hydra more astonishing than that of Lerna. Divided lengthwise in the middle of the body, each became a monster with two heads. I divided many of them transversely, and placed the sections upon each other. They became engrafted, and only composed a single animal.

To this prodigy succeeded another. I turned them inside out, as we do a glove. The animal lived, grew and multiplied, as before. These animals, which multiply by budding and by scions, which may be engrafted and turned inside out, are a species of polypi. The species are exceedingly diversified. Many never change their place. Others divide spontaneously, and form beautiful bell-shaped flowers.

I have observed an analogous fact, appertaining to another branch of natural history. I had heard the fact asserted and denied, and I made the trial for myself. A long black hair from a horse's mane was left in a wooden trough, to soak in rain water, during the sultry days of August, for ten or twelve days. At the end of that time it had become white, and had acquired a protuberance at one extremity, like a head. It moved about, folded, and unfolded itself, showed sensibility when touched, and had become in fact that singular animal, of which naturalists, as far as I know, have taken no notice; but which farmers know well by the name hair-snake.

The science of insects is called *entomology;* and these animals are classed by naturalists in the eighth class of the animal kingdom. Their characteristics are, animals with a body without vertebræ, having legs with many joints, undergoing a double, and, some of them, a triple metamorphosis. They multiply by generation, and but once in their life. Their first state is that of a larva, or worm. From this, by different changes, they pass to the chrysalis state. After remaining in this condition for a length of time, conforming to the nature of their species, they undergo a transformation, which develops the perfect insect. This class is one of the most numerous, curious, and difficult to understand, of all the tribes of the animal kingdom. Linneus wrote upon entomology; but with too much diffuseness and want of method. The celebrated professor, Lamarck, has brought order to this science, and his arrangement is generally followed. It is divided into orders, sections, and genera. The orders are eight, the sections are thirteen, and the genera about a hundred and eighty. I should confound and perplex, and perhaps revolt my reader with the hard names, and numerous details, of this classification of a study which recommends itself rather to curiosity than utility. A few of the more prominent facts will show us, that providence has not passed over these singular races, some of them exquisitely beautiful, and some noxious and revolting, without impressing upon them indications of wisdom and benevolence.

What prodigies may be learned in studying the history of a swarm of bees! Who does not love to repose in the shade near their waxen realms, so deliciously aromatic, and listen to their soothing hum, as they arrive and depart in dark and streaming lines through the air? No associations can be more delightful, than those which gather round the thoughts, as the little plunderers are seen bringing home their tithes from every thing in nature that is beautiful and fragrant. They furnish the cheap wealth, medicine, and wine of the husbandman. Every rural establishment in our vast country should possess swarms of bees, established by a clear spring, a green carpet, and under the mulberry shade, for the high and innocent pleasure of beholding them, and taking care of them, were not their culture a source of sure and great profit. Mazaldi, Swammerdam, Reaumur, Schirach, Bonnet, and Huber, in some sense consecrated their lives to the study of these little governments; and they have been sung in strains of the richest music by Virgil, Delille, and Thompson.

'Young girl endowed with beauty,' said Pythagoras, 'ask of the laborious bee, if flowers have no other use than to please the senses?' The invariable order established in these little governments, the unremitting industry with which each individual labours for the public good, the grand principle of utility which regulates every movement, offer the example of a perfect commonwealth. The genius of Montesquieu invented nothing so perfect, as a model of communities. All the dreams of political reformers are here realized in a living example. A queen, respectfully surrounded by fifteen or twenty thousand of her subjects, of which she is at once the monarch and the mother, legislates for her realm, so as to produce unlimited obedience and the most perfect order. Where she advances, the circle opens with the profoundest homage. For her they store their waxen cells; and if she dies without leaving a successor, the whole nation perishes; for the subjects immediately abandon their labours in utter discouragement. Why should they not? With their mother and their queen, perishes their hope of posterity, and the book of their history is closed. The philosophers, metaphysicians, moralists, politicians, who imagine that no intelligence remains on the earth, beyond human reason, are struck with surprise.

The ancients, including the philosophic Virgil, were ignorant that the queen is the mother of her people. This is obvious from reading the beautiful fable at the close of the Georgics, in which, because flies and other insects swarm in summer round a carcase, he evidently supposes that bees may spring from such an origin. A rural French academy, filled with learned men, incorporated by letters patent, provided with microscopes and other aids, and calling themselves 'The Academy of Bees,' investigated the secret of the generation of bees to no purpose. To confound the pride and parade of human knowledge, the secret was reserved for an unlettered domestic of Huber, who was himself blind, from his youth. His name, Burneus, is perpetuated with his discovery. He was determined to learn the sex of every bee in a swarm of thirty thousand. He spent eleven days, with unexampled patience, in examining the living bees one by one. He neither took repose, nor remitted his observation for a moment, during the whole time. Braving weariness and watchfulness and the stings of the bees, he effected the discovery, and learned with certainty the secret of their generation. The drones are the males. The queen is the single mother of the community; and the working bees are neither of one sex nor the other. The sciences have had their martyrs; but never a disciple more disinterested, affectionate, and heroic, than Burneus, the domestic of Hubert, the historian of bees.

In sketching an outline of the miracles of natural history, I might show you the family of the polypi, already spoken of, multiplying under the knife that dissects them. I might present the history of the grub, which, apparently without fecundation, incessantly reproduces its kind; the spider-fly, which lays an egg as large as itself; and the rotifer returning to life, after having been dead for years. More than fourteen thousand muscles have been counted in a single caterpillar. Hook discovered fourteen thousand mirrors upon the eye of an humble bee, and thirteen thousand three hundred arteries, veins and bones, to subserve the processes of life, in a carp.

What spectacle can be more splendid, than the large and gaudy butterfly of some of the American climates, with a plumage gayer than that of the peacock, vieing with the splendor of the gayest flowers, and shining with all the varieties of prismatic brilliancy, fluttering from flower-cup to flower-cup, or what more astonishing when we call to mind its recent transformation from the loathsome larva to the revolting chrysalis, and thence to its gay and ærial existence?

The ever-verdant palm, this gaudy insect, and the unquenched taper, have been aptly selected as the emblems of resurrection and immortality.

I close these wonders among the minute and ephemeral tribes of insects, by citing the filaments of a spider's web, the production of an insect itself not one of the least astonishing prodigies of nature. The body of a spider encloses four small masses, pierced with great numbers of almost imperceptible holes, the apparatus of the insect's astonishing loom. All these filaments, to the number of many thousands for each mass, unite beyond the holes, and form the entire thread, with which the animal weaves its web. This single thread, itself so attenuated, is composed of more than four thousand filaments. Leuenhoeck observed, with a microscope, spiders of the size of a grain of sand; and that these spiders wove threads so fine, that it would require four thousand to equal the size of a hair. But since each of these threads is composed of four thousand filaments, it would require sixteen millions of the latter to equal the size of a hair. Yet the spider, in elaborating this filament, probably supposes itself engaged in a work as unique and important as the manufacturers, in a rope-walk, preparing a cable for a seventy-four

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LECTURE VI.

ATTRACTION.

The grand analogy in support of the Pythagorean doctrine, that every thing in nature is endowed with sensibility, is furnished by the Newtonian system of physics. The general law of mutual attraction is, if I may so say, the principle of life and sensibility in worlds. There is a reciprocal tendency of all the bodies in the universe towards each other, like that of iron towards the magnet. It presents itself most palpably to our senses, in the tendency of all ponderous bodies to descend. We have remarked, that this principle is called gravity. This phenomenon, in appearance so simple, enabled Newton to explain the system of the universe.

The mass of matter in the sun being beyond proportion greater than in all the planets of our system, the attraction of the whole towards it so far prevails over their reacting attraction of the sun towards them, that the latter is a comparatively small element in the calculation of the movements of the solar system. But the reaction takes place in the ratio of the mass of their matter, compared with that of the sun. This principle prevents the planets from wandering into the abysses of space. The attractions are adjusted with such a perfection of wisdom, that they roll on in unvarying harmony from age to age. Astronomy has taught their movements with such admirable precision, that we can foretell, for a century to come, all the eclipses and occultations that will take place, in regard to the planets of our system, to the period of a minute; and distances, in celestial space, can be measured with more accuracy than distances from one place to another on the earth.

The history of the great discovery of Newton, relates that, lying under an apple tree, an apple fell on his head; and that the circumstance led him to reflect on the cause of its falling. He asked himself, if the apple would not have fallen from any conceivable distance, and even the height of the moon? He was convinced, that the gravitating tendency was in the apple, let it be placed in any position, or howsoever remote. But as the moon does not fall upon our heads, he comprehended that a centrifugal impulse acted upon it, in combination with its gravitating tendency, and prevented this result. By the aid of the simplest principles of geometry, he satisfied himself that an apple, at the distance of the moon, projected into space with a swiftness equal to that of this planet, would never fall. He perceived that the terms *upwards* and *downwards* are merely relative; and that the inhabitants at our antipodes, would call that upwards, which we call downwards; and that they are in no more danger of falling downwards than we are of falling upwards.

As all the planets of our system revolve round the sun, the moon round the earth, and the satellites of the other planets round their primaries, he deduced the grand and general conclusion, that the sun, endowed with the attractive power common to all matter, by the vastly greater amount of its mass, and the consequent central attraction towards it, keeps all its dependent planets from being lost in infinite space. He saw this gravitating power filling the whole immense orbit of the sun. La Place has extended his reasonings, and has settled the action of this general law, in reference to many phenomena which Newton did little more than conjecture. Various astronomical observations have satisfied us, that this power extends to the fixed stars; nor can we doubt, that gravitation is a universal law of nature, bringing within the sphere of its harmonious rule, the whole system of systems.

'All the planets,' says Buffon, 'with their satellites, moved round by one law, compose a wheel of vast diameter, whose axle bears the whole burden; and which, revolving with such infinite rapidity, ought, according to the nature of motion, to grow warm, and to ignite to such a glow of heat and light, as to diffuse caloric and light through the whole extent of their orbit.' What great results are involved in trifling causes! But for the fall of an apple, we might have remained in ignorance of the cause of the motions of the heavenly bodies; and, like the ancient Celts, might still have been in fear that the falling heavens would crush us.

You will ask me, what sustains the suns, which belong to the immensity of worlds, that roll in space beyond our system? If there be a point where the sphere of worlds terminates, these systems, having no suns to attract them in a contrary direction, it would seem that gravity would tend to consolidate all the systems round one aggregated centre, which would form one measureless sun. Science knows not how to respond to this question. It finds the basis of a tranquil confidence in the visible and apparently immutable harmony of these distant worlds; and is able, from the known wisdom and power of the Creator, dimly to divine that a law of dimensions too vast to enter the ken of human conception controls their movements round a central point, itself the sun of the universe, and the centre of a system of systems. One hand alone could wield such a power, and one mind only comprehend the harmony.

'An undevout astronomer is mad.' No man with eyes to look upwards, and a heart to feel, can go forth under the sublime spectacle of the starry heavens, and not be filled with sentiments of awe and veneration. Those men of genius, to whom it has been given to look most profoundly into the laws of nature, have almost invariably been men deeply religious. Pascal, after acquainting himself with the circle of human sciences, deemed all knowledge comparatively valueless, in view of those higher thoughts which he directed towards heaven. The science of worlds elevated the mind of Newton to the contemplation of God. The attraction of universal love raised the spirit of Fenelon to the source of love. The study of the people in sounding the human heart, and contemplating upon death, exalted the spirit of Bossuet, the Cicero of the Christian pulpit, to the source of all power. All these great minds concurred in proclaiming, that the only worthy object of man's transient mission upon the earth is to know God in his works, and to study them with gratitude and humility. All these minds, by different routes, arrived at the same point. The sun, notwithstanding its splendor, has no voice to praise. The stars utter no sound in their everlasting courses. The roar of tempests, and the bursting of the surges on the shore of the sea, are expressions of power without intelligence. The animals that hymn the return of light, the waters welling from the mountain sides, and winding through their green forests and vales, listen not to the birds that sing among the branches, admire not the flowers that expand upon their borders. In their fall they raise no voice, articulate with love and pious confidence. Man alone animates a nature, which, without him, would have been mute in aspirations of gratitude and praise. It is in him alone that just views of nature, the fires of the sun, the eternal movement of the waves, the murmur of the forests, the still and the living voices of nature, find a scribe and an interpreter. His voice praises, his intelligence understands, his heart feels and loves. The wisdom, goodness, and power of Him, who dwells in light, and is the fountain of immortality, and whose absence is the darkness of the spirit, stand before him, confessed and unveiled.

LECTURE VII.

AFFINITY.

In process of time, as the views of the human mind became extended by observation, it was seen, not without surprise, that there was a still stronger indication in nature, that every thing is sentient, than the tendency in all matter to incorporate with all its parts, however widely separated. To imagine, that something like love was the grand connecting principle of creation, it was not necessary that the observer should listen to the plaints of the turtle in the groves, or the strains of the nightingale sitting near the parental nest; steel and the magnet, amber and straw, and the tendency of numerous substances to amalgamate into a kind of incorporation seemed to give plausibility to the hypotheses of Pythagoras.

That power, which causes certain bodies to tend to incorporate with each other, a power which seems diffused as widely as creation, we call *affinity*. It is, probably, a modification of the same power, which, when acting at great distances, sustains the worlds, and is called *attraction*. It seems a kind of material life, though a very different principle from that, which we call life in organized beings. The fossils, metals and gems, which are found in the bosom of the earth, owe their form and specific properties to affinity. To this mysterious principle of nature we are indebted for the regularity of forms and qualities in organized and animal life. From this power it results, that the seeds of every thing bring forth fruits after their kind. This affinity aggregates round the central nucleus of the seminal germ, be it the minutest molecule, a progressive pattern of the archetype. Without this principle, the basis of order and classification in science would be destroyed; and the universe would be full of monsters, before nature returned to chaos. This is clearly the cause of the phenomena of crystallization, and the intimate union of the cohesive parts of matter, which prevents our globe from dissipating into vapor and dust.

There are two forms of this affinity. The first is that, which only takes place between bodies of the same nature, and is named the attraction of aggregation. Two drops of water, and a cube of gold are aggregations. It is the union of the affinity of the molecules, forming a uniform body.

The second is that, which takes place between bodies of a different nature. This is the great principle of decomposition and recomposition. By this law nature, in her season, embellishes herself with foliage and flowers, still elaborating in progressive union the elements necessary to the matured fruits of harvest. The requisite aggregations for the finished work having been completed, the product commences, on the same principle, a tendency to decomposition; the work thus uniting, separating, crumbling and recomposing in an eternal cicrcle; and yet the whole process of results, apparently in opposition to each other, springing from one identical cause. This prodigy of affinities is incomprehensible. But it shows itself to us, as a chain of love rising insensibly from the bond of the hardest stones, united by this principle of attraction, to man, who is equally impelled by nature to unite with his kind.

These phenomena of attraction and decomposition are the chief elements of the science of chemistry. To present you all the laws which have been deduced from these would only bewilder you in a labyrinth of phrases and difficult terms. A few of the most important definitions and doctrines, that lie at the foundation of the science, follow, and are all that come within the limits of my plan.

Whatever theory we may adopt in regard to the nature of the simple, constituent monads, molecules, or atoms of matter, we cannot but perceive that matter itself is infinitely divisible, so far as those terms are applicable to any analysis or disintegration, that human art can effect. To obtain, as far as analysis may effect it, an intimate acquaintance with the nature of bodies, their affinities and mutual action on each other, is the object of chemistry. The grand agents of chemistry are the imponderable, undecomposable bodies, heat or caloric, light and electricity. The chief agent in effecting combustion is oxygen. Hydrogen with oxygen forms water. The chief acids are nitric, sulphuric, phosphoric, carbonic, boracic, fluoric, muriatic, tungstenic, arsenical and molybdenic. These belong to that class formerly called mineral acids. The vegetable acids are the acetic, oxalic, tartarous, citric, malic, gallic, mucous, benzoic, succinic, camphoric, suberic. The animal acids are the lactic, prussic, formic, bombic, sebacic, zoönic, lithic. This table only comprises the more important and generally experimented acids. The mineral acids have known and simple bases; the vegetable acids have double bases; and the animal acids triple bases. They are decomposed by combustible substances, and with metals form oxyds.

The alkalies are potash, soda, ammonia and lithina, of which the three first are known to have metallic bases.

The earths are lime, magnesia, barytes, strontites, silex, alumine, yttria, glucina, zirconia, thorina. Three or four of these have been decomposed, and been found to have metallic bases. It is probable that they are all of this character.

The malleable metals are gold, platina, palladium, silver, mercury, tin, copper, iron, lead, nickel, zinc, cadmium. The unmalleable, or brittle metals are arsenic, bismuth, selenium, tellurium, cobalt, tungsten, molybdenum, titanium, chrome, antimony, manganese, uranium, columbium, iridium, osmium, rhodium, cerium.

The acids are the simplest among saline substances, deriving their name from their sharp and sour taste. One of their most obvious properties is, to change to red the blue color of an infusion of violets, and most of the vegetable blues and purples, to form neutral salts with the alkalies, and to oxydate the metals. Their affinity is first for fixed alkali, next volatile alkali, then some of the earths, such as lime and barytes, and next to these the metals. Administered in a concentrated form, they are strong poisons, for which the remedy is the application of alkalies drunk in solution.

Alkalies are saline substances, which have a sharp, mordant taste; which when concentrated, attract the humidity of the air, convert the syrup of violets to a greenish color, unite with acids rapidly, and in most instances with effervescence; and corrode, and oxydate the metals, forming peculiar salts.

The modes of ascertaining the composition of bodies are two, *synthesis* and *analysis*. Synthesis unites two or more bodies. Analysis separates the compounds into their constituent parts. For example, forming sulphate of copper, by uniting sulphuric acid and oxyde of copper is synthesis. The separation of sulphate of copper into its constituents, copper, sulphur and oxygen, is analysis.

These processes are chiefly effected in the dry way by heat; in the moist way by liquid mixtures; and in the gaseous by distillation. The most indispensable parts of a chemical apparatus are a portable furnace, blow pipe, crucibles, anvil and mortar; distillatory apparatus, pneumatic table, retort, air pump, thermometer, barometer, calorimoter, deflagrator; furnace for the production of oxygen and other gasses, copper boiler, refrigerator, and copper gasometer. The most important mechanical agent in chemical processes is sulphuric acid.

The products of modern chemistry, which excite the greatest astonishment in unpractised observers, are the fulminating powders, such as those of silver, gold, mercury, and platina, which detonate in very small quantities, and are fixed more easily, and explode with far more powerful and destructive results than gunpowder. In the form of prussic or hydrocyanic acid, it has produced the most deadly poison yet known. In medicinal preparations, modern chemistry has wrought results of the utmost utility, delicacy, and ingenuity. It has produced more scientific compounds of the mineral medicines. It has separated the hurtful properties of opium from its specific and desired effect, giving us in morphine its benefits without its injuries. In cinchona, it has found its beneficial principle in the concentrated and beautiful form of sulphate of quinine, and has effected more perfect, intelligent, and exact formulas in the decomposition and recomposition of the whole class of medicinal compounds. In the arts, in colouring, in bleaching, in making porcelain, in preparing and applying oxydes and acids, in bleacheries, and in glass manufactories, it would utterly transcend my limits to enter into a specification of the details of its advancement and utility. The great changes in the face of society from modern improvement, may be probably traced more directly to the prodigious advancement of modern chemistry, than to that of any other science.

But, wonderful as have been the attainments of human invention and ingenuity in this science, they fade into obscurity when compared with the inimitable results of the great chemical laboratory of nature. What wonderful delicacy, what gigantic power in these operations! Of the latter, earthquakes, volcanoes, and thunder-storms, furnish us terrific specimens. Of the former, see the same leaf, by the tendency of a different affinity, take the form of an unctuous milk in the elaboration of kine, of warm and fine wool upon the back of the sheep, and of a brilliant silk in the body of the silk worm, which, of this beautiful material, forms its own tomb.

The same plant changes its properties by changing its climate. The dog's tooth, panicum dactylum, grows in all countries. Goats browse upon it in Europe and America, the same as in the plains of Angora. But it is only the goats of that region, that, by some modifying process of animalization, change this food to that fine fleece from which the Turks fabricate their magnificent stuffs. This peculiarity of the fleece is due, without doubt, to the long and silken grass of that species, which those plains produce. Nature puts forth no ostentation of apparatus, riches, or prodigality. Simple, skilful, not desiring display to diversify her works, she only varies her affinities.

To become impressed with the effect of varying these affinities, imagine two invisible gases — the one is inflammable in itself, the other aids inflammation by supplying one of its elements. These two gases are united, and have not only lost their separate properties, but become a visible fluid which extinguishes fire. The composition is water.

Sulphuric acid and caustic potash, taken separately, act as violent poisons which occasion death. United they form a salt almost neutral in its effects, and possessing only a slight bitterness to the taste.

There is another universal law, apparently the exact reverse of affiuity which incessantly tends to separate those bodies, which that principle holds together. The cause of it is a subtle element diffused through the universe, which is called caloric; but by a seemingly inexplicable mystery, both principles appear to proceed from the same body, the sun. It is the great central point of attraction; its rays at the same time falling on bodies, incessantly tend to separate and disperse them.

One of the effects of attraction brings the molecules of water into closer union, and in this way consolidates it into ice. The sunbeams fall on this crystallized water; the molecules expand, and it becomes a fluid again. Increase the heat to another point, the molecules separate still further, and become an elastic vapour, which, in the form of steam, has been guided by human intelligence to the most astonishing results. A little further rarefied, it becomes invisible vapour, and is blended with the whole mass of the atmosphere. I wish you here to reflect, in passing upon the admirable harmony which exists between these three states of water, and the wants of the earth. It is one of the many phenomena, that most strikingly unfold the divine intelligence. If water had not this property of being volatilized and of ascending to the higher regions of the air, what power would have been sufficient to draw up from the bosom of the ocean, and to transport to the remotest interior of continents a sufficient supply of moisture, which, when condensed in the higher regions of the air, and on the cold summits of mountains, returns in springs, streams, and rivers, spreading verdure and fertility in its meandering course to the sea, whence it sprung?

The sun being the parent-source of these two great vivifying powers of nature, the one of which decomposes and the other recomposes, you can readily see why these processes are slow and almost extinct in the wintry regions of the polar circle. The frozen earth allows little movement to the molecules of bodies, and feebly tends to the germination of foliage, flowers, and harvest. Yet as soon as some cheering rays of the sun fall upon these funereal regions, nature awakes from her lethargy; the affinities resume their power. Animal and vegetable organized life makes a rapid effort at development, soon to sink again under the icy influence of winter.

LECTURE VIII.

STARRY HEAVENS. RIVERS. ANIMAL HARMONIES.

I go forth in the silent and meditative hour of evening, under the cerulean, star-spangled dome of the firmament. These numberless stars, this multitude of movements, these radiant orbs, this earth of our habitation carried round in space, like a frail vessel borne upon the ocean, penetrate my mind with profound astonishment. I attempt to scan the grandeur and power of Him, who has placed us in presence of such magnificent spectacles. I contemplate the motion of worlds compared with that of the humblest insect; the planets which circulate in the void without ever deviating from their path; animals moving in their appointed spheres from an interior impulse; and man, whose thought, more astonishing still, transcends the limits of time and space, without the accompaniment of the body which it animates; the two motions of the earth, the one on its axis, the other round the sun; and they are all radiant with the wonderful impress of the Creator's beneficent intelligence. One of the earth's compound movements is inexplicable upon any of the known laws of physics. Attraction causes bodies to tend towards a centre, but gives them no impulse of motion. Who can fail to admire the exact equilibrium of these motions and the wants of man and nature! The earth inclining on its axis, presents in turn its two hemispheres to the sun causing us the grateful alternations of day and night; while the other motion presents us with the varied aspects and delightful vicissitudes of the seasons.

It is another harmony of the motions of the earth, that while we are carried round with it with the greatest absolute rapidity, we should have the sensation of being at rest. The atmosphere, and every relative landmark by which we could measure, and be made to perceive this motion, are carried round with us, and we have a consciousness that we have not changed our place. We have familiar examples of the deceptive character of this motion. The fisherman, abandoning himself in his boat to the stream, borne down by the current, sees the shores apparently ascend, and seems himself at rest. The spectator on the shore measures the progress of the boat by the trees, and discovers its true and absolute motion. To us the sun and planets seem to advance from the eastern to the western horizon. A person who could contemplate this motion from a fixed point in the heavens, would see the true and absolute motion to be that of the earth advancing rapidly from west to east.

A beautiful harmony of the universe, resulting from this illusive appearance of relative motion, compared with absolute rest, must not be overlooked. While movement and repose, darkness and light, the changes of the seasons, and the march of the stars, which diversify the decorations of the world, seem to result from real change of place, they are successive only in appearance, and in reality are permanent. The scene, which is effaced from our view, is repainted for another people. It is not the spectator, but only the spectacle, that has changed. The author of nature has seen fit to unite the absolute and relative progress of succession, as well as motion in his beautiful work of creation. The one is placed in time, the other in space. By the one the beauties of the universe are perpetual, infinite, always the same. By the other they are multiplied, finished, and renewed. Without the one, there would be no grandeur in creation. Without the other, it would have been all monotony. In this way, time presents itself to view in a new relation. The least of its fractions becomes a complete whole, which comprehends every event and modifies every change from the death of an insect to the birth of a world. Every moment is in itself a little eternity. Bring together, then, in thought, the most beautiful accidents of nature. Suppose you see at the same moment all the hours of the day, and all the aspects of the seasons, a morning of spring, and a morning of autumn, a burning noon of summer, and a noon of frosts and snows, a night bespangled with stars, and a night of darkness and clouds, meadows enamelled with flowers, and forests robbed of their foliage by winter and storm, plains covered with springing corn and gilded with harvests, you will then have a just idea of the aspects of the universe at the same moment to different spectators.

It is an astonishing fact, that while you admire the sun sinking under the arches of the west, another observer beholds him springing from the regions of the morning. By a wonderful arrangement of the Creator, this ancient and unwearied luminary that reposes from the heat and dust of the day behind his golden canopy in the west, is the same youthful planet that awakes, humid with dew, from behind the whitening curtains of the dawn. At every moment of the day, to some of our fellow-beings the sun is rising, blazing in the zenith, or sinking behind the western wave. Our senses present us this charming illusion. To a spectator, beholding from a fixed point in space, there would be neither east, meridian, nor west; but the sun would blaze motionless from his dome.

Let us imagine the view of the spectacle, if the laws of nature were abandoned to the slightest change. The clouds, obeying the laws of gravity, would fall perpendicularly on the earth; or would ascend beyond condensation into the upper regions of the air. At one period, the air would become too gross, and at the next too much rarefied for the organs of respiration. The moon, too near, or too distant from us, would be at one time invisible, and at another would show herself bloody and covered with enormous spots, or filling with her extended orb all the celestial dome. As if possessed of some wild caprice, she would either move upon the line of the ecliptic; or, changing her sides, would at length discover to us a face which the earth has not seen.. The stars, smitten with the same uncertainty of motion, would rush together, and become a collection of terrific conjunctions. On a sudden, the constellation of summer would be destroyed by that of winter. Boötes would lead the Pleiades, and the Lion would roar in Aquarius. Here the stars would fly away with the rapidity of lightning; there they would hang motionless in the heavens. Sometimes crowding into groups, they would form a new milky way. Again disappearing altogether and rending the curtain of worlds, they would open to view the abysses of eternity. Reason as we will upon the inherent laws of nature, second causes are not sufficient to explain all the phenomena. There must be a perpetual and omnipotent vigilance always sustaining these laws in their equilibrium. God would need no other effort to destroy the great work than to abandon it to itself. Our confidence that these laws will never change, must rest upon our conviction of the immutability of his character.

The first law of motion is, that a body being at rest, except moved by extrinsic impulse, will always remain so.

Cavillers have objected to this law, a weight suspended by a thread. Cut the thread at the point of suspension, and, though no motion is communicated, the weight falls. This is in fact no other than applying the impulse of gravity. The second law is, that a body put in motion, unless arrested by an extrinsic force, will always continue its motion in the line of the direction. It is true, that a ball impelled along a billiard-board, soon loses its impulse and returns to a state of rest. But the friction of the ball upon the board, and the resistance of the air are extrinsic causes of its abatement of motion and final rest. These removed, and motion once communicated to the ball, it would preserve the same swiftness and the same direction forever.

Let us note some of the benefits which accrue to our world from these two laws of motion. The basin of the seas has been disposed in the lower parts of the globe, that all the streams might glide down to it by a gentle and regulated inclination. The streams of fresh water receive this motion, not only to embellish and irrigate the regions through which they flow, but to preserve, by their motion, the purity which stagnant fresh waters would soon lose. Sleeping without motion, they would have borne miasm and death to all the habitations of men. A more rapid declivity of descent from the hills to the sea would have carried the earth before the waters, marking their course with desolation and ruin. They now murmur gently over their pebbles, dispensing health, irrigation, verdure, and plenty in their course.

The poet will not fail to tell you that these irrigated meadows and groves, need still another charm in addition to their verdure and freshness. They have that charm; for it is in these places that Providence has dispensed that fertility that attracts inhabitants. Here are the cottages of peace and privacy, shaded with trees, covered with honey-suckle, and tenanted by healthful and laborious cultivators of the earth. Here are born the children of industry and innocence, to sing the morning and evening hymn of praise, and sigh for no feverish pleasures and costly shows of cities;

but to offer to the Divinity a constant sacrifice of labour, contentment, and obedience, to the laws of Nature.

Let us contemplate some of the phenomena of motion in respect to animals. The immovable plant is obliged to wait for the refreshment of the dew of evening; but the stag bounds to quench his thirst in the spring fountain. What an apparatus is requisite to perform this single action for this one animal! Eyes to point out the position of the fountain; feet to bear it thither; muscles to give them motion; a will to animate the muscles, and an appetite to move the will.

Another fact worthy of remark is, that the animals to which nature has not given arms for defence, are endowed with an extreme fleetness, as the hare, wild goat, chamois, and camel; while the animals strongly armed, as the bull, elephant, rhinoceros, and hippopotamus are endowed with a motion naturally slow and grave. Reptiles, the bodies of which are composed of muscles and moveable rings, need neither legs nor wings, because they find their habitation and nourishment in the first hillock. Yet it is wonderful to see with what ease and rapidity, in their serpentine gyrations, they move onward.

Long legs are essential to birds that inhabit the muddy borders of marshes. In consequence, the crane, stork, ibis, and the numerous class of the smaller marsh-dwellers, have their bodies balanced on a kind of stilts.

We may add, that the feet of animals are proportioned to their size, habits, and movements. The prodigious weight of the elephant is supported upon strong columns; while the stag, wild goat, and Peruvian sheep, are provided with legs at once muscular and slender, which seem formed purposely for agility. The feet of animals that live much in the water, as the otter, beaver, swan, goose, and duck, are provided with a membrane capable of expansion and contraction, which they can manage like an oar. The mole that is compelled to dig, is provided with a pair of hands, formed for that purpose. The elk, that bounds over the snow, has inflexible legs, and preserves his straight-forward course over the most slippery surface, by which means he escapes his fatal enemy, the wolf. The cloven foot of the goat aids it to climb the steep rocks. The large, callous, and cushion-formed feet of the camel are peculiarly adapted to the moving sands of arid deserts. It makes a step in proportion to its size, but half as far as other animals; while its long legs enable it to advance over as much space. Its great neck at the same time, raised perpendicularly, places its head above the waves of sand. Its eyes, defended by fleshy eyelids, bristled with bearded hairs, and half closed, point out its route from afar, along the scorched plains, amidst clouds of sand that obscure the air. These advantages procure the camel a sure and an easy march along a country, where other animals move with slow and painful steps, and soon perish. The camel is the ship of the sandy deserts, without which man would not have crossed them. The feet of animals have a structure universally arranged to their pursuits, and the countries they inhabit. Mollien, travelling in central Africa, relates his having noted with astonishment that the ass, so sure-footed in European countries, stumbled and fell almost at every step, sometimes along the muddy marshes, sometimes over the arid rocks, where, however, he recognized fresh foot-prints of the hippopotamus. But these huge and ponderous animals have feet covered, as it were, with four shoes provided with thick soles, and tread lightly and securely upon a soil, for which the structure of the foot of the ass has not been fitted. He remarked at the same time, that this hardy animal of almost all climates was unknown in that country.

In regard to the means of defence and annoyance with which animals are provided, the same wonderful adaptation to their wants and modes of subsistence is apparent. 'The bull,' says Anacreon, 'has his horns, the horse his powerful feet, the lion his terrible teeth, the timid stag swiftness; the fishes fly through their liquid element by fins; and the birds gaily cut the air with wings; to man wisdom was imparted; and to frail woman, at first view left unprotected, beauty; with which experience demonstrates she is more strongly armed than with the lion's fangs or the warrior's steel.'

Let us note the same wise provision for the insects. When the taupin, *elater*, is turned upon its back, it avails itself of a spring in its breast, and like a skilful leaper, by a kind of vault comes back upon its feet. The butterfly escapes the flight of birds by a course more zigzag than their swiftness will permit them. The spider escapes the pursuit of an enemy by spinning a long filament, and dropping down upon it as a sailor slides down his cable. The hemerobe covers all its body with sandy atoms, and floats upon the water, in appearance a piece of rotten wood. In the evening it becomes a fly, and puts forth a pair of brilliant wings. It is beautiful to see the gyrin describe circles so rapidly that the eye can scarcely trace them on the unruffled crystal; and the tipuli execute their fleet and mazy dances beside them without wetting their feet in the water.

If we note the structure and habits of fishes, we shall be struck with their adaptation to their native element. Beside the wonderful power they possess in their fins, nature has furnished them with a vesicle, or bladder, which they can expand or contract at will. Diminishing or enlarging the volume of their body in this way at their choice, they mount or sink according to their wish. Others flit through their pellucid element by first bending themselves like a bow, and then impetuously unbending themselves, they receive an impulse like an arrow. The zoöphytes have an appropriate way of advancing, by moving their muscles in a way that can scarcely be described. The holoturiæ dart out a quantity of water enclosed in their stomachs, with force, and by means of this reacting pump are strongly impelled backwards. I ought not to forget that most of the fish are provided, like birds, with an oily gland, which varnishes their scales and defends them from the relaxing effect of the water, and at the same time, by lubricating their bodies, facilitates their movement through the waters. The most surprising part of the fact is, that this gland is so arranged in their head that the act of swimming smears their bodies with the oil by the natural power of the water. But for this admirable contrivance, the fish having neither feet nor hands to squeeze it from the secreting vessel and spread it over their bodies, the provision would have been useless.

I shall hereafter recount other adaptations in the animal kingdom of a similar character; but I intend here to sketch only a few of the prominent facts touching the harmonies of nature. These few may serve as certain indexes of the whole. The details, besides filling many folios, would confound your memory. I hope to present you with a sufficient number, to convince you that from the worlds that roll in space, to the insect that moves by the play of its muscles, every adaptation of the worlds, or the insects, has a specific object, and bears the impress of intelligence and goodness.

LECTURE IX.

SELF-PRESERVATION, DEFENCE, &c.

Let us cast a glance upon the different beings that people the earth. To render sketches of the history of the most diminutive of them interesting in your view, I need only inform you that such men as Fontaine, Reaumur, Buffon, and Bonnet, have been their historians. Instinctive forecast, ingenious management, wonderful stratagem, and invincible parental tenderness, preserve their races and guide and defend them with as much certainty, as the laws of the heavenly bodies preserve the unvarying harmony of their movement through infinite space. The strong and sanguinary races do not destroy those that are feeble and defenceless. Such a perfect equilibrium reigns in nature, that nothing is destroyed. The most imperceptible insect has received such means of defence as to be able, either to combat or evade all its enemies. The lion, that conceals himself in the bushes, where he lies in wait for the timid gazelle, which flees him with the fleetness of the wind, is not able to provide himself more amply with prey than the spider, which spreads its web as a net for gnats and flies. Are the arms of the wild boar more dangerous than those of the wasp and musquito? Does the kangaroo, with its prodigious leaps, better escape its enemies than grasshoppers, whose spring is like an arrow darted from a bow? A beetle and May-bug, in proportion to their size, are six times more robust than a horse. Linneus says, that if an elephant were as strong in proportion to his bulk as a horn-beetle, he would be able to uproot the largest trees and overturn mountains.

The ocean is full of its countless millions, all miracles in their way, and according to their kind. Examine the torpedoes and electric eels, which, though in appearance abandoned in defencelessness, are in fact armed with a galvanic pile, and deliver themselves from their voracious enemies by palsying them with a thunder-stroke. Whole shoals of fish spring out of the water, and sustain themselves in the air, to avoid the pursuit of the gilthead. The swift argonauts embark their elegant shells upon the waves, and sail in little fleets over the solitudes of the ocean. When they divine the approach of a storm, they submerge themselves to the bottom of the sea, and reappear only on the return of fine weather. The cuttle-fish, when pursued, emits a black ink, which forms a dense cloud in the water, in which it hides itself and escapes in the obscurity. The doripes has received two paws longer than the other two, which it reaches up to sustain two sponges on its head. Concealed between them, it sinks unharmed to the bottom of the sea; while the hermit-fish seats itself in an empty shell, like Diogenes in his tub; and the little crabs squat themselves in their bivalve shells, and, tenants in common with the blind mollusci, stand in advance, as sentinels to warn the others of their danger.

The habits and stratagems of the animals that live upon the earth, are not less interesting. We cannot but be struck with the extreme nimbleness of the lynx, the flight of the galeopithæ and the laganus, the horns with which nature has armed the forehead of a multitude of animals, the thorny coat of mail with which others are clad, and the scales with which almost all insects are defended.

The time would fail were I to present the habits of those families which pursue their spoil by night, and roll themselves up indolently in their burrows by day; of the porcupine and hedge-hog family, which dart their sharp and barbed quills at their enemies; of the dormouse and rat family, which rear themselves on their hind paws, and clean their whiskers with their claws; of the beavers, which, in building their habitations, show themselves perfectly acquainted with hydraulics, mechanics, and architecture; of the prairie dogs, which settle in a town of contiguous burrows, to which they render the access formidable by taking in a ground rattlesnake as a tenant in common, with which they consort in an established compact. As a still further security, they always keep sentinels at the entrance of their community, which by their barking warn the town of the approach of strangers. The crows of our forests, the most sagacious of plunderers, never invade a field of grain without stationing spies on the fences, at whose ominous note the marauding army rises with hoarse cries into the air. The gray-squirrel, in crossing our wide rivers, selects a piece of bark on the shore, of a form favourable for sailing, on which it embarks, erecting its tufted tail for a sail, which it veers with admirable precision to the wind.

A proof of the preservative arrangement of Providence is presented in the fact, that although war has existed between the different races of animals from the beginning, the equilibrium among them still exists. The harmless tribes increase much more rapidly than the animals of prey. Their greater number so distracts the pursuit of their enemies, that a part is always in an asylum. They find their food, which is diffused every where, without difficulty, and enjoy it without combats. The animals of prey, on the contrary, rarely banquet on their bloody feasts, but spend their time in guilty terror and apprehension, crouching in ambush for carnage.

For the preservation of the weak and harmless against the prowlers that thirst for blood, Providence has provided them with other arms than swiftness and stratagem. It is the instinct of parental love. In fact, this law acts with greater or less force upon the whole living universe. The cruel eagle, the pitiless vulture, are as much attached to their young as the sparrow and the linnet. The insect lost among the grains of dust, has the same maternal foresight as the elephant, for the young of its family. We cannot note without admiration, that the teats of the latter animal are placed near its breast, because it is obliged to suck its own milk with its trunk, and empty it from that into the mouth of its young.

Enter the groves, and contemplate the multitude of insects and animals that circulate under the vaults of verdure. Some are established on the borders of streams, with which their habits and necessities will be found to have a particular sympathy. Others find a world in some little particles of turf. All exercise an appropriate industry, and are endowed with peculiar instincts, which may be easily discovered to have relation to their individual modes of life. Armed with long augers, saws, rasps, pincers, they animate their little labours by an art peculiar to themselves. The wolf-spider, for example, surrounds its eggs with a silk of the most delicate texture, that it may carry them with it in its travels with safety. The tipula lays its eggs in the branches of the juniper, having previously bored out a nest with its sting, as a place of deposit. Scarce has the psylla placed its eggs on the leaf of the Veronica before the leaves of that plant fold over them, and surround them like a cradle. Contemplate that worm, so repulsive in appearance, which its mother seems to have abandoned. It moves on, devouring leaves and flowers before it. On a sudden it stops, apparently arrested in its course. It envelopes itself in a tissue of silk, and buries itself alive. But a mystery is yet to be accomplished. On a sudden, its tomb is rent. A superb butterfly emerges. With its loathsome form; its devouring teeth are laid aside; for, destined to rise from a crawling insect to the condition of an ærial existence, it henceforward feeds on honey and drinks aromatic dew, by a trunk fitted to extract its sustenance from the cup of flowers. The most feeble and timid animals become courageous at the time of rearing their young. The hen bravely defends her chickens from the birds of prey. The fearful deer assaults that enemy with fury, which approaches the copse where her young are deposited. The kanguroos, manicous, and oppossums, have on the under-side of their bodies, a membranous bag, or pocket, in which the young take refuge in time of danger, and with which the mothers fly to the covert of the forests. The squirrels build their nests on the most inaccessible part of high trees, roofing them warmly with leaves and moss. The mother of young apes carries them in her arms, caresses them, gives them the breast, plays with them, corrects them for bad manners, and gives applause when they show marks of reformation. The oriole darts fiercely in the face of those that carry off her hanging nest; and the mother, taken with it, has been known to persevere in covering her eggs until she died in the effort. The maternal affection of these little beings, which raises them above the fear of death, has an impress of grandeur which creates the feeling of the sublime.

Equally admirable is the industry and art, which the birds put forth in the construction of their nests. Preparatory to this, we notice one of the most beautiful and truly poetical passages of the whole history of nature. It is the return of the birds from foreign climes to the groves, where they reared their young of the past year. Nature has prepared for their return, by decking the groves with verdure and flowers, and warning them that all is ready, in the whispers of the southern breeze. Then they are seen making glad the forsaken bowers of their former loves and joys, by songs of congratulation and joy. With the notes of their loves, they resume their great work of preparing for another generation. To whose heart have not these notes of gladness made their way? Who has not inquired, over what seas and mountains they have returned, by the unerring guidance of instinct, to the very forests where they established their families of the former year?

It is wonderful to see the conformity of the construction of their nests to their instincts and wants. Those that build in humid places in the midst of reeds, line the bottom of their nests with down from their own breasts. The tadornæ place their eggs in a kind of burrow, which they dig like a rabbit. The bulfinch takes care to make the opening of her nest on the side least exposed to storm and rain. The loxia, or Phillipine sparrow, rolls its nest in a sort of spiral, and suspends it from a branch over still waters, to put it out of danger from reptiles. The hanging sparrow pursues a nearly similar plan; and we often see five or six of these nests on a single tree, like an ærial city. The sewer-bird has the address to sew a leaf detached from its stem to another, placed at the extremity of the branch, in this manner forming a kind of cradle, in which it deposits its tender young.

There are few spectacles of this sort more admirable than one which I have often witnessed. The bank-swallows of the Ohio and Mississippi valley scoop hundreds of little circular chambers from the hard and chalky banks of the rivers, always so chosen as that portions of rock, or of the solid bank, jut over their little municipal establishment, and defend it from rains and storms as a roof. Such are their social instincts, that, where circumstances admit, they seem to prefer attaching their habitations to those of men. I have noted two of these cities. In one, they were sheltered under the protecting roof of a naturalist, who cherished them. In another, they were settled on the south wall of an arsenal, and have continued to return to that place for a great number of years in succession. While recently surveying one, which contained some hundreds of habitations, I was informed that they had reared the greater part of this city in a single day; and it could not have contained less than as many hundred pounds of clay as there were families, all cemented firmly to the brick wall. The habitations were built in parallel curves, leaving streets between them. Nothing could exceed the neatness and exactness of the arch that was turned over them. They darted backwards and forwards into a hole, that seemed scarcely large enough to admit their bodies, with the rapidity of lightning. Each one invariably entered its own home, and all seemed quietness and peace.

What I most admired was, that under the shed of the naturalist, conscious that they needed no protection from rain, none of their habitations were provided with arches; while on the naked and unsheltered wall of the arsenal, each one was so secured. Unhappily, instinct, as well as reason, is sometimes at fault. The last time I saw this city of swallows was after a great southern rain; for which, being at that season unusual, they seemed not to have been prepared. The clay had been softened, and whole portions of their city inundated and washed down. Hundreds of the young perished; and their parents, as they darted backward and forward over the ruins, uttered a sharp note of wailing, like the survivors of an inundated city.

Scarcely are the nests completed, when the females begin to lay. These little beings, before so flighty, inconstant, and vivid, become staid and faithful to their new charge. The females sing not; for in doing it, they would indicate the locality of their nests, and attract pursuit. But the male places himself on a neighbouring tree, too far from his mate to expose her to danger by his song; and there he soothes her maternal constancy with the sweetest symphony which his organs can utter. With two more facts I shall close these sketches of the preservative laws of animal instinct, abounding with details to an interminable extent.

Maternal tenderness having accomplished its first object, the beak of the young chick, enclosed in the hard shell, now warmed to life, is found armed with a bony point, which it uses, as a pick-axe, to break through the walls of its prison. Soon after the unfledged little animal has emerged to the light, this bony protuberance disappears.

Maternal tenderness, the preserving principle of the living universe, would have been unavailing without the impulsive instinct of love. As soon as the vernal restoration of nature is accomplished, the flower expands its beautiful and aromatic cup in a splendor to which the glory of Solomon was not to be compared. From the stamen it is fructified. The flower, having enjoyed its short hour of beauty and love, withers, and dies. At the same time the peacock spreads his proud plumage to the sun, and displays his splendor of gold and diamonds. All the wood warblers put on their green, scarlet, and gold, the one color fading into the other with a downy softness, a changeable brilliancy, a richness, tempered with a delicacy which nature alone can lay on. Joy, pride, exultation, and love, show in every movement. They are wooing their loved ones in the branches; and their song, if we could interpret it, would be felt to possess all the poetry, ardor, and persuasion of love. But, as soon as the brief vernal hour of delight has past away, the purple, green, and gold fade. The peacock no longer expands his dazzling plumage. The bird of paradise loses its crest. The splendid combatants for their rival loves lay aside their collarette and their fierceness at the same time. They become sad and mute. The nightingale, instead of harmonious concerts, utters a croaking and plaintive note.

LECTURE X.

ELECTRICITY.

I SHALL now give you a brief introduction to the study of the natural philosopher. We will look at his instruments. With some he surveys the stars. With others he determines the weight of worlds. With some he extracts fire from the air, and with others from the water. He kindles his furnaces. From gold he produces you a fulminating powder, which kindles into a conflagration without fire, and explodes with far more noise and force than gunpowder. With silver he prepares a powder still more destructive and terrible. In his hollow glass globes, he creates a great number of invisible gases. Some burn, and others extinguish fire. One produces water. The slightest quantity of the third inflicts death. While he speaks to you, his hairs rise and bristle. He touches a tube of copper, and he is covered with brilliant sparks, and rays of light crown his head.

'Give me a lever and a pivot,' said Archimedes, 'and I will move the world.' 'Give me matter and motion,' said Descartes, 'and I will make a world.'

With his magic lantern, the philosopher evokes shadows and spectres, invested with their sepulchral horrors. With phosphorus, he traces upon a tombstone a writing like that which the horror-struck Babylonish king saw inscribed on the wall in the midst of his high festival. By means of the burning mirror, he verifies all the reported prodigies said to have been wrought by Archimedes, and so long deemed incredible. Following the indications of Pherecides, he deems that he can foretell an earthquake. More daring than the famed Dædalus, soaring on his waxen pinions, with his balloon, he sails into the upper regions. Among catacombs and ruins, one genius has been found capable of decyphering the hieroglyphics and the mysteries of the Egyptian priests. Most of those arts, believed in ancient time, and, until very recently, by the moderns supposed to be wrought by magic, are now the trite and easy sports of the chemist and philosopher.

The Greek fire was discovered in the seventh century by Callinicus, a Greek engineer, and was lost from that time to the reign of Louis fifteenth of France. It was then discovered anew by Dupré. This terrible fire has also been prepared by Sir Humphrey Davy. Thenard composed it of charcoal, iron, and calcined potash. By the reunion of the iron and potash, a hydrate of potash is produced. The result is a black mass, very inflammable, which kindles as soon as wet. The historians of the early Turkish wars are eloquent in describing the dismay and ruin produced among the Christian crusaders, when the Turks cast this terrible fire into their fleet. Louis, the beloved, refused to avail himself of this terrific element.

Man upon a world of dust, to which in a short time he returns, measures the immensity of the heavens, and declares the size, swiftness, and distance of the stars. Interrogate him, touching the structure and vegetation of a blade of grass, and he is silent. You see him amusing himself with the magnet, with one end attracting needles and with the other repelling them. He delights his young family, by placing before them a number of beautiful waxen ducks in a large vessel of water. He seems to be able to impart life to them. He bids them swim from one side of the vessel to the other, and by a concealed movement of his hand, in which he holds a magnet, they appear to understand and obey his voice. He holds bread to them on one side of the vessel. A magnet is enclosed in the bread. The birds immediately swim to the side of the vessel, as if to devour the bread. To you, who comprehend the fact of magnetic action, this sport, which seems magic to the uninformed, appears puerile. To confound this pride of intellect, I ask you the cause of this action? You are silent. Yet this inexplicable power is the star of navigation, and was the key that unlocked the American hemisphere.

A little amber indicated the laws of the inexplicable phenomena of electricity, and taught that an iron rod would conduct lightning harmless to the ground. A few particles of vitrified sand form both a microscope, which enables us to discover myriads of inhabitants in a drop of water, and a telescope, by which we discover thousands of worlds in the depths of celestial space. The sea, which seemed to the ancients shoreless and illimitable, has become to us a short and measured highway. Hence the mechanic arts, which subserve our wants, supply our comforts, and embellish our abodes; and the abstract sciences, which supply the power of thought with food. With the simple elements of cyphers, lines, circles, and triangles, our engineers operate miracles in the construction of great public works, like the fabled results of the contests of the demigods, heaping Pelion upon Ossa. With a composition of black powder, cliffs are exploded, walls overthrown, and a new character given to the destructive art of war. The power of steam has been rendered capable of performing the labours of millions of hands, and of driving thousands of vessels against wind, current, and tide.

As electricity is one of the most surprising, inexplicable, and universal powers of nature, I shall here present you some of the phenomena and laws of this fluid in an abstract and tabular form.

I shall assume that you understand the materials and form of an electrical machine, and that electric sparks are produced by friction, created by the rapid turning of this machine. The raising of sparks creates a phosphoric odor. The sparks are drawn out by steel applied near the surface of the machine. If the sparks are received upon the finger, a tingling sensation is produced. The light, which renders these sparks visible, is probably air heated to incandescence, by the compression, which the rapid passing of the fluid through it, occasions. Light bodies are attracted towards the machine, such as pith, cotton, cork, and the like; until they have become saturated with electricity, when they are repelled from the machine. Glass and resinous substances, when rendered electric by friction, strongly retain the electric matter on their surface; which, when extracted by applying the hand to it, is only drawn off at the point where the hand is applied. But if that part of the electric apparatus, called the conductor, communicate with the earth, or the foot of the machine by a brass chain, no electricity can be accumulated on the plate by turning the machine. The reason is obvious. Metals conduct the fluid freely, and the glass does not. Hence we see, why the conductor must be supported on glass columns.

Glass and metals are not the only bodies which exhibit these opposite electrical properties. All substances in nature are divided into the class of conducting or non-conducting substances. Vitrified substances, earths, metallic oxydes, sulphur, air, crystals, silk, wool, hair, feathers, the resins, and oils, are non-conductors. The most obvious conducting bodies are the metals, water, coal, living animals, and vegetables.

To insulate a body is to place it upon a non-conductor. Electrified bodies attract those which are not electrified. Bodies possessing the same electricity repel each other. An electrometer is an instrument to measure the intensity of the electricity. The most simple is a thread, with a small ball of cork or pith attached to each extremity. Suspend them in contact over the conductor. As soon as they are electrified, they diverge; and their distance from each other measures the intensity of the electricity.

The conducting power of bodies does not depend solely on their nature, but is modified by their form. Large and round bodies conduct much less than sharp and pointed bodies: To show the flow of electricity from a conductor, a little instrument, turning on a pivot, called an electric mill, is used. When the machine is put in motion, the sharp points of this instrument receive the electric action, and turn the wheel with a rapid motion. A man, standing on a stool with glass legs, becomes electrified; but experiences no new sensation in consequence. But his hair stands erect, and the finger of another person pointed near him, draws a spark from him, which is sensible to the one who parts with it, as well as him who receives it.

The accumulation of electricity on a connected surface is shown by an apparatus, called the Leyden jar, which is a glass jar coated with tin-foil, and covered at the top with sealing wax prepared for the purpose. The interior coating of this jar is charged, by connecting it with a wire to the conductor. Several of these jars, connected with a wire, constitute an electric battery. This is not safely discharged, except by an instrument called a discharger, which consists of two metallic arcs, or knobs, moving on the principle of pincers, on an insulated handle of dry wood coated with sealing wax. The one extremity of the discharger is made to touch the outer surface of the jar, and the other touches its ball. The power of the battery is in proportion to the extent of the surface. If it be considerable, when the discharge is applied, a sharp report is heard. Small animals are killed by the spark. It melts and burns metallic wires, fires gunpowder, alcohol, detonating gas and various other combustible matters. It may be increased to the extent to kill a man or an ox, like a lightning stroke.

It is well known that electricity exhibits the opposite phenomena, which are commonly called *positive* and *negative* electricity; sometimes *vitreous* and *resinous* electricity; because the one form is obtained from glass, and the other from resin. Both these kinds are produced in various ways, and in fact, at the same time, the one in the rubber and the other in the body rubbed. The principal difference between them is seen in the phenomena of attraction and repulsion. Two bodies which repel each other when they have the same electricity, attract each other when they have opposite electricity. The same electricities repel each other, and the opposite electricities attract each other, and the one electricity destroys the other.

Many beautiful phenomena are exhibited, when they are presented in the dark. Passing through the exhausted receiver of an air pump, the light is seen of a beautiful white. Stars, fountains, divergent and convergent rays, the illumination of a wheel coated with metallic lines, and innumerable forms of brilliance, varied at the will of the operator, present in a darkened chamber very attractive spectacles to an unpractised beholder.

The theory of Franklin was, that electricity is an infinitely subtle matter diffused like caloric through all bodies. Its particles repel each other, but are attracted by other bodies. Where this matter is in a state of equilibrium, no electric phenomena are produced. But when this matter is accumulated above equilibrium in one place, or diminished below it in another, the first accumulation is positive, the second negative electricity; and the electric phenomena, such, for example, as thunder and lightning, are produced by sparks darting from the one place to the other to restore the equilibrium. When the cloud is negatively electrified, the spark is discharged from the earth to the cloud, and the reverse when the cloud is positively electrified in relation to the electricity of the earth.

The hypothesis of Symmer is now more generally received. According to this theory, there are two kinds of electric matter which mutually attract each other; but the particles of each, taken separately, repel each other. Their union, called combined electricity, produces equilibrium; their disunion the electric state. When the clouds have vitreous or resinous electricity, their homogeneous atmospheres repel each other; when one has vitreous and the other resinous, their heterogeneous atmospheres attract each other. There are various other sources of electricity than those here named. When glass is rubbed by mercury, it becomes electrified. Blowing upon a dry plate of glass with a pair of bellows will produce upon it the vitreous electricity. Various mineral substances show signs of electricity when heated. Such are the tournalin, topaz, diamond, and boracite.

Every one is acquainted with the almost inconceivable rapidity with which the electric spark passes through space. It is said that a wire, bent to a circle of a league in circumference, was cut open so that two persons could stand together, each holding to the extremity of the section. A shock, communicated to the first, was felt at the same moment by the other. Consequently the spark must have travelled a league too quick to render the time of its journey perceptible.

The facts that heat and cold have a great influence upon electrical phenomena, that water passing to a state of vapour shows electric appearances, as also water thrown upon burning coals; and that electricity is produced when charcoal is consumed; when sulphur, wax, and resin, are melted, and when iron is dissolved in sulphuric acid, show that there is an intimate connexion between the laws of electricity and those of chemistry. We shall hereafter consider some of these facts in the view which we propose to take of galvanism.

The study of chemistry in the writings of the great modern chemists, and the exemplification of their positions in experiments, might alone occupy a life. Usefulness would be found always in some way connected with these speculations and experiments; for the sciences all have an intimate union of influence, and are so associated as to lead out the arts by the hand. Optics taught painting that charming art which reproduces the universe. We are led from knowing the constituent elements of water to the contemplation of dew, rain, icy mountain summits, dashing torrents, streams, rivers, and the sea, to which they are perpetually returning. It is wonderful to see a creature, born the feeblest and most defenceless of animals, cast upon the wild elements and the desert earth, who rears himself by the single force of his thought, to create sciences and arts, to build magnificent cities, to clothe himself in purple, and in the midst of the beautiful creation around him, in the numbers of poetry and the tones of music, to celebrate the wonders of the Eternal.

LECTURE XI.

AIR, ACOUSTICS.

In this lecture I shall consider the air in some of its relations with physics, chemistry, and natural history. The fluid, in the midst of which we are always plunged, and which preserves life and vital heat to all beings, answers the additional important purpose of rendering human thought audible. Had not the air possessed the capacity of sonorous vibrations, nature would have been destined to perpetual silence.

We have ceased to consider the air, as the ancients did, as one of the simple, unchangeable elements. Though its particles are too subtle to be apprehended by the eye, it has not escaped the beautiful analysis of Lavoisier and modern chemistry. We have remarked, that its principles have been discovered. It has been decomposed and recomposed, and its different phenomena have become the basis of the most valuable discoveries.

The ancient philosophers, Anaximines, Diogenes of Apollonia, and Archelaus, held air to be the entire principle of nature, and even the Creator of all things. Their visionary hypothesis was sustained by one beautiful analogy.

The Creator, like the air, is invisible, and is known only by the life he imparts, and the benefits he diffuses.

Air is the vehicle of sound, without which the voice of sympathy and friendship would never have explained to one heart what was passing in another. The diffusion of sound is not like that of the aroma of flowers to which it has been compared. The flower wastes by the diffusion; but the striking of a clock takes nothing from the body stricken. If you touch the strings of a harp, their vibration communicates a corresponding one to the contiguous air. The ærial waves of vibration spread like those of water, until the tremulous movement reaches the tympanum of the ear; and sound is this vibration, as perceived by the mind.

It hardly requires that you should possess the temperament of poetry to imagine, that in the air you possess a multitude of sylphs, always at hand to convey your orders. Continually occupied in gathering up your thoughts, as soon as you give vocal utterance to them, they sail away to repeat it to the hearer. Such is their fleetness, that they traverse a thousand feet in a second. We may naturally view these airy beings, as taking the colour of the thought of the speaker. If your thoughts are pure, the bearer's will be clad in sunbeams; if revengeful, in the colour of the noxious miasms; if polluted with any of the baser passions, invested in the hue appropriate to pourtray it.

In a word, the manner in which sound is propagated, has been justly compared to the circular waves which spread from the central point, where a stone is thrown into the water. The vibrations of sonorous bodies create similar waves, which, as they expand, communicate sound onward until they meet the ear.

To convince you that air is a vehicle of sound, it is only necessary to repeat a well known experiment. The sound of a pendulum, striking a bell inclosed in the exhausted receiver of an air-pump, grows feebler in proportion as the air is exhausted. You still see the wheels move, and the hammer strike. But the silent bell no longer repeats the hours. Who can imagine the horrible silence, which would prevail in a world without air! The higher we ascend mountains, the more rare the air becomes; and in the same proportion air loses its force. Saussure fired a pistol on the summit of Mont Blanc, and only heard a feeble report like that of the breaking of a walking stick. On the contrary, the deeper we descend into the earth, the heavier is the air, and the louder is sound heard. Father Kircher affirms, that in the wells of Fulda, which are of immense depth, a stone falling on their bottom produces a report like that of a cannon. The intensity of the sound results from the pressure of the air in these depths, causing it to reverberate as from the tense surface of a drum. Morland, Kircher, and Poxta, each claims to be the inventor of the speaking trumpet. Neither, however, did more than restore to use a forgotten instrument. Grecian history makes mention of the famous trumpet of Alexander the Great, with which he collected his dispersed army, issued his orders, and proclaimed his purposes as if in presence of each individual soldier.

The mechanical formation of speech merits a moment's attention. The *glottis* is an oval cleft, by which the air passes into the lungs. The glottis presents two lips, the movements of which, more or less close, produce all sounds, from the gravest to the most acute. Thus, by a mechanism like the tuning hammer of an instrument, the sound of speech is formed before it reaches the mouth.

The manner in which sound is communicated, will enable you to comprehend the cause of echoes. When the waves of air encounter an obstacle, there is a repercussion of the sound emitted ; that is to say, the waves are reflected, and the undulations carry back the sound to the point whence it departed. Vaults of an elliptical figure have a singular property. Let the vault be of great span, two persons placed at the two foci of the ellipse, can converse with each other before a crowd of spectators without being overheard. The undulations move in the line of their natural tendency; and echo alone remains in the confidence. There was an echo of this sort in the great church of Agrigentum in Sicily. If we may credit Brydone, this phenomenon for a long time unknown to the multitude, was the cause of many adventures. The persons, who came to confession, were placed at one focus of the ellipse. Persons in the secret of the echo placed themselves at the other, where they lost not a word either of the confessions of the penitent, or the advice of the confessor. In this way the most secret intrigues were speedily divulged. There was no talk in the city, but of fortunate lovers, and the misadventures of unhappy husbands. The ladies, affrightened at the terrible celebrity of their loves, changed both their lovers and confessors. But the new intrigue was equally followed by a new development. Finally, the church of Agrigentum became the palace of truth; and perhaps there would not have remained a single happy family in the city, if chance had not discovered the mischievous invention of the architect. The confessional was arranged in another part of the church, and every thing returned to its customary order. You have, no doubt, read the touching anecdote of the two lovers, whose parents lived on the opposite sides of a river; and, irreconcilably hostile to each other, rigidly interdicted the intercourse of their children. The constant lovers discovered the secret that sound communicated to one extremity of the bridge, on the principle just recited, was conveyed to an ear placed at the other extremity. By these means, they conversed across the river; and the slightest whisper of love, pronounced on one shore, was swallowed by the listening and confidential ear on the other. I need only add, that their ingenuity and fidelity met its reward.

A phenomenon of another kind takes place at the castle of Simonette, near Milan. The slightest chords there produce the effect of a numerous concert. The castle has two great wings reared, the one in front of the other, and is adorned with a prodigious number of false windows. The architect has disposed them with so much art, that they reverberate sounds as mirrors multiply the light of a lamp.

The rapidity of sound being accurately calculated, we can know very nearly the distance at which the lightning-stroke falls. Count the number of strokes of the pulse between the flash and the report. The distance is about a thousand feet to a pulsation.

That is a wonderful mechanism by which we are made acquainted with the thoughts of others. Sounds introduced into the ear glide along numerous cavities, follow a multitude of windings, during which they put in play various wonderful contrivances, and experience different reflections before they arrive at the soul, and bring it acquainted with what is passing in the mind of another. The correspondence established between the nerves of the mouth and the ear, is a part of this surprising symmetrical arrangement for a certain end. 'It is admirable,' says Willis, 'that the voice in accord with the hearing, is, so to say, its echo; and that what we hear by means of one of these sets of nerves, the voice expresses by the other.

The varied forms of the ears of animals, would alone make the subject of a very curious book. The ass points his, like a horn, in the direction whence the sound is heard. That of the timid hare is of wonderful structure, and serves him, if I may so say, to reconnoitre the enemy. The mole, plunged in his obscure passages of the earth, has no need of keen sight. But to warn him of the approach of enemies, he possesses hearing of exquisite delicacy; and that the ears may not be obstructed by earth, they have, for a second covering, a slight membrane, which the little miner has the power to open or close at will.

The feeble and timid animals have the sense of hearing in much higher perfection, than those that are strong and fierce. Hares, rabbits, gazelles, rats, moles, and fawns, distinguish the most distant sounds, and their ear seems to be all nerve. Bats that have a very feeble sight are provided with great ears, the sensibility of which is so exquisite, that by the impression of the air alone upon them, they are aware when they are approaching a body, and never strike it even in the greatest darkness. The rhinoceros and hippopotamus, who only see in the twilight, have hearing in great perfection; while the cat, the lynx, the lion, and tiger, have eyes keener of perception, in proportion as their hearing is more obtuse.

Birds have no external curtains to their ears. These would have augmented the weight of their head, and would have impeded the swiftness of their flight. But they are indemnified by an interior apparatus of hearing, which, in most birds, is of great size.

We might pursue these details of adaptation and harmony in the nocturnal birds, such as the gray owl, the screech owl, and other birds of that class; and in various large birds that live upon the land, as the cassowary and ostrich; and equally in those carnivorous birds that perch upon trees and old walls.

But, to return to man, what a sublime harmony between the air, the ear, and the soul; between an invisible fluid and the wants of a feeble creature, who is great and happy only by means of thought. Nothing furnishes a more impressive example of great results from trivial causes, than the fact that a little air, put in motion by the mouth, is the cause of peace and war; of the one, when proceeding from a master-spirit of ambition and cruelty; of the other, when inspiring good will among the nations from the mouth of Penn and Fenelon.

It transcends my plan to speak, in conclusion, of that delightful form of sound, music — soothing pain, exalting joy, and furnishing the most delightful anticipations of that heaven, of the purest joys of which music is supposed to constitute so essential a part.

LECTURE XII.

MORAL INFLUENCES OF THE WINDS.

Allow me to dwell for a moment on the sounds of the wind and the voices of nature, in their influence upon the spirit of man. There are intonations of the voices of nature, which exercise a controlling influence upon a meditative mind. They place him alone with nature and its Author, and naturally associate his thoughts with the past and the future.

The poetry of the ancients is beautiful and endearing, because they had ears exquisitely attuned to the perception of these voices. In this view you see the cause, why they surrounded their temples and tombs with forests. Still deeper associations are created by these sounds when heard from ancient and mouldering towers, the vaults of deserted cloisters, and the monuments of cities crumbling to ruins. Imagination hears them as the speech of time, uttering a lament over the memory of life, busy exultation, and gladness, which were once heard there and are now heard no more. It is said that in the north of Scotland, a country of storms, mountains, and ruins, the people have learned to increase the effect of such sounds, by suspending Æolian harps to the walls of ruined towers and the forest trees. These ærial sounds are heard to swell and die away, near at hand, retiring, or far in the distance, varying like the sweet modulations of the harmonica. The imaginative traveller easily supposes that he hears the bards of Ossian discoursing from their clouds of their wars and loves, and of the memory of their joys that are past.

Antiquity offers similar examples. The walls of Thebes were in this way harmonious; and the statue of Memnon appeared to become animated by the first rays of the morning. The Chinese, in particular, have carried the art of varying the modulations of the wind, in the form of harmony, to the highest degree of perfection. By harmonic illusions of this sort, they give an air of enchantment to their voluptuous gardens. Sometimes the agitated earth trembles under the feet of the listener. Terrible sounds, and the groans of pain, are heard. The visitant imagines, that he hears the cries of combatants, the neighing of steeds, and the sound of the trumpet. Sometimes along the walks of a smiling valley, the song of birds mingles with the sound of a rustic flute. Sometimes rocks appear in the distance, enveloped with mist, and bordered with arid sands. The traveller stops, and imagines he hears the roar of the sea in a tempest.

What a diversity of sentiments even the natural movements and sounds of the atmosphere, constituting, if I may so express it, the *voluntary* of nature, are capable of inspiring! The mariner, returning to his natal fields, walks beside the waving grain. The movement of the breeze upon the wheat fields, seems to his eye as it waves along the changeable verdure, as the ripple of the sea when gently agitated. The tempests, the waves, the perils, the far countries, all return to his thoughts.

Burning under the ardors of the sun, the traveller turns from the dusty road, and courts the shelter of the aspen shade. While the zephyr fans his temples and stirs the rustling foliage, half lulled to sleep, he imagines that he hears the brawling of the spring near the spot where he was born. But none of these voices of nature so readily evoke solemn thought, as the noise of a storm swelling and dying away in the tops of a wide pine forest, when heard from our bed in a night of rain and tempest.

Poets have often found a theme in painting the mixed associations of joy and sadness, called forth from the shadowy halls of thought and memory, in listening to this music of nature. They have yet to explain, in their songs, the harmony of these phenomena with the heart, both in its extremes of joy and sadness. The same sounds, the same verdure, the same blithe vernal splendor of nature, which animate the youthful sports and dances of the young inhabitants of the country, impart matter of melancholy musing to the hoary senior, who is seeking the green tree under which he would wish to take his last sleep. The same rustling of the leaves that lulls and charms a cheerful spirit, inspires revery and sadness in one that is sorrowful.

It belongs to the poet to yield himself to these grand spectacles, these inspiring sounds. These voices, these aspects, are the sources of his sublimest inspiration. Schiller, like all poets of a high order, loved to meditate upon the arid rocks of the mountains. In the midst of a storm, he was often seen to throw himself into a boat, and abandon himself to the dashing waves of the Elbe. He felt his thoughts rise with the increasing fury of the storm; and his conceptions swelled with the roar of the tempest. He saluted these aspects of nature, in her terrors, with cries of gladness; and an inexpressible joy pervaded his mind.

There are people who pass their whole lives amidst these exciting spectacles and sounds. Goldsmith has faithfully depicted the peaceful Swiss exulting amidst his rocks and mountains: —

> 'Dear is the shed to which his soul conforms,
> And dear the hill that lifts him to the storms;
> And as the child, whom scaring sounds molest,
> Clings close and closer to the mother's breast,
> So the loud torrent, and the tempest's roar,
> But bind him to his native mountains more.'

In the midst of the deserts, the Arab leads a wandering and exposed life. The aspect of a flowering Oasis, an isle of verdure in the burning sands, indemnifies him for fatigue, hunger, thirst, and danger. But he soon wearies of the cool fountain, the verdure, and shade; and he resumes his adventurous journeys across the ocean of sand, where the tempest brings no rain, the wind no coolness, and the burning sky is tempered by no clouds.

The red man of the American forest sleeps soundest, when cradled by the roar of storms; proud in the consciousness how little he depends on any thing but himself. The boundless range of woods is his home; and it is only among fields and harvests that he feels himself a stranger. Nature bids him be strong or die, and he feels that in spirit he is strong. He loves the woods, for they are desolate, like himself.

In the severe and wintry climates of the polar regions, enveloped in perpetual fog, or beaten with incessant tempest, the inhabitants love their ice, storms, and rocks, and the hoarse roar of the storm-driven surge. They find happiness in the contemplation of these stern and awful scenes, and perpetual food for courage in daring to encounter, and learning to conquer them. The souls of their heroes, in the ancient days, swelled with no higher aspiration than after death to incorporate with the storms, and to return to behold their posterity from their clouds. Ossian, bard of melancholy, what dost thou, sitting on the stone of tombs? Art thou dwelling on the memory of heroes that are no more? I hear the sad tones of thy harp. Thy kindred shades, leaning from the misty halls of their ærial palaces, listen with joy. Malvina, pouring her dirge for the loss of Oscar, accompanies the strain with her voice. The funereal burden of her song is, 'the spring will come without renewing my vernal days. I vanish, like the mist of the hills. The warrior will search for me on the green heights, but will not find me.'

Such are the influences of the voices of nature, as depicted by the Caledonian bard. Thus he consoles himself for the loss of children that are no more. The grass waving on their tombs, or rustling in the breeze, recals the memory of his forefathers, and the distant roar of storms awakens the thoughts of his youth. Who has not been aroused to feel the musing sadness, connected with the memory of those who are no more, by these voices of nature? The soul instinctively attaches itself to such thoughts; for they are associated with immortal hopes, and with the eternity of the past and the future.

LECTURE XIII.

WEIGHT OF THE ATMOSPHERE.

In briefly discussing the weight of the air, I shall recall to your recollection some of the most extraordinary and beautiful phenomena of physics. Let us weigh the air with Galileo, Torricelli, and Pascal, who first demonstrated that it has weight. To the discovery of the weight of the atmosphere, we owe the most useful of pneumatic machines, the air pump and the barometer. The pressure which the air exerts upon a man of ordinary size has been calculated, and found to amount to thirty-three thousand, six hundred pounds. It is a fact worthy of admiration. The air, introduced into our lungs by respiration, is sufficient to maintain the equilibrium, and to sustain us without a sense of pressure under this enormous weight. If the air could be entirely exhausted from our bodies by the air-pump, the internal resistance to this great external pressure being removed, our bodies would be crushed like a potter's vessel. The ancients denied the pressure of the air, though sustaining it at the very moment of denial.

The barometer is a graduated glass tube, hermetically sealed at one end and open at the other. It is filled with liquid mercury, which has been carefully boiled to deprive it entirely of air and humidity. Putting the finger upon the orifice, the tube is inverted. The finger being withdrawn from the orifice, the mercury descends in the tube to the height of about twenty-eight inches. At that height it is sustained by the pressure of the atmosphere on the bottom of the tube. You easily comprehend the cause of this phenomenon, and that it exactly indicates the pressure of a column of air, of the same dimensions with that of the mercury in the tube, to the height of the atmosphere.

If the weight of the atmosphere from any cause diminishes, the mercury in the tube descends. This happens immediately previous to rain; because then the vapours, occupying a large space in the atmosphere, and being specifically lighter, cause the mass of air with which they are mixed, to become lighter than unmixed air. We can easily understand, however, that this indication is always in some degree equivocal, because there are other circumstances beside those named above which concur to produce rain or clear weather, while the ascent and descent of the mercury in the barometer, depend exclusively upon the variations of the atmosphere. The barometer, notwithstanding, furnishes the most certain grounds for prognosticating rain or fine weather, of any mode with which we are acquainted. As the air over the sea is more uniform than that over the land, the standing of the mercury in this instrument there, is a surer guide for calculation than upon the land. There are recorded instances, in terrible storms at sea, when the mariners, exhausted and desponding, have abandoned all hope of saving their ship and their lives, and of course have suspended all efforts to preserve them, and yet, by being simply told that the mercury was rising in the barometer, have cheerfully returned to their duty and resumed their courage. Is it not wonderful that a little instrument of this sort should become the basis of an almost unerring calculation of the weather upon the great deep?

Pascal, wishing to convince the learned world which still denied the gravity of the air, engaged his friend Perrier to ascend a mountain near their residence. 'If the air possesses weight,' he observed, 'the mercury will descend.' In fact as Perrier ascended, the mercury in the tube fell. At the summit of the mountain, it was nearly three inches lower than at the foot. The volume of air becomes lighter, as we mount towards the higher regions; and, pressing less upon the open part of the column of mercury, causes that column, balanced by so much less weight, proportionally to descend.

The weight of the atmospheric pressure exercises, likewise, a certain influence upon the human body. The natal air is that we most love, and ordinarily is most salutary to invalids. When the inhabitants of the Alps, habituated to respire a very rare atmosphere, journey into climates where the weight of the atmosphere is greater, the increased pressure becomes sensible to their lungs, and is no longer in harmony with the organs of respiration. The guides over the summits of Chamouny, strong and untiring among their mountains, when they descend to the low plains, soon sink with weariness and exhaustion. The circulation of their blood being driven by new laws, their mind sympathizes with the variation, and they become the victims of sadness and discontent. If far from their country, they experience a longing desire to return. If they happen to hear the songs of their childhood, this inclination becomes still more urgent. When they hear the *ranz des vaches*, which reminds them of the lowing of the kine of their mountains, the evening song of the shepherds, and the sounds of the domestic animals mingling with the distant roar of storms gathering among the Alps, even the brave Swiss mercenaries in the French army become afflicted with such an invincible home-sickness, that they seize the first opportunity to desert and return to their country.

When they sung at Granada, in the middle of the fifteenth century, the beautiful romance composed by the Moors on the taking of Alhama, such strong associations with the day of their triumph and glory were excited, that the whole multitude who listened were seen dissolved in tears.

I touch, in passing, upon the spring or elasticity of the air, the property by which it extends its volume to its former magnitude, after it has been compressed. This property will serve to explain the phenomenon to which I have alluded, and which the ancient philosophers, Strabo and Pliny, frequently mention, in their writings, the harmonious sounds which proceeded from the mouth of the statue of Memnon at the rising of the sun.

This statue was on the borders of the river Belus, near the temple of the Egyptian god Apis. In the morning, when struck with the rising beams, it gave forth melodious sounds; and in the evening a sad and melancholy music, as though regretting the departure of light. Father Kircher thus explains the phenomenon. The statue was metallic and hollow. The volume of air in the body of the statue was warmed and dilated by the morning rays. When the mouth-piece of a wind instrument was applied to the mouth of the statue, the dilated air, escaping through the instrument, produced clear and agreeable notes. As the sun disappeared, and the statue became cooled, the external air, entering by the same aperture, produced a deep and mournful sound.

Nature avails herself of the dilatability of the air to render certain portions of the globe habitable, which, without this property of the air, would have been incapable of sustaining animal life. The burning atmosphere, rarefied by the continual action of the perpendicular sun of the tropics, is perpetually replaced by the cooler and heavier air, which rushes in from the northern climates to fill the vacuum. Ulloa has particularly noticed this fact in relation to Peru.

Air is capable of igniting combustibles by rapid compression, forcing an immediate escape of its caloric. This is shown by means of a common instrument to light cigars. A tinder-match is placed at the bottom of a hollow cane. To the head of the cane a piston is attached. The piston is drawn and rapidly returned. In this way the caloric, disengaged from the compressed air, fires the match at the bottom of the cane. This beautiful and common experiment furnishes an easy explanation of the cause of a phenomenon, which has often been asserted and denied, the apparently spontaneous combustion of forests. Those who have affirmed that the fact takes place, have generally attributed the kindling of the fire to lightning. To refute this supposition, it is affirmed that the forests are often inflamed when there has been no lightning near. Whirlwinds in a thick forest, pressing on all sides towards a central point, would naturally ignite the dry leaves, as in the example given above. The same air which kindled the flame, would blow it to fierceness. The flame, by rarefying the air about it, increases the rush of the cooler air to supply its place. The fire, thus acting and reacting as cause and effect, increases the fury of the winds.

Lucretius speaks of these spontaneous fires in the ancient forests. Bernier relates, that in crossing the high mountains which separate the country of Bember from that of Cachemire, he saw far below him vast and deep forests. Their moving summits, agitated by a strong wind, presented the aspect of the waving of a sea of verdure. But the valley was so deep below him, that no sound of the movement reached the ear of the traveller. Surprised to see so much commotion in the profound gulf of forest which his eye penetrated, and to hear no noise in consequence, his guides assured him that after these furious whirlwinds, a flame was often seen bursting forth, and that soon the burning forest seemed to be an ocean of fire.

Bernier could offer no solution of this phenomenon. He had not learned from modern chemistry that air is impregnated with caloric, and that rapid pressure causes it to issue in the form of flame. Beside the solution of supposing such fires kindled by lightning, others attempt to explain their origin by the friction of the branches rubbing the one against the other, as the savages kindle fire by rubbing sticks together.

The compression of the air, among many other beautiful experiments, furnishes that of the *air* or *wind-gun*. Compressed air, in the barrel, discharges from twelve to a hundred balls in succession, with a force approaching that of gunpowder. This substance exhibits phenomena still more surprising. It is composed of 75 parts of well purified nitre, $15\frac{1}{2}$ parts of prepared charcoal, and $9\frac{1}{2}$ parts of sulphur. The strength of the powder depends upon the purity of the constituents, and its complete trituration and mixture.

The more perfectly the particles are pulverized, and the more intimately they are mixed, the more immediate contacts of inflammable surfaces are presented to each other, and the greater the volume of elastic gas evolved, and the greater compression of elastic air. The results produced by firing this powder are but too well known. Can there be produced a more wonderful example of the achievements of chemistry, than to see it concentrating such a prodigious power of air in a few grains of black dust?

Plutarch relates that when Quintus Flaminius, the Roman governor of Greece, in the name of Rome, restored liberty to Greece by proclamation, the force of the ascending shouts and acclamations so rent the air, that ravens that were flying above the assembly at the moment, fell dead. Subsequent writers doubted the fact. The narrative of the good Plutarch may be credited, and the fact naturally explained on the principle of the compression of air, created by the shouts of this vast assembly.

LECTURE XIV.

BIRDS.

Expect not the order of didactic treatises on physics and natural history. I touch upon a subject in one aspect, and soon, without repetition, I would hope, present it to you in another, and in new relations. From the properties of air, I naturally digress to the habits and harmonies of its dwellers, the birds. While they are privileged with the enviable power of passing through the air, they constitute one of the most striking embellishments of all positions. Forests, rocks, groves, deserts, and the sea, are animated by their presence and their note. But the whole race naturally ranges under the classes *terrestrial*, *aquatic*, and *ærial*. Some are formed to enjoy the night, and some the day.

The storm birds, sea mews, and gulls, follow the tempests upon the ocean. The nightingale pursues the train of spring round the globe. Some surround themselves with terror and solitude, as the hawk, the vulture, and the eagle, the robbers of the air. Others unite in societies, and organize governments, as crows, rooks, pelicans, and herons. Storks, cranes, and flamingoes, form themselves into warlike phalanxes, place sentinels in advance of their camp, and obey their chiefs. The wagtail prefers pastoral life and the furrows of the plough, follows the shepherd into his meadows, and seems disposed to guard his flocks. There are birds to inhabit all heights of the air, from the eagle that soars, to the ostrich and cassowary, which only use their wings to aid them to run upon the ground.

Nature has formed some for still, and some for agitated waters, from the swan, that majestically ploughs the tranquil surface of the lake, to the tringa, that plunges into the cataracts for its prey, and finds it among the foam of the whirlpools. The water black-bird, less daring, plunges to the bottom of rivers resplendent with its surrounding air-bubble, like a diver under his glass diving-bell, and enjoys the coolness, pursues its route, and rises to the surface without being wet. But it is directly above the abysses of the ocean, that birds exhibit the most surprising habits. These habits prove that Providence designs that all the elements shall sustain life, and even the storms have their inhabitants. In the midst of the most fearful swelling of the mountain-billows, by the glare of lightning, the terrified mariners see the storm-bird unfold its white wings, as if in mockery of their dangers. In the midst of the commotion and darkness, it glides along the hollows of the waves which roll under it with fearful rapidity. Its asylum is the wave, which vainly menaces to swallow it up. It dips its feet in the billow, skims it with its wings, and runs along the heaving furrows of the waves, as the sparrow in the furrows traced by the plough.

What nature has accorded to the solitudes of the ocean, it has not refused to the solitudes of the earth. The pelican, like the camel, has the faculty of being able to preserve in its bosom a supply of pure and fresh water. The same power which has placed the palm in the midst of arid sands, and causes a wine to distil from its puncture, has prepared a living fountain in the breast of the pelican. Thus a tree, a quadruped, and a bird, have each been formed for the desert, and each carries a fountain destined to the wants of the traveller.

We shall see, in another lecture, that the extraordinary migrations of birds, are an arrangement and benefit of a law which migration seems to disturb. Analogy would lead us to conclude, that the birds which people all parts of the globe would never pass established limits, to prevent the invasion of each other's provinces. The regions, they occupy, seem to be a domain assigned them by Providence. Faithful guardians of the very animals upon which they prey, they allow no other enemy to approach them. They never destroy beyond their wants, and this waste is balanced by a power of reproduction, adjusted to preserve the equilibrium. Hence the weak increase by the side of the strong, the harmless along with the rapacious, and the victim beside the tyrant, in such an order that no species becomes annihilated. The same pursuits, combats, and victories, are incessantly renewed, and still the same harmonious order of being is preserved. The whole earth resembles those banana trees, which travellers meet in the solitary forests of Guinea. Their summit is covered with apes, that live in society. Myriads of serpents twine round the trunk, and encircle it with their horrid folds, and not being able to crawl higher, dart their heads and forked and crimson tongues from under the foliage. The flexible extremities of the branches are adorned with a multitude of nests of moss, where the larger pie, with its changeable plumage of blue and gold, secures its timid family in an asylum beyond the reach of the serpents and apes, that are at the same time its neighbors and its enemies.

It is a part of the general arrangement of intelligence, that to arrest the depredations of the animals of prey, to oppose a barrier to their voracity, nature has found an adequate resource only in varying their conformation. From this variety, the diversified and ever-shifting pictures of the universe have sprung, as by enchantment. To one, it has given a beak like a hatchet, and placed it on the shore of the sea, to open shells. Another, instead of feet, has received a pair of oars, with the property of expansion and contraction, and its home is in the waters. Another stalks onward, amidst the half-liquid mass of mud and water, upon a pair of stilts. A nerve of exquisite delicacy, placed at the extremity of its beak, indicates its prey in the mud, which, without this organ, it would not have been able to discover. The pecker never leaves the bark of the trees, under which the insect that nourishes it, takes refuge. The conchroma is provided with a sharp spoon-shaped bill, which, from its willow, it plunges in the water and draws up the fish which it has seized. The scissor-beak can neither bite nor peck, but its under bill is longer than the upper; with this it scoops up the fish swimming on the surface of the sea, and never abandons the shores where such are found. Unable to vary the use of their instruments, birds of these classes remain attached to the particular tracts of country where their prey is found. Various races of smaller birds devour the grain, which the husbandman sows in the earth. There are tribes of rapacious birds which prey in their turn on these, and seem placed like faithful sentinels, in the heights of the firmament, as the guardians of the fields.

Such is the law of nature. It is executed with a sternness of inflexibility, which would seem barbarous, if the destiny of the world was not attached to it. A perpetual conflict between man and animals results from it; a struggle, which has been so provided for, as to hinder their mutual annihilation. Facts connected with the migration of birds offer a striking proof. At the time of harvest myriads of quails and plovers descend upon the fertile plains of the south of Europe, and levy their tithe upon the harvest. But it costs them life; for vast numbers are taken by the net and the gun. We see, that the same instinct, which guides them to their food does not forewarn them of the ambush of man. A line seems to have been marked out for them in the sky. They invariably return to the same shores, brave the same perils, and still find man on all sides waiting to destroy them. Had it not been provided, that nature should teach them one lesson, and conceal from them another, the birds would have learned to remember and fear the snares of man, and would have sought harvests in new climates, and the inhabitants of these countries would have been interdicted from this copious supply of their favorite food.

From this variety of forms and instincts, of necessities and habits, springs the variety of their movements and songs. The music of the dwellers in the groves is flighty and brilliant, as it is heard amidst the rustling of thé foliage and the murmurs of zephyr. In deep forests and on high mountains the cries of the birds are sharp and piercing; while amidst the roar of thunder and the dashing of the waves the screams of the mews and sea-gulls strike the ear, like the fifes and trumpets of battle.

The dying song of the swan has generally been considered a baseless ancient fable. Along the valley of the Mississippi the flocks of swans, in their aerial march of emigration, utter a succession of notes, not unlike the sound of a trumpet. On the frozen coasts of Iceland, during the dark and stormy nights of winter, flocks of swans are heard careering through the air, echoing harmonious accents, like the notes of a lyre. The inhabitant of the storm-beaten cabin from his warm couch hears this aerial music with joy, for it announces the cessation of snows and storms, and the return of his brief vernal season.

The European goldfinch sings all the year. So too does the red bird and blue bird of our climate. The only intermission of their music is the period when they cease their loves. In abandoning their native climate they often abandon their song. The nightingale flies the European winter; and the traveller, who meets them on the shores of Syria, or the fertile plains of Egypt, is astonished at their silence. They remember the copses of their nests, their loves, home and country; and though less fertile, they are more dear. Like the exiled Jews on the banks of the magnificent Euphrates, they will not sing their native songs in a strange land, though more beautiful than their own.

The variety of the movements of birds is as marvellous as their voice. Some in flying trace out zigzags and undulations, sweep circles, or glide up and down the firmament, as if swimming in the air. Others at one moment dart with the rapidity of an arrow, and then hang motionless, as if suspended in the sky. Who has not noticed the regular balancings of the twilight night-hawks, the sinuous and lightning speed of the swallows, skimming the surface of the waters, the regular movement of the vast flocks of blackbirds and pigeons, the triangular phalanxes of the geese and swans, the playful evolutions of the sand-hill cranes, sleeping as it were in the dome of the firmament, their notes heard and their white pennons occasionally glittering in their aerial heights, like snow flakes in the sunbeams. Some exercise movements of stratagem, as means of preservation. At St Domingo flocks of those beautiful birds, called organists, light upon a tree, shelter behind its leaves, and become invisible to the observer. As he changes his place the flock makes a corresponding movement to the opposite side of the tree in silence, and with admirable finesse remains concealed. The frigate bird, in emigrating, mounts into the clouds, and is thus borne along the wastes of the ocean. The mews make diurnal excursions of two hundred miles to sea, and return to their accustomed haunts in the evening. A carrier pigeon has borne a letter from Aleppo to Babylon, a journey of thirty days' march to the inhabitants, in one day.

Nothing is more striking than the efforts of the maternal birds to tempt their young to make the first experiment of trusting themselves to their wings. The nightingale flutters around her nest, holding an insect in her bill at a little distance, to draw her young to the edge of the nest, and to incite them through their appetite, to make their first effort with their wings. The Iceland diver offers a still more striking spectacle of maternal solicitude. The bird builds its nest on the steepest summits of mountains near the shore of the sea. As soon as her young are fledged she ceases to bring them their habitual food. But she continues to visit them, to flutter about the nest, to show them the power of her own wings, and to invite them to follow her. The young bird, oppressed by hunger, approaches the edge of the precipice, hesitates, and finally falls into the air. Its wings are too small to sustain it, and it would dash upon the rocks below. The mother summons the aid of the male. They spread their wings in concert a little beneath their young, to allow free play to its wings. Thus they gently let the bird down to the shore, partly by its own exertions. When it has reached the shore, clouds of their kind assemble round the young bird, and raise cries of congratulation at the view of this new companion, that maternal love has emboldened to the first attempt at flight.

The grossbeak of Bengal attaches itself to the society of man, and, like the pigeon, is never faithless to the message, which is sent by it. Suspending its nest from the foliage of the palm, it divides it into four little apartments, each to contain one of the young. This bird is often seen at midnight, environed with a bluish light. Sparks stream from the nest, and that part of the tree is illuminated. It has caught fire-flies for its young; and reserving them for their future food, appropriates them to the present use of torches, to illumine and cheer the darkness of the young family.

Like insects, birds often unite in societies. Crows of a certain species build cities, which have their police, laws and constitutions. Foreign birds are interdicted access to these establishments. Like the Chinese, they are enemies to foreigners and hospitality. They raise armies, and give battles to preserve, what they doubtless phrase their independence and liberty.

The grossbeak offers the most striking example of this sort of political union. They arrange their municipality on the summit of the enormous and slippery trunk of a species of *mimosa*. Eight or nine hundred families build the aerial city out of the reach of their enemies, the reptiles and monkeys. Each has his individual apartment; and all these habitations, as if they formed but a single nest, are covered with one entire roof, which rises above the summit of the tree. They have neither senates, chiefs nor distinctions. Each one is free, and answers for himself. Wide streets lead in all directions, and the leaf-enveloped borough offers the spectacle of peace, repose and happiness.

These are the true air-castle republics of Plato, in which the people are all free and equal. It was to see such republics, which unhappily are not to be found elsewhere, that Aristophanes exalted Plato in a basket into the air in his celebrated play of 'The Clouds.' The Athenians could not forbear laughing to see the sage, in his wicker pulpit, searching for a reality in the air, which, notwithstanding the vaunting of so many political theorists, is scarcely to be met with on the earth.

LECTURE XV.

BIRDS.

I WILL not fear fatiguing you, by dwelling further upon the history of birds. You will not fail to be impressed with the intimate analogy, which exists between all the classes of animated nature. The air and the earth are different empires, whose inhabitants could not exist without each other. The beautiful musicians of the air, beside their own individual enjoyment, delight us with their plumage and song; and alight upon our plains, to deliver them from insects and noxious reptiles. Having found their own happiness, and reared their family, and delighted us with their beauty and their notes, and performed these guardian offices for our fields, they confide themselves to the zephyrs, which bear them to other climates, where they resume the same offices.

Every site has its plant, and every plant its bird. Among the species of the larks, some are attached to the heaths, the meadows, the woods, and the sea shore. The crested lark lives along the roads. Cæsar, who was an accurate student and observer of that nature, which he conquered, compared the crested lark to a soldier of his enemy the Gauls, who covered his head with a casque, and, clothed in a short dress, was always erect, brisk, hardy, sprightly and joyful. The domestic hen has its counterpart in the sea hen, that dwells in the water, and in the wild and beautiful hen of the western prairies. Of the same class are the pintades, India fowls and heathcocks. The wild species remain perpetually attached to their favorite food, tree and district. But the domestic kinds every where follow the abodes of man. In marking the free course of the doves through the air, you would suppose that they knew no home. But they return, with unabating fidelity, to the roof of their master; while the turtle and the ring-dove, subservient to their rustic propensities, utter their plaintive notes in the solitary groves. The wild duck, in its vernal and autumnal migrations, in passing directly over the poultry yard, vainly strikes the air with practised wings, and utters the wild cry of liberty, to invoke the domestic duck to follow it to the free woods and waters. The barn fowl hears, rears its head, shakes its wings, and responds a welcome to its vagrant relative; thinks, perhaps, of the pleasures of the far stream, the odors of the blooming willow, and liberty; but an after thought of repose, security and abundance, prevents its being tempted to turn savage, and trust to the barren luxuriance of nature.

The whole feathered family is more or less organized for flight. But we shall find a marked organic difference between those destined to emigration, and far and frequent flights, and those, which are seldom disposed to quit the ground, and soar towards the clouds. If we carefully scrutinize the structure of the former, we shall find their bones slender, hollow and deprived of marrow. We shall discover artfully contrived cavities communicating with the lungs, by means of which they are inflated with warm and rarefied air, which increases their lightness. They are universally penetrated with these cavities, all capable of voluntary dilatation; and by these means they become almost capable of rising in the air, like balloons. Such is the admirable structure of the eagle and the lark. They thus escape bondage to man, to whom they would have been useless; while the birds, that subserve our necessities, such as the turkey and the domestic fowls, have large bones with no uncommon cavity, and seem constrained to sojourn with us even by the necessity of their organization.

Insects present many similar phenomena, and in a manner still more admirable. It has been generally supposed that the wings of these little animals are of a single piece. A more accurate observer has remarked, that the wings of insects, though for the most part infinitely thin and transparent, are composed of two membranes, between which there is an interval provided with aerial canals. These canals, by an apparatus of incredible delicacy, communicate with their organs of respiration. The air, which fills them, being dilated by the warmth of their body, sustains them by its levity. Thus insects swim in the air, as fishes in the water. As we bring these beautiful facts together, it is impossible that we should not recognize the singleness of the thought which moulded the creation.

A vigilant nature has appointed to each climate its beneficent bird. The vultures and buzzards, the scavengers of the country they inhabit, abound in sultry climates, in marshy regions, where a rank luxuriance of organic life strews decaying vegetation and carcases on every side; and where, of consequence, miasm is most abundant and deleterious. At Carthagena, in South America, they inhabit the roofs of houses, walk in the streets, and are so far the servants of man as to clean the city, which would be otherwise uninhabitable. Every one has remarked the innumerable congregations of them on the lower courses of the Mississippi and Red river, where public opinion, aware of their utility as general scavengers, protects them. The jackdaw of the Phillippine islands, and the *secretary* devours the serpents of the Cape of Good Hope. Swans descend in flocks upon the marshes of Holland and Germany, and resume their voyage as soon as their presence is useless, from having devoured the seeds of miasm. The gnat-snapper destroys insects, which increase in innumerable companies in some parts of the torrid zone, and pursues them even upon the shoulders of the inhabitants; and when satisfied with the chase, cools itself by unfolding its tail for a fan.

We shall find the same sort of arrangement of means to ends over the whole globe. In the warm and humid countries of Guinea, there is a prodigious abundance of ants; and nowhere on the earth has nature so multiplied the birds that destroy them.

The air in some parts of the torrid zone is often infested with a prodigious number of flies; and in the same region we find great numbers of birds, that subsist by devouring them. The cranes trample over the marshes to gather up the worms and toads. The herons roam over the African plains to feed on reptiles. The swallow performs the same offices in respect to our climate, in devouring our flies and insects. The same guardian care watches over Egypt. When the waters of the Nile have subsided, and the humid shores are covered with venomous reptiles, long lines of pelicans, cranes and aboumas arrive there from the shores of Greece and the Red Sea. Benefactors sent from Heaven, they alight on the fields, and cleanse them of their numerous enemies. Thus while the reckless mameluke, sitting upon the ruins, which he contributes to destroy, sees with unconcern the contagion, that threatens him with death, nature comes to his assistance, and guides to these fertile and inundated plains, clouds of birds to cleanse them. Always constant in her untiring march of benevolent intelligence, she sheds on this degenerate and declining people the same benefits, which in the first ages she diffused upon Sesostris and Cheobus.

These birds are the direct ministers of the laws of Providence. They are operatives, which are ordered through the air, to assist in preparing the different countries, they visit, for the comfortable habitancy of man. The traveller, who wanders in the wild forests of Africa, hears a shrill cry. It is the note of the herald cuckoo. He raises his head, and follows the bird, that advances fluttering before him. The bird alights upon a rock, or a tree, in the hollow of which is a swarm of bees. As a reward for its discovery, the bird expects a piece of the fragrant honey comb. In China the falcon is trained to dart into the air, or plunge into the water to grasp its prey, which, instead of devouring, it lays at the feet of its master. The ostrich yields its back to the daring negro, who is borne along the sandy deserts by this plumed courser with the fleetness of the wind. The South American Indian finds a faithful servant and a companion in the agami. This bird, with its changeable neck of green and gold, is docile to the voice of its master. It follows, or precedes him with demonstrations of affection and joy, like a dog. It knows the friends of the house, runs to caress them, and drives away strangers, with whom it is not pleased, by pecking at them with its beak. At evening it is often seen driving before it the flocks of sheep confided to its care, which it has found in the pastures, and conducted to its master's fold.

But the fishing cormorant of China presents the most extraordinary spectacle of all. Scarcely are the porcelain towers of the populous plains gilded with the first beams of morning, when a lake formed by the waters of the river Luen is covered with a fleet of small boats, and adorned with ribands and streamers. The boats, pushed from the shore, are abandoned to the gentle breeze, and the wave. On the yards of the masts are these birds of the most brilliant plumage. At a given signal, the aerial laborers dart away, suspend themselves a moment over the unruffled bosom of the wave, to see their prey. They plunge beneath the surface and reappear each with its fish, and each returns, amidst acclamations and shouts of joy, to the boat of its master.

The most interesting phenomenon in the history of birds is their migration. Naturalists have puzzled themselves in attempting to account for the restlessness, which impels these aerial travellers to commence these distant journeys. Unable to explain the fact, some have denied it. Others have believed, that the swallows sleep out the winter with the fishes at the bottoms of the lakes and rivers. Dr Mather, in a number of the 'Philosophical Transactions' of England, seriously sustains, that these travelling birds retire, during the winter, into a satellite of our earth, which, though not far distant, is as yet unknown to us. These conjectures are well known to be the mere coinage of the imagination, having been entirely refuted by more accurate observation. There are few travellers, who have not noted the migrating birds in intermediate stages of their journey over the midst of the seas, or on foreign plains.

Our own vast country, which embraces two climates, furnishes ample demonstrations of this sort. The hectic invalid, who departs from the remote north of our republic, with the first menace of winter, to breathe the milder air of the south, finds, that the robin and the oriole of his native orchards have emigrated before him. Their note in these far countries is the note of a stranger; for they sing their real domestic songs only in the regions where they reared their young. Sannini observed the summer birds of France spending their winter in the isles of Greece, Syria and Egypt. The time of their departure and arrival varies with the prevalent winds. By a phenomenon as certain, as it is inconceivable, this epoch is always in exact harmony with the maturity of those fruits, upon which each class feeds. The jay and the turtle are seen in Greece at the exact period, when the fruits, they love, offer them delicious nutriment. The pies and flycatchers light upon the isles of the Levant at the epoch, when the insects begin to be so numerous as to threaten to destroy the harvest. The wood pigeon, on the other hand, divines the time, when the husbandmen are casting their seed into their furrows.

Who teaches the birds of the north when the figs of the south ripen? How do they divine the prevalent winds, and the vicissitudes of the seasons in distant countries? Who teaches them to fly from region to region, and from harvest to harvest, every where to levy a tribute upon the labors of man, or the bounties of nature, and thus keep pace with spring, or harvest, over the whole globe? But though the earth is their country, we find that one consecrated nook in it, is the place of their songs, their domestic bowers and their loves. Reckless as they seem, and the plunderers of all harvests, these Arabs of the air still have their home. Obeying the intimation of Providence they execute their great voyages at the return of the equinoxes, when unvarying winds prevail with great force in the direction of their migration. They sail upon the winds over mountains, rivers and seas, as if these aerial currents had no other purpose than to convey them from one country to another.

There is not another more striking proof of the infinite intelligence of Providence, than this apparent understanding between the order of nature, and the wants of all animals, by which they are enabled to avail themselves of its powers.

At the return of spring, when the reanimated earth decks itself anew with flowers, insects spring to light again, reptiles are quickened, the butterflies burst their tombs and frolic with the zephyr; crowds of rats, field mice, moles, and serpents, come forth from the earth, and exult upon the flowering turf; snails, enveloped with thin veils, devour the tender leaves and buds; brilliant flies stream through the air, and beetles of a thousand colours and forms, creep, fly, and march, in the midst of the springing verdure. All these little animals seem to labour in a general conspiracy for the destruction of nature. Some skilful miners attack the roots of trees. Others gnaw and tear the foliage. Their numerous battalions know no repose. Armed with rasps, saws, pincers, hammers, and teeth, they boldly attack the largest vegetables. The huge, cloud-aspiring oak, falls under the effort of a vile insect, and the fruits of autumn are devoured by imperceptible flies.

The earth has been long parched, and the air sultry. Providence awakens a gentle breeze upon the shores of Asia and Africa. It blows steadily westward, and becomes a zephyr upon the isles of the ocean. The battalions of emigrating birds, attentive to the mysterious signal, assemble upon the ruins of Thebes and Memphis, formed in martial phalanxes, or long triangles, the more easily to traverse the plains of the air, they gaily commence their voyage. The husbandman along the shores of the sea, who happens to be abroad during the night, hears their ærial songs, cries, and acclamations, as they wing their way along the dark space. The arid sands of Africa send Europe her dainty quails; while the woodpeckers, swallows, cuckoos, becafigos, stock-doves, fly-catchers, the lark with its beautiful crest, and the little linnet mount into the atmosphere, raising their note of pleasing melancholy as they leave their wonted abodes. The nightingale, which has been wandering in the roseate bowers of the East, confides itself to the wind, for which it has waited; and all these fleeting families cross the seas to gladden the cooler climates of Europe.

In no part of the globe are these migrations more marked with beautiful regularity, than in our American climate. The meadows of New England, desolate and ice-clad during the long winter, scarcely put forth the yellow cowslip and the first-born spring flowers, scarcely has nature decked their nuptial couch with verdure, before the sky is enlivened with the ærial legions. The robin sings his own welcome to his native bowers. The boblink chatters in the meadows an air of inexpressible gladness and gaiety. The perwink and the thrasher draw out their canzonette among the birchen thickets. The martin chatters under his accustomed window. The swallow skims the surface of the streams. The night-hawk darts down the sky, proud of his feeble imitation of thunder, and the whip-poor-will again soothes the laborers to their evening rest. Every meadow, stream, and field, has its musician; and the fair girl, who watched the oriole in its hanging nest the preceding year, sees the same gilded traveller return to build again on the pensile branches of the whispering elm.

Poets have seen in these migrating travellers of the air, only the desire to live in the bosom of eternal spring. 'They come to us,' say they, 'with the month of flowers, dwell in their peaceful groves while they are green, and disappear with their verdure.' We have here attempted to point out the secret purpose of Nature, and the harmony and benevolence of her design. It is admirable to see her sending, with the unvarying regularity of the seasons, armies of birds feeding upon grain and insects, precisely at the epoch when the earth seems to implore their assistance.

The autumnal departure of these ærial voyagers has always been to me, a period of not unpleasing melancholy. Many of them in our climate, as the boblink, the oriole, the robin-red-breast, mount the air for departure with a business note indeed, but not of song. There is a plaintive sadness in it. They sail over the bowers where they were born, where they have found their loves, and reared their young. Their note seems to me the dirge of exile. In my ear it sounds as if questioning, whether, at the renewal of spring, they shall return to their natal bowers?

Between their departure and the settled reign of winter, we have our flocks of plovers and ducks, of sandhill cranes and pelicans, of geese, brants, and swans, that descend upon the western prairies. They are joined by armies of ravens and vultures. They complete gathering the harvest of seeds and fruit, and cleansing away the last remains of decaying animals. Having finished their work, enveloped with fogs, they mount the wintry winds, and push their southern course, raising their sinister croakings, and winter resumes its reign of silence and sadness.

LECTURE XVI.

WINDS.

I SHALL now touch upon the winds and their causes. The winter is past, and the voice of the singing-bird is again heard in our land. The sun has ascended his chariot of light. The stars have fled, and the morning mists are rolled away from his course, like the raising of a magnificent curtain. The flowers exhale their odours, as they shake off their pearly drops. The lark soars and sings. Nature, coming out of her chambers of darkness, resumes her vivid colours and her freshness. Man springs from sleep to enjoy this renovated existence, and goes forth to his labour in the fields.

At this moment a gentle breeze precedes the chariot of the sun. You may cry with Archimedes, that you have found the great secret — that you have divined the origin of the winds. The gentle zephyr which breezes from the east, is air-dilated and rarefied by the first rays of the sun, extending itself by its elasticity. The cooler air rushes in to supply the vacuum. Such is the cause of the trade winds of the torrid zone.

The warmth of the sun acting upon the air, so extremely easy to rarefy, condense, or expand, is the first and prominent cause of the winds. This orb, in pursuing its sublime path, and heating the masses of air under its course in the torrid zone, produces those regular breezes called the trade winds. Astonishing wisdom and beneficence of Providence, which, in that very culminating fierceness of the sun's rays that would render the climate uninhabitable, has provided a remedy for the heat in a steady, cool, and refreshing breeze, which fans the burning rays that create it!

What a spectacle would the blue expanse above us exhibit, if the air was visible! We should see the atmosphere rolling in waves, as much more impetuous than those of the sea, as air is lighter than water. What fearful omens in the discoloured miasms, and the seeds of pestilence walking in darkness, disclosed to the eye in its gloomy tinge of combination with the atmosphere! The simple apparatus of a flask will enable me to show you some of the more striking properties of the air. You are aware that the heroes of Homer were enabled to procure, of the god of the winds, certain bags of that element for their individual use. Virgil represents the winds as prisoners caged in a cave, and I hope to show you the causes of the wind at the bottom of a flask of glass. Why not? Has not Don Cleophas, in his '*diable boiteux*,' presented the most amiable of demons corked up in a bottle? Has not Rabelais assured us, that Panurge found truth in a bottle? In the same vessel I hope to show you the cause of the winds.

I present a close corked flask to the action of heat. Scarcely has the air contained in the bottle begun to feel the influence of the rarefaction, before the flask bursts into a thousand pieces. Judge by the action of heat upon the air contained in this small vessel, what force the expansion of the air must have, when dilated by the action of that vast burning planet, the sun, a million times larger than the earth! Do not conclude, however, from this experiment, that the expansion of a part of the atmosphere is the entire cause of the winds. Nature has a thousand expedients to obtain the same result, while the student has but one head to study them. Some philosophers affirm, and it seems to me with reason, that the action of the sun and moon must produce a flux and reflux of tides in the air, as certainly as in the abysses of the ocean. Electric clouds are a prolific source of winds. We all feel the cool streams of air flowing towards the electric machine in motion. We have seen the terrible impulse of thunder-clouds upon the winds, and have felt the refreshing coolness which succeeds such storms, the grand ventilators of the atmosphere. When the mass of air which circulates over our heads is rarefied by any cause, the atmosphere at the point of rarefaction becomes sensibly lighter. The wind rushes towards that point. Observe the reason, why we expect a storm when the barometer falls. Though all the elements that concur to form whirlwinds, tornadoes, and hurricanes, may never be detected by the sage, we can see, in the heat of the sun, the play of electric clouds, the unequal distribution of heat and cold in the different zones and climates, and the perpetually changing temperature of mountains, sufficient causes for all degrees of wind, from the zephyr to the hurricane. Even these last terrible phenomena may occur to perform an immense lustration of the atmosphere, purifying it from the seeds of disease and death. For example, the city of Cesi, in Italy, is built upon the declivity of a mountain, through the opening of which breezes a cool and refreshing wind. Yet this breeze is felt only in the summer between morning and evening, and is even proportioned to the heat of the day. The little town of Nyon, in Languedoc, arises in the midst of a fertile valley covered with olives. A river and many small streams wind through it, diffusing life and coolness in their course. Nature seems thus to have provided a remedy for the parching influence of the sun's rays, which, concentrating in this narrow basin-shaped vale, incessantly threaten to burn up the harvest. But the streams and trees are not enough. She has placed, upon the summit of the mountain above, a grotto, from which there escapes every morning a fresh and light breeze, which tempers the warmth and fertilizes the fields. During the revolution, the people became wise enough to imagine that they could correct Nature, and they stopped up this grotto. Nature resented their ignorant rashness, by scorching the olive-trees and burning up the harvest. Aware of their outrage upon this wise and beneficent mother, who is never offended with impunity, they demolished their wall, and supplicated from the grotto its fresh breezes. The valley resumed its verdure, and harvest its abundance.

The most brilliant spectacles of nature are due to the air. It is in the air, that the clouds are formed, with their cerulean, brazen, and rosy tints. At one time they are coursers covered with gauzy veils, bringing us tidings along the sky from the sweet south. It is there, the magazines of thunder put forth their terrific power. It is thence, that Aurora makes her triumphal entry; and thence, that, in cloud-canopied grandeur, the sun departs to visit another hemisphere. This is the field of rains and tempests, and equally of dews and the light. The rains fall, the dews are condensed, and the streams are volatilized into vapour, and carried back to their sources on the wings of the wind. The greater portion of that order of the universe, most essential to us, comes from this invisible fluid which surrounds our globe, and follows its movements in its revolutions. What a spectacle would the world exhibit without it! Sometimes a fleet zephyr, it plays upon the turf, waves the young harvest, caresses the flowers, and sighs in the groves. Sometimes an impetuous wind, it sweeps along the sky, shakes the summit of the forests, and mingles its sublime voice with the roar of thunder and the resounding billows.

But the winds play a still more important part in the phenomena of nature. Charged with vapor from the surface of the ocean, they traverse the spaces of the sky, driving the clouds before them; and, as the provident purveyors of the world, scatter verdure and harvests in their course. Stifling heats threaten the plains of the torrid zone; and providence forthwith sends the breezes to fan the burning atmosphere.

We can never too much admire the equality, with which the wind distributes clouds, dews and rains. It seems to measure the waters for each climate, each plain and garden.

Again, rains scarcely ever fall in Egypt. From the earliest dawn of spring, this climate is under the scorching power of the sun. Verdure dries up. The flowers hang languid on their stems, and the parched earth seems to invoke the beneficent supplies of water. On a sudden steady winds begin to sweep the atmosphere; and for a whole month bear clouds without rain onwards to the elevated summits of the vast ranges of mountains in Nubia and Abyssinia. On these tempest-beaten summits the clouds do not distil gentle rains, but burst, and pour down torrents, mingling their roar with the crashes of thunder. The swollen mountain streams, the lakes and reservoirs pour their waters into the Nile. The fertile vale of Lower Egypt is entirely inundated, and the inhabitants traverse their fields, and glide among their palm trees in skiffs; while in the kingdom of Gojam, where the overflow received its supplies, and where the inundation would be useless, it flows tranquilly onwards amidst groves and meadows confined to its bed.

You will ask me, perhaps, why providence has departed from its general economy to water Egypt in this remarkable way? Unbelievers would have the country supplied with water by the same showers that feed the fountains of the Nile. Could human foresight have divined, that rains would raise mortal miasms from these burning plains, which are neutralized, and swallowed up by the turbid waters of the Nile? This observation is founded upon experience. For, if by an extraordinary cause, it happens to rain along the plains of Lower Egypt, epidemic maladies, fever and plague, immediately ensue. But, as soon as the banks of the Nile are inundated, the plague disappears. The change wrought in the air is so sudden that the ravages of death are suspended in the same proportion as the waters rise. Providence, foreseeing that rain would be noxious to Egypt, instructed the winds to guide the vapors and clouds towards the mountains of Nubia and Abyssinia.

It requires about eight minutes for light to come from the sun. But what is that light which presents to us the admirable spectacle of the universe? The thunder rolls; man hears, directs, and even imitates it. But what is the cause of thunder storms? The wind blows; its rapidity is measured. Invisible as it is, its elements are discovered. Even its power becomes subservient to human genius. It swells our sails upon the abysses of the ocean; and yet its cause remains unknown. Amidst this mass of inexplicable natural phenomena, scarcely are a few philosophers able to conjecture the causes of things.

If human aberrations could be a source of amusement, it would be amusing to listen to the different systems and theories of philosophers, who have attempted to explain the origin of the phenomena of the universe. For example, St Pierre supposed that the tides are caused by the melting of the polar ices. He imagined that the flood was occasioned by a change in the position and movement of our world, by which the sun traversed the equator at right angles, instead of moving in the course of the ecliptic. A certain philosopher undertook to explain the cause of the trade winds, by supposing them to be occasioned by the agitation of the *lentiscus marina*, which grows in abundance in the seas under the tropics. Demaillet affirmed, that in his view man originated from a fish. Kepler and others insisted, as we have seen, that the world is an animal.

LECTURE XVII.

AIR.

I PROCEED to dwell on the utility of air for the embellishment of nature. Its color is a mild azure. The blue, which bounds our view in the celestial dome, is of that color. The strata of air, which fill the firmament to the height of forty-five miles, produce the same effect upon vision, as plates of glass, when laid the one upon the other. Their color increases, in proportion, as you augment the number. These strata of air cause the blue of the atmosphere to become visible, and prevent vision from penetrating objects beyond, except the stars and planets.

But if light vapors arise of a character, as sometimes happens, to divide these strata, or layers, the horizon enlarges; distant objects open, and the mountains appear. Experience teaches the inhabitants, however clear the air may be, that this unwonted visibility of distant mountains portends a storm.

Habit has hindered us from admiring, as we ought, the harmony which exists between the paintings of nature and the transparency of the air. If nature showed herself to us in a perfect vacuum, she would lose all that freshness and beauty of coloring, with which she is enveloped, from being plunged in a blue and transparent atmosphere.

The gentle breath of heaven seems created for flowers as well as man. It raises their perfumes towards the sky, and takes charge of their winged seeds, to deposit them in the places where nature has designed to plant them. They sail through the air; and the wind is the conveyance, which the Eternal has provided to seed the great garden of nature. Thus, although the vegetables have not the faculty of voluntary motion, they employ the winds to send their little colonies from one plain to another. The mountain trees, the ashes, elms, and maples have winged seeds borne by the winds. The plants which flourish beside waters have seeds with shells, which serve for pirogues, canoes, and boats. Such are the walnut, hazle, and olive.

It seems as if nature had divined that man could only elevate monuments destined to crumble and decay. She piously shelters the ruins of his proud temples, palaces and mansions, with the family of mosses, the ivy, the chelidonium with its broad foliage, and the tribes of creepers that twine their flexile stems around the mouldering columns.

In the north the trunks of trees are clad with a thick and silken vesture of mosses and lichens. They constitute a kind of fur, destined to preserve them from the injury of storms and frosts. On the contrary, in the torrid zone, odoriferous vines cover the lofty trees with their garlands, and form alcoves of verdure, opposing their foliage to the ardors of the sun. The bignonias in our climates raise their large scarlet bells above the summits of the cotton wood and pecan, which glitter in the sunbeams, and attract the ceaseless play of the brilliant humming bird. In the sultry climates these verdant vaults form a dome of flowers, beneath which the tiger-cats, apes and parroquets, creep, run, balance themselves, and dart about with restless agility. Other plants are placed, like immense fans, to protect the young shoots, that spring beneath them. Such seems the destination of the arborescent heaths.

The maternal care of nature has produced still another vegetable miracle, most striking of all. It has created a plant to which the earth is useless, and which, cast upon the desert air, grows there, and multiplies with such rapidity, that in a few years it shades the most extensive forests. The Chinese form domes of verdure with this flower of the air, (*Epidendrum flos aeris.*) Often a whole city is shaded with its alcoves of verdure. Its vine and foliage, which are not nourished from the earth, seem environed and sustained as if by magic.

I have remarked that in the cold climates the trunks of the trees are entirely covered with moss. Nature has been less prodigal of them in the temperate climates. The trees are only covered upon the northern exposure; and this half covering of fur is always exposed to the most cutting winds.

At the entrance of a valley, I remember to have been struck with the aspect of a rustic cottage under a canopy of linden trees. Its walls were covered with massive ivy, among which the great white bell flowers of a beautiful species of creepers stood forth conspicuous. Its roof was garnished with moss, over which fell wild grape clusters in swinging garlands. Nature had embellished this cottage with ivy and laurel plants, which crown the brows of heroes and poets. Walking round to survey the other fronts of this beautiful rustic asylum, I was surprised to find them entirely naked. There were no mosses, no foliage or flowers on the bare walls. In searching the causes of this singularity, I remarked that the other sides were sheltered from the prevalent winds by small hills, while the sides, which faced the entry of the valley, were continually beaten with them. I looked up to that beneficent Providence, which, in arranging the most beautiful order, regarded only the useful; and bestowed a vestment of verdure and flowers on a cabin, to shelter the humble inhabitants from the cold and wintry storms.

The same circumstances take place in forest and orchard trees. I find them enclosed with mosses, lichens and ivy, on the side most exposed to the fierce and pinching winds. The lily of the field, so magnificently clad, neither toils nor spins.

The long moss, of the swampy southern districts of our country, hangs down its pensile wreaths of funereal crape, apparently to warn the inhabitants not to build near the points where it abounds — it being a kind of vegetable indication of the presence of miasms and humidity, adverse to life.

LECTURE XVIII.

AIR.

In the midst of an innumerable multitude of globes, cast by the Divine Hand into space, there is one, whose atmosphere is composed of nearly the same elements, as aqua fortis, or nitric acid. The first of these elements contains the material of devouring flame. It has a power, of which time avails itself, to rust and destroy steel and the hardest metals; and in some of its more concentrated forms, it is the base of mortal poisons. The second element extinguishes flame, and is instantly fatal to the animal that inspires it. What beings, you will ask, can inhabit a world with such an atmosphere? It is man, and this is the air which we respire.

Air is not an element, as, until very recently, was universally supposed. This invisible fluid Lavoisier and Priestley submitted to experiments. Its elements, as invisible as the air they compose, have been discovered. One mortal gas united to another most active and devouring, — such are the elements of air. Separate, they would both have been fatal to all life. United, they are the indispensable aliment of life. Who can doubt the wisdom of that power, who has balanced these fatal principles in a vital compound, in such admirable proportion? Change these proportions in the slightest degree, and you hasten the end of all that has life upon our globe. These two gases, a little changed, form nitric acid, a liquid, which consumes whatever it touches. But the transformation, slight as it is, chemists obtain with difficulty, and by passing the electric spark many times through a mixture of the two gases, which form air. When lightnings dart through the stormy atmosphere, why do they not convert it to nitric acid? On the small scale of our experiments, such would be the effect. But I have no fear. A beneficent Providence so balances the elements, that the vital fluid of our world will always retain its admirable proportions.

Light a taper, fix it in a saucer half full of water, cover it with a glass bell. You will see the flame first diminish, assume a blue color, and then become extinct. The water will arise to occupy the place of the air absorbed by the flame. Children had amused themselves with this experiment, long before it conducted Lavoisier to the most brilliant discoveries. Children, too, had unconsciously analyzed light, by blowing up soap-bubbles with a straw, long before Newton had demonstrated this splendid problem upon the prism. In the experiment of the extinguished taper, you will readily divine that the air absorbed by the fire, was the only part in the saucer capable of sustaining combustion. It is called oxygen. Combined with arsenic, copper, and other metals, it becomes a mortal poison. The gas, which would not burn, is called azote — a Greek term, importing — without life. It makes three parts in four of the composition of air. Cast an animal into this gas, and it instantly expires. But if you make it speedily respire oxygen gas, you restore it to life.

The import of oxygen is, that which engenders acid. But acids have been more recently discovered, the acidifying principle of which is hydrogen. This term, therefore, is no longer strictly exact, since oxygen is not the sole acidifying principle, as was supposed. But it is to this gas, that we owe that multitude of vinegars which make so important a figure in the arts, cookery, and the toilette. It is to oxygen that we owe the bleaching of cloths, muslins, gauzes, and laces.

I have said that oxygen is the only part of air capable of supporting life, and yet it must be united with another gas, noxious to life, in order to temper and modify it. Its power to nourish flame is so great, that a steel wire plunged into it, and kindled, burns with a light too brilliant for the eyes to contemplate, and is soon consumed. To prevent the whole universe from kindling into one sweeping conflagration, a proper balance of azote has been mixed with it.

To comprehend the experiment of the taper, observe that oxygen is combined with a large proportion of caloric, or the matter of heat. You will ask me, what became of the caloric when the oxygen combined with the wax of the taper in the combustion? The answer will instruct you in one of the most brilliant discoveries of modern chemistry.

The attraction of aggregation which exists between the molecules of combustible bodies, being an obstacle to their combination with oxygen, there must be a means of diminishing this force of attraction, in order to produce combustion. Caloric alone has this power. To set wood or coal on fire, is to cause it to absorb oxygen from the atmosphere, and to liberate the azote combined with it. You divine at once what becomes of the caloric, which was combined with the oxygen of the air. In the same proportion as the oxygen appears in a sensible form, there is a disengagement of light and heat. We see, then, that the heat of a body in combustion, is produced by the atmosphere which surrounds us, and not by the burning body itself.

You see that a body which has been burned, has not been destroyed, or a particle of it annihilated. Its constituents have partly flown away in a gaseous form, and a part has been reduced to ashes, combined with the oxygen of the atmosphere.

When you blow the fire, you kindle and increase the flame, by forcing a greater quantity of oxygen to combine with it, in the same proportion as you force it to decompose more air. The fuel is the instrument, of which nature avails itself to disengage and set at liberty the caloric in the fuel and in the atmosphere about it; and the heat and light, which are ordinarily attributed to the fuel, really belong to the atmosphere which has been decomposed by its instrumentality. When one body combines rapidly with another, heat seems to be given out in proportion to the rapidity of the combination. One of the most familiar examples of showing this, is in uniting caustic lime with water in the process of slaking it. The heat is given out with so much intenseness, that in a dark night some degree of incandescence, or a redness approaching that of flame, is seen over the process. This will serve to explain to us what takes place in the process of combustion. The oxygen of the atmosphere unites, with greater or less rapidity, with the carbon, the oil, and inflammable matters of the fuel. Caloric is given out in proportion to the rapidity of this union. It is a property of all bodies to become incandescent, when red hot. Even water, strongly confined in a boiler, and intensely heated, becomes red hot. The air above the ignited fuel, heated to incandescence, presents us that phenomenon which we call flame, and this seems to be the explication of the appearances in combustion.

It is well known that Voltaire was strongly addicted to the study of philosophy, and procured the translation of Newton's discoveries for his especial instruction. Perhaps had he been acquainted with the modern discoveries in chemistry and philosophy, the pernicious activity of his mind would have been absorbed and occupied in those interesting studies, and his writings against Christianity would never have appeared. Unhappily his philosophical pursuits were arrested in their commencement. 'I have renounced the study of physics,' he gaily observed one day, 'because, in blowing my fire, I began to reflect, and to ask, why fuel made fire? No chemist, no philosopher could tell me.' No experiment had reached the solution of this most familiar fact. At this day, the fair pupils of our female schools can explain the phenomenon that confounded this witty writer.

LECTURE XIX.

AIR.

In touching upon the harmonies of the animal kingdom, I propose to attempt to describe to you what passes within us in consequence of the act of respiration. A little air is inhaled by the lungs. On that depends our life. By what operation does the air acquire this property of nourishing vitality? I give you the thoughts of Lavoisier upon this most interesting question. The blood, in passing from the heart to the extremities, gives out its caloric to the body; and in losing its vitalizing principle, oxygen, loses its bright, flame-colored scarlet, and becomes purple. Nature, sensible that it requires to be imbued anew with oxygen, collects it from all the surfaces, and drives it back to the fountain, where continued inspirations of the lungs impart oxygen to it again, as the bellows kindles the flame to brightness. It reacquires its lost caloric and its bright scarlet color, and is impelled onward to the heart, and thence to the extremities. Again it parts with its caloric, loses its oxygen, again to return and be supplied anew with the principle of vitality. This perpetual circle of movement in these our fearful and wonderful structures, sustains life and prolongs the mysterious secret of existence.

The discovery of the circulation of the blood, strange as it may seem, was reserved for a very recent period. This discovery is commonly attributed to Harvey, an English physician; though there are sufficient intimations in the writings of Michael Servetus, the celebrated Genevan victim, that he was acquainted with the fact. But long after this discovery, the world remained in ignorance respecting the cause of the difference in color between arterial and venous blood. It was not, until the beautiful discoveries of Priestley and Lavoisier, that the cause of the scarlet color of the one, and the purple hue of the other, were amply explained, and the analogy between vital warmth from respiration, and heat from combustion, was well understood.

The air, which passes into the lungs, undergoes a real decomposition. Having given out its oxygen, and become mephitic and noxious to life under the name of carbonic acid gas, it is expired. Frail condition of man, who lives by poisoning the air which gives him life! Thus we see, that the purpose of respiration is to furnish oxygen and caloric to the blood, and, in decomposing it, to disengage from it its noxious principles. A current of oxygen gas is thus blown upon the lungs in respiration, as the bellows force it upon the burning fuel in the process of combustion.

There was more than poetry in the ancient comparison of life to a burning torch, which only burns by consuming itself. There is a stronger analogy, than the ancients divined, between respiration and combustion. To respire is to burn. A taper inclosed in a vessel of atmospheric air becomes extinct as soon as the oxygen, contained in the vessel, is entirely absorbed. An animal, placed in this vessel afterwards, expires in a few moments. It is something more than a figure in poetry, to say that we carry within us a torch of life, which, like ordinary flame, has need of air to sustain it. Though the flame does not burn to the senses, the breath we exhale is a kind of smoke. In effect, this vapor has the same properties as that from burning charcoal, and like that is carbonic acid gas. This gas extinguishes flame, and is fatal to the animal that respires it.

You divine from this view, that oxygen gas, in combining with the blood, gives out its caloric, which communicates the vital warmth to all living bodies. The animal which has lungs of great strength, and which respires often, would naturally be expected to have a higher temperament. This is found to be the fact. Tortoises, frogs, and lizzards, which have an icy feeling to the hand, scarcely respire once in a quarter of an hour; while birds, whose lungs and respiratory vesicles fill the cavity of their breast, and the bodies of which are penetrated by air, respire fifty times in a minute, and their temperature is high in proportion. In the bitterest inclemency of a Canadian winter, when all nature was bound in chains of ice, and enveloped in a thick covering of snow, and when the thermometer was thirty degrees below zero, I have admired to see a little bird of the class of the pies, not larger with all its plumage than the end of the thumb, skipping and chirping on the icicles, as though it were a vernal morning. What a mysterious process of life must that be, which communicated vital heat to such an atom, in a degree to enable it to remain warm and full of life, when the lion and elephant would have survived the cold but a few hours! It is of no consequence, whether the works of nature are reared on a large or a small scale. They are as perfect, in their minutest forms, as in the largest. The Chinese have put this phenomenon of the warmth of birds, during severe cold, to profit; for we are told, that in the severity of winter, they hold quails and partridges in their hands for gloves.

We have seen that plants have a certain sort of sensibility, that they have sex, that they make love in their way, and rear families. We need not be surprised, therefore, that they respire, like animals. Their leaves, gently agitated by the breath of the sky, are a species of mouths, through which they absorb, and exhale air.

How does the air always preserve the same purity? Why does not the respiration of so many millions of animals, all emitting steams of carbonic acid gas, corrupt it in a moment? Oxygen, we have seen, is the beneficent gas appropriate to human life. But plants prefer azote, hydrogen, and carbonic acid gas. What a wonderful action and reaction of Providence! Animals would pollute the atmosphere, if vegetables were not perpetually absorbing that noxious air which the animal kingdom exhales. Thus each in its contrary action is necessary to the other. But for the absorption of noxious air by the vegetable kingdom, man would perish. But for the creation of a supply of those gases the vegetable kingdom could not exist.

The earth does by no means furnish, as is commonly supposed, all the elements necessary for the growth of plants. The juices, the perfumes, the fruits, the vegetable tribes which nature incessantly renews with the seasons, derive much of their aliment from the air. The delicious pulp of the peach, of the orange, pears, plums, ananas, the multitude of melting fruits, with which autumn fills her horn of plenty, the fresh rose bending under the pearly dew, the proud oak, the superb cedar, the baobab, that giant of trees, which covers whole acres with its shade, are little more than consolidated gas, to which nature, elaborating them in silence, has imparted their peculiar properties on a basis of air. How incomprehensible are the works of this mysterious power!

It is not enough to purge the air of noxious gases, that plants exhale the vivifying gas of oxygen. That decomposition of water, which science considers it one of its proudest triumphs to have accomplished, has been hourly effected, from the beginning of the world, by the feeblest plant. We are surrounded with multitudes of little, silent chemists, who incessantly drink the hydrogen of water, and disengage its oxygen so friendly to animal life, and diffuse it in the air. Thus all those green surfaces, those flowering meads, those verdant groves, those velvet turfs, which delight our eye, continually lustrate the atmosphere by emitting a quantity of oxygen equal to that which the animals destroy. The respiration of vegetables sustains a perfect equilibrium with that of all living beings. We furnish them the supplies of carbonic acid gas, as they prepare for us the requisite abundance of oxygen. This invisible correspondence between the vegetable and the animal kingdom gives birth to one of the harmonies of the universe. With what different eyes must we contemplate the glorious and beautiful nature that surrounds us, after this information! What stable ground for confidence in the beneficent being, that has thus arranged every thing in nature by weight and measure!

We may imagine that this harmony between vegetables and animals is interrupted during the total cessation of vegetation in winter. Contemplate anew the wisdom of Providence. The storms of winter are among its benefits. They establish an aerial circulation between the poles, the tropics and the equator, and equalize the oxygen of the various countries of the world. Besides, immense numbers of terebinthines, and trees always green, which send their salubrious exhalations abroad, are reserved for the colder climates. The lichens and mosses subserve the same great purpose. They are sources of oxygen perpetually flowing from the north to the south. Thus tempests, which threaten the destruction of nature, are found to be among its conservative laws. At the view of these wonders can we avoid discovering why this transparent fluid, which forms the atmosphere, has been placed between us and the abysses of space, to bring us light and heat, to bear the clouds which fertilize the earth, to supply aliment to fire, without which it would become extinct, to renew and sustain vegetation, to serve as the medium and vehicle of sound, and to give life to all creatures? Behold the singular dependencies between this invisible fluid and man, between man and a planet of fire, between this planet of fire and the world! Admirable harmonies, which cause, that the heavens, the earth and air, plants and animals, winds, storms, water and fire, all concur to the well being of a thinking atom, lost upon the surface of a globe, which is itself lost in the immensity of space!

What a distance separates a spire of grass from man! Yet our life depends, by a double necessity, upon the existence of the frail tribes of vegetation. Astonishing creation, from which you can take nothing without the destruction of all! Saadi's beautiful Persian fable of the nightingale and the rose proves that he understood, as a philosopher, this harmony, which he sung as a poet. The nightingale is imprisoned in a cage of glass with a rose bush blooming with roses. Each owes life to the other. Deprived of fresh air, the bird would soon cease to swell its little throat with harmony. The rose greedily absorbs the air which has been respired by its loved philomel, and blushes to brighter tints; respires, transforms, and returns it purified, to be inhaled anew by the bird of song. As often as the nightingale decomposes the air, the rose neutralizes the poison in its own bosom, and sends back pure air to its fellow prisoner. When the bird at length expires, in singing its dirge of gratitude, the rose bush withers and dies.

LECTURE XX.

CARBONIC ACID GAS.

Carbonic acid gas will be the subject of this lecture. This is the product of the combustion of charcoal with oxygen. Its gravity shows one more of the innumerable instances of the foresight of nature. You recollect, that it is from this mephitic gas, that plants draw almost all their nourishment and life. Behold the reason why its weight brings it to the ground, while the other gases preserve more or less elevation, according to the wants of man. The gas, of which I speak, is often found in caverns, wells, and deep places of the earth; particularly at the grotto *del cani* near Naples, and at the baths of Cæsar at Mont d'Or. These mountains are full of caverns, from which it escapes. This air filled the melancholy cave of Trophonius, and, mixed with other gases, probably formed the intoxicating combination that produced the contortions and the inspirations of the Pythian priestess of Delphos. Thus a little mephitic air originated oracles, which settled the destiny of nations.

Dogs, from which the grotto *del cani* derives its name, cats, and all other animals, die instantly upon being plunged into this gas, as it issues from the cave. From the Rock Spring at Saratoga, a stream of this gas is constantly emitted, which produces the same effect upon animal life.

We pass from this mephitic gas, the product of charcoal, to the most brilliant substance in the universe, which decomposes light, and reflects all the colours of the bow, decks the bosom of beauty, and shines in the diadem of kings. This substance, called diamond, is pure charcoal. We owe the knowledge of this fact to Lavoisier, Tennant and Guyton Morveau.

I shall not be able to repeat to you the numerous and beautiful experiments of these great men. It is sufficient for you to know that carbon is one of the bodies which nature has most extensively diffused in the formation of the universe. It makes more than half the composition of vegetables and animals; and is found combined with minerals.

I have been astonished that geologists, who have so long and earnestly sought for the elements of the universe, have never imagined it to have been formed from an immense diamond. What a beautiful spectacle, to behold the world springing from chaos, in the form of a huge brilliant, whirling upon its axis, and emitting torrents of dazzling light! Would you prefer to suppose with Buffon, that the earth was a spark struck off from the sun; with Burnet, that it was at the beginning a bowl full of water; or with Palissy, that it was a shell? What a charming opportunity for me to bring forward my system; or if you prefer it, to prove, that there is no idea so extravagant, that it may not be rendered plausible by a theory sustained by seductive reasonings! I could write a large book to prove that a world of diamond is the most beautiful and feasible form of a world.

Recollect that carbon is the base of vegetables and animals, and is found diffused over the whole surface of the earth. If it be true, that this element is distributed with so much profusion, and that stones and trees include carbonic acid gas, as chemists prove, imagination has little more to do to make a world of diamond to my hand. I see in the present form of the world proofs of its primitive condition and ancient opulence. O happy epoch for queens and beauties, when the undue proportion of the sun's rays and the oxygen of the atmosphere had not yet converted this globe to earth, vegetables and dark mould! Science is about to renew that age, not of gold, but of diamond. Already the forest trees are transformed to columns of diamonds. Their branches, flowers and fruits are in our eyes so many mirrors, as luminous as the rays of the sun. The meadows put forth brilliant adamantine flowers. The flocks and herds graze and bound under a crystal canopy of transparent splendour. Bread, vestments, air, all is diamond! While the sun darts his rays upon these glittering prisms, man, dazzled with finding himself in the midst of a globe of light, becomes himself a diamond!

To operate these prodigies, it is only necessary to find the secret of reducing charcoal to the state of pure carbon. Nature would then present the dazzling spectacle, of which I have here given you a sketch. In waiting for this discovery, I hasten to propose to our fair the cheaper substitute of bracelets and collars of charcoal, one day to become pure diamond. Fashion, as you know, has the power to embellish every thing.

But this gas, which serves to form foliage, fruits and harvests, produces effects not less surprising in the interior of our globe. It is probable, that to its combinations in perpetual operation, we may attribute the formation of metals and minerals. Earthquakes, water-spouts, volcanoes, meteoric stones seem, also, to owe their origin to the different aerial elements in combination with carbonic acid. The gases circulate in the depths of the earth, as the blood in animals. Perpetually varying, and renewed by their affinities, we can no where descend deep into the earth, without encountering their effects. Hence miners are often the victims of carbonic gas, which gives them apoplexy; or hydrogen, which takes fire, and destroys them, as with a lightning stroke.

I would be glad in this place to relate to you the affecting narrative of Goffin and his fellow laborers, who were assailed at once by water and a blast of hydrogen in the coal mines of Beaujou. Europe still remembers their misfortune, and the heroic efforts of their magnanimous leader. A blast of gunpowder opened a reservoir of water upon them, which barred up their ascent to the surface, and was continually gaining on them. Goffin, not daunted with the cries and despair of the company, thus shut up in the bowels of the earth, with these destructive elements, encouraged them and his young son to great efforts, to open to themselves another passage to the air. In making these exertions of despair, another blast opened upon them a torrent of hydrogen gas, in a state of inflammation. Even that terrible conflagration reached not the part of the mine where they were collected, and passed without destroying them. Goffin and his young son, who had hitherto kept their torches burning, encouraged, and harangued their fellow prisoners to new efforts, until their torches burnt out, and left them in this sepulchre without a ray of light. Three, four and five days past away without bringing any hope, and famine added the last horror to their condition. At the close of the fifth day they heard an uncertain and heavy sound, which seemed to come from above. They are transported a moment after with the cries of their friends and parents. They are drawn up from this terrible tomb, to see the pleasant light, the green forests, and their peaceful cottages.

LECTURE XXI.

LIGHT.

In this lecture, I shall consider light and caloric in some of their relations with physics, chemistry, and natural history. Is the fluid of light a subtile matter which fills all the sphere of the universe, and upon which luminous bodies impress agitations which are transmitted, one after another, as the vibrations of sonorous bodies are transmitted through the air? Such was the hypothesis of Descartes, admitted, as we have seen, by many modern philosophers. Does light proceed from an emission, or radiation, of real particles from the luminous body, darting, by the effect of continual agitation, from all sides of the body? In this hypothesis, which is that of Newton, light — at least in regard to the manner in which it is produced — resembles the corpuscles emanating from odoriferous bodies.

But, before I treat of light, I must be allowed a word upon night, the friend of wisdom, and always loved by the contemplative. It was during the night, that Galileo divined the true system of the universe. It was in a dark cell, that Newton analyzed the seven rays of light, and Fontenelle wrote his *worlds*.

There is an admirable harmony between night and sleep. The eye, no longer irritated by light, closes. The ear no longer disturbed by sounds, permits the spirit to yield to the charm of repose. Many of the vegetables seize this opportunity to sleep with man. Every evening, we see the bells of the convolvulus, and the petals of the lion's tooth, close. The *draba*, that raises its little silvery head upon the turf, the trientalis Europæa, and the impatiens balsamina, recline their supine heads at the dim approach of twilight; while the *nenuphar* plunges its cup under the water, and only reappears with the morning. While these flowers sleep upon the turf, lulled by their perfumes, other flowers gently awaken, and unfold their light veils. The nocturnal vanilla, whose corolla is inodorous to the light, during the night exhales the most delicious fragrance. The *tree of sadness*, of the Moluccas, awakens during the darkness and sleeps at the dawn; while the mirabilis jalapa and the nictantes sambac, open their perfumed cups, and seem to enjoy the coolness and repose of night. But, finding myself alone under the star-spangled canopy, I turn instinctively from these transient tenants of the fields to the aspect of the numberless suns, that crown the diadem of night. My spirit expatiates in the infinite space, and is conducted, in contemplation, to the throne of the Eternal. Can we fail to think of the time, when the spirit, emancipated from its prison of clay, shall see all these suns burning in their onward course beneath her feet? How grand, how majestic is this vault! Where are the columns that support it? Where are the beams of those chambers, through which the stars roll their everlasting courses? Could we reach the limits of this dome, another, and still another, would glisten with stars beyond. And where is the end?

The swiftness of light may give us some idea of the immensity of space. We perceive the sun eight minutes after it has risen; that is, its light reaches us in eight minutes, passing through more than a hundred million of miles. A cannon-ball would require eighteen years for the same passage; that is, light is more than a million times swifter. Prodigious as the distance of the sun appears to you, attempt to imagine that of the nearest fixed star, whose light would be six years in reaching the earth. It is six years since the rays, which now render this star visible to you, emanated from it. Suppose it annihilated, you would continue to see it for six years to come. If the Eternal has created stars only a thousand times more distant, and our world has not yet existed six thousand years, there are stars, however brilliant, however great, whose light has not yet reached creation. Herschell supposes that there are stars, whose light will require two million years to become visible to the earth. How little is man, how short is life, how vast is immensity — how great is God! Piety cannot fail to result from the study of astronomy.

Shall I say nothing of that peaceful moon that rolls along the azure of the firmament? Consecrated to melancholy and love, it is the star of poets and lovers. Its silvery tide, poured from amidst the stars, diffuses the secret of meditation and profound thought. The sun is sinking in crimson splendor from our eyes, while the people of another hemisphere, at the same moment, behold the glorious orb arising in the splendor of morning.

But when he disappears from our view, another planet receives his rays, becomes illumined, and reflects upon us the tender and softened light which it has in charge for us, when the sun has gone to enlighten another world. I am ignorant of the extent of that influence, which this planet exercises upon the inhabitants of the air. But we know that, by its soft light, the nightingale awakens its sweet and melancholy strain. There are countries, where it has the same influence upon all the birds. A celebrated navigator relates, that, in an isle of the south sea, near Otaheite, the songs of these musicians of the air, are only heard for some hours after midnight. The melody ceases with the first ray of morning.

The moon seems to exercise an influence of another sort upon some kinds of nocturnal fishes. Every year the young eels, which are bred in the *lagunes* of Commachio, near Venice, move out of the water in shoals, cross the meadows, and, guided by a mysterious instinct, throw themselves into the sea. But this emigration only takes place during dark and stormy nights; and the feeblest light of the moon arrests their march. Let that planet appear in the sky, and the slippery caravans pause in the grass, as if terror-struck. But, the moment a fleeting cloud veils the moon's disk, they resume their march to the sea.

To this real influence of the moon, I add a word, touching the influence which the superstition of past ages assigned to it. It is wonderful to hear the great historian, Tacitus, describing the effect of this planet upon the revolted Roman legions, during the reign of Tiberius.

When the revolt commenced, this planet was moving in a sky without a cloud. In the midst of the tumult, its orb began to darken in an eclipse. The cause of this prodigy being unknown, the soldiers saw in it a presage of the destiny of their insurrection. They exclaimed, that if that planet should resume its light, their cause would triumph. To aid the moon to regain its lustre, they made their camp echo with the clang of steel and the sound of trumpets. Their confidence fell, as the moon became more obscure. At length it was totally eclipsed; and the courage of this infuriate multitude, which had braved the sceptre of the terrible Tiberius, sunk in consternation. The silence of death succeeded their acclamations, and the din of their arms. The fiercest were persuaded that heaven, in wrath, announced to them perpetual misfortune and defeat. They implored the clemency of their chiefs, and hope returned to the camp with repentance. Tiberius had now only to punish; and with him, this was to reign. The empire of the world would have crumbled, if the moon at that emergency had not been in eclipse.

Before we jest with the superstitions of the Roman legions, let us consider some of the weaknesses of modern sages. Let us look into our calendars. Let us recollect the various and opposite influences there attributed to the moon; and we shall see, that there has been the most laughable credulity elsewhere, beside among the soldiers of Tiberius. For example, our farmers consulted the moon to know when to kill their cattle and swine, when to perform operations upon their domestic animals, and when to cut their bushes. No rural process would prosper, commenced in the dark of the moon! Observing that, on the return of the vernal moon, vegetation sprang up as if by charm, they concluded that a certain period of the moon was peculiarly favourable to planting, sowing, and pruning. From the world of nature, this faith communicated to the world of mind, and poets wrote verses, and theorists projected systems by the influence of the moon. I know certain authors who have more or less genius, according to the phases of the moon, and whose inspiration evidently proceeds from that planet. While I write, the moon is in its last quarter; and this, I hope, will extenuate any follies you may find in this lecture. I hope to gain your indulgence until the new moon shall have inspired me with a hundred interesting facts which remain to be developed.

LECTURE XXII.

LIGHT.

According to Descartes, motion comes from the sun, and is the only cause of light; and the matter, which this motion is destined to render luminous, is diffused through space, and surrounds us upon all sides.

This system was for a long time abandoned; but, in modern physics, it is again coming into favour. Those who would be thought sage at present, believe that the matter of light exists around us by night the same as by day, and only wants the property to be visible! The sun causes light to be seen, as motion causes sounds to be heard through the medium of the air.

When you light a lamp in the night, then you only give motion and impulse to the light which surrounds you. Your torch exercises upon a little portion of luminous fluid, the same influence which the sun exercises upon the ocean of light, in which our world is always plunged.

But if you object to adopting this system, I present you another to which this gave place, which, in its turn, waits perhaps, for some more recent theory. It is that of Newton. 'Light,' said that great man, 'flows in torrents direct from the sun.' Imagine, if possible, a rain of light which every morning fills the immensity of the sky, and falls through space with such fearful rapidity, that a ray of light, proceeding from the sun, arrives on our globe in eight minutes. This ray, like an immense filament of gold, spins out without interruption, touching at the same moment the sun and the earth.

It should seem that the world would be reduced to dust by this torrent of fire, which strikes, penetrates, and enlightens it. But the rays are so light, that they inundate objects without augmenting their weight; so fine, that it is impossible to collect them; so powerful, that the most formidable winds never cause them to diverge; so weak, that the slightest cloud is sufficient to arrest them; so penetrating, that they pass through the hardest rocks; so terrible, that their concentration would inflame our globe; and so full of life, that their presence covers the earth with verdure and flowers. Light is, perhaps, the single element of the worlds.

Why is this element never exhausted? The sun is perpetually pouring torrents of rays into space, and yet from age to age shines on with unabated splendor. Philosophers propose the example of a grain of musk, which, for years, diffuses round it to a considerable distance millions of odoriferous particles, without sensible diminution of weight. But the size of an atom of musk, though altogether invisible, is enormous, compared with that of a sun-beam. Imagine, if you can, the extreme tenuity of a globule of light which enters the eye of a *mite*, or a gnat, and the inconceivable diminutiveness of the images which it conveys to the sensorium of those animals.

If you want confidence in these remarks, I give you the demonstrations of Baron Lindeneau, or what he considered such. 'It is proved,' according to this philosopher, 'that the successive consumption of the sun, from the beginning of the world, is not yet visible to our eyes. Suppose its diameter nearly a third of a million of miles; or, in astronomical phrase, two thousand seconds of a degree. But as there is no astronomical instrument with which we can measure the diameter of a star to the exactness of a second, the sun may diminish onē two-thousandth of its diameter, without the possibility of its being perceived. Suppose that the sun now diminishes two feet of its diameter a day, it would require six thousand years to consume two seconds of its diameter, and six millions of years for its entire consumption.' For me, I have no faith in its diminution in the slightest possible degree. Whatever be the nature of light, I am confident that there is a balance between the emission, and some inexplicable mode of supply. The Creator has not left upon any of his glorious works such an impress of imperfection, as this tendency to decay would suppose.

But, if you are dissatisfied with the theory based on the grain of musk, and the seconds of baron Lindeneau, I present you with other solutions. Buffon, after Newton, will tell you, that comets fall into the sun to replenish the loss of its rays by these perpetually radiating streams. It would seem from this view, that these wandering masses of light journeyed to the utmost verge of the sun's orbit, to collect the dissipated rays, to add them to its accumulating mass, and to travel back, to return and deposit them in the immense fountain, from which they emanated, to radiate and return by the same process.

If you are dizzy with these empyrean calculations, let us dismount from our aerial steed, for we perceive a glow stealing upon the fair face of nature. New scenes open without end in the distance. Mountains rise; forests wave; cities emerge from shade; and yet the star of day is not visible in the east. How has his light preceded him, in reaching us?

Nature, in passing suddenly from profound darkness to the full blaze of day, would have fatigued the human eye. A tender twilight, a softened radiance, prepares it for the full splendor of light. Admirable wisdom, which derives the most beautiful spectacles of nature, those of twilight, from an arrangement accommodated to human weakness.

Philosophers attribute the phenomenon of twilight to our atmosphere, which, before the sun ascends the horizon, deflects his first rays, and turns them from their direct course, to send them down upon our earth. These properties of light and air procure for us the charming softness of twilight, and the grace and beauty of the dawn. The Eternal caused the air to refract light, when the dawn of twilight ushered in the first morning.

Thus the wind, which fills our sails upon the great deep, the atmosphere, which we respire, is the source of a thousand benefits, of which the multitude are ignorant. The heavens owe to it their azure, and the morning the softened light of the dawn. The azure of the celestial vault is but air. The first steps of morning in the horizon, those golden masses of light, are but the play of the atmosphere. The breath of the Eternal, in the form of air, has spread out this shining dome above us, which the ancient sages believed to be solid chrystal, or diamond.

The power of the sun seems to be the principle of vegetable life. Yet what an astonishing distance between this star of fire and the lily of the valley, that it colors and nourishes! What a wonderful relation between a globe, a million times larger than the earth, and the eye of an atom lost in space! When we note the influence of this planet upon our world, we are almost tempted to believe, that Providence has imparted to it a foresight of the wants of man. Observe the singular fact, that the dry fruits, as almonds, filberts, chestnuts, walnuts, in fact the fruits of all the papilionaceous plants are found in cool countries, and ripen in the cool season of autumn; while, in the midst of the highest heats of summer, our gardens present us gooseberries, raspberries, cherries, plums, peaches, apples and pears; and those of the tropical countries oranges, lemons, bananas, mangoes, and a variety of similar fruits, which offer their succulent pulp, or their acid juices to the thirsty and panting inhabitants. This phenomenon is exactly contrary to the common law of physics, which is, that the high heats of summer should evaporate the fluids of fruits, and dry up the verdure of the foliage. On the contrary, these fires of the sun elaborate fruits full of a delicious juice, and refreshing drinks, ripening them in succession, according to our wants.

I cannot resist the desire of giving you a brief outline of the succession of flowers, from the vernal violet to the helianthus of autumn. The yellow stars of the ragwort shine upon the borders of the waters with the first swelling buds of the trees. Soon after, the daisy with its golden disk bordered with rays of silver and carnation, enamels the meadows. To this succeeds the aquilegia, with its cups of porphyry; the stem of the polygala, which seems covered with violet curtains ; the blue drapery of the veronica, and the globular azurea, whose round head, gently agitated, seems to roll upon the turf. Still later the eye reposes upon the white cistus, which goes to sleep with the sun. It contemplates the yellow curtains of the hederaceum, and the red stripes of the crepis, whose little flowers sleep in the evening, and awake in the morning. Every plant and flower is soon in preparation for a higher office, and the coming season. A slight bud folds up the veiled roses of the epilobium. Blades of grass conceal the campanulas with their blue bells, the perfumed wreaths of the origan and the superb spiræa, whose white tuft raises it from the turf, like a queen on her throne.

Such is the magnificent spectacle which the sun diffuses over the earth. The gigantic monarch of the firmament, he does not indeed crown his head with flowers, but sows them under his feet. He does not store harvests in his shining globe, but causes them to spring up under the hand of man. Though the source of light, he paints not his own burning disk, but decks nature with the richest colors. Immense as the universe, he is at once in all places, without even moving from his place. With the sacred poet, we may say, he displays his power in the sky, and the earth is resplendent with his wonders.

LECTURE XXIII.

THE DARKENED ROOM AND THE EYE.

'I WAS on a visit,' says Aimé Martin, 'to a female friend equally amiable and instructed. A city, mountains, plains, ships and the blue sea were under our eye. I expressed myself with enthusiasm in regard to the beauty of the prospect.' 'I have often attempted,' she replied, 'to paint this landscape, but with no adequate success. I lose myself in details, and the assemblage, overloaded with them, wants

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grace and majesty.' I replied, 'It is because art cannot reach nature; but allow this nature before us to paint herself, and you will be satisfied with the production.' 'I do not comprehend you,' was the answer. 'Let us close the shutters then,' I rejoined, 'and the fact will explain itself.' 'When we are in utter darkness, I presume we shall have a picture worth seeing,' ironically exclaimed my friend! 'You think me jesting, I perceive,' said I. 'But to the point, and I will show you how nature paints herself with the utmost accuracy. Are you not informed, that Heraclitus, the more profoundly to contemplate nature, made himself blind? Know you not the paintings of the blind bard of Greece, spectacles of a brilliance, that three thousand years have produced nothing to equal? Are you not conversant with the astonishing "Paradise Lost" of Milton, who was also blind?' My friend bade me proceed to my work of enchantment. I closed the windows. She regarded me, the while, with surprise. I had placed a convex mirror near a circular opening in the shutter, and arranged a royal sheet of white paper vertically at some distance from the opening. The mountains, plains, herds, cottages, churches, the ships and the sea were seen painted in admirable proportions and justness and delicacy of coloring. What excited more admiration was, that this picture was not only true, but animated. The pines waved to the zephyr. Their shade followed their graceful bending, and shadows coursed over the sun on the forest tops. The ships moved upon the sea. The sea-fowls were flitting over the waters. The lambs bounded, and the inhabitants came forth from their houses.

My friend was in an ecstasy of delight and surprise, and could not enough admire to see nature paint herself so beautifully in miniature on a sheet of paper. After a steady contemplation, she remarked, that all the images on the paper were inverted.

I answered, 'every body radiates the luminous rays, which the sun has imparted to it. These rays are reflected, and bring me the image of the body, to paint it at the bottom of my eye. But the rays in converging upon that point cross each other, and thus produce an inverted painting. What you see on that paper may serve for a description of vision. The darkened apartment is the interior of your eye. The circular opening of the shutter is the pupil. The convex glass is the crystalline; and the retina performs the office of the sheet of paper, where you see the painting of external nature.'

'Is it possible,' she exclaimed, 'when I see a beautiful country, immense plains, high mountains, the sea, the sun and the sky, that the whole scenery is painted in miniature on my eye? That so small a space can receive without confusion such vast and diversified scenes, and that light can multiply itself to a degree to bear the same image to millions of percipients at the same time?' It is precisely so. The eye is the darkened room, in which light paints nature.

But my friend, apparently desirous of confounding me, added earnestly, 'We have two eyes, on each of which this scenery is painted. But we neither see objects inverted, nor double.' 'Argus,' I replied, 'had a hundred eyes, and Polyphemus but one. But the beautiful Io was seen, a single fair one, by the hundred eyes of Argus, just as Galatea was by the single eye of Polyphemus. The ancients thought to explain this fact, by comparing it to the single tone given by two lyres, whose strings are tuned to unison. In most animated beings the two optic nerves, which proceed from the eyes, unite, and run into one, before they reach the sensorium, and of course carry but a single image there. If the nerves could be separated we should see objects double. This probably happens to the chameleon, whose visual nerves do not unite.'

Certain confident metaphysicians would go farther, and explain to you how this motion, and these species flying from bodies cause a slight vibration in a certain nerve, which carries these species, as images to the brain, and how this impression, communicated to the commune sensorium, produces a corresponding impression upon the mind, which places these inverted images upright, and gives birth to ideas. Much theory, possessing a great show of learning has been brought to bear on the subject; and we have been introduced to an exceedingly comminuted and ethereal matter, intermediate between brute matter and mind, by which a communication is established between that, which has parts and material properties, and mind, which is said to have none, and which results in the production of ideas. As I regard the communication between matter and mind utterly inexplicable by the human faculties, I shall pass all these theories by, only observing, that if you join two philosophers in consultation, you will be almost certain to have three different opinions, varying to infinity, if you could make an infinite number of changes of philosophers. One of the most important points of science is to teach us, where we are ignorant, and where attempted investigation will be thrown away.

Why should we stumble upon inexplicable theories of mental philosophy, when the study of the eye offers a sufficient number of accessible and interesting prodigies, to occupy all our intelligence? It would be a delightful task, for example, to paint the aspects under which nature shows herself to the vision of different animals. The eyes of a gnat and an elephant, a fly and an eagle, do not contemplate things in the same magnitudes and relations. Reaumur speaks of certain ephemera, that have eyes of two colors, which see on one side meadows of gold and azure, and on the other plants of the color of purple and the rose. Every insect has its vesture. The most brilliant colors have been lavished upon all. Some are covered with diamonds, others with all the colors of the bow. Some, as the glow worms, have received a glittering spark, which they kindle, and extinguish at will, as they fly in the dark. Whether we examine the classes that fly, hum, or crawl, they each show us a world of prodigies. Some, like those of the sage insect, present a tissue of symmetrical meshes, wavy, and sowed with tufts and knots of crystal. Others, as those of the mercurial, form a silken bar, embroidered with gold. The borders are ornamented with a fringe of spherical and translucent pearls, whose pendant clusters form into a circle, like a dazzling garland. No doubt, they enjoy the spectacle of each other's beauty; for they have eyes to see, nerves to feel, and an organization to enjoy, as perfect in its kind, as that of man.

I recently contemplated a little bug, of a family common on the Ohio, through the solar microscope. To the naked eye its feelers were visible, and blended colors of green and gold on its oblong body of thrice the size of a pin's head. What a spectacle was presented! The feelers had an apparatus of hair and feathers, and showed formidable trunks, like that of the elephant. But what a glorious field appeared in the compartments of the body! How perfectly regular the stars, gems, and parallelograms! There were the richest colors in nature. There was the regularity of the geometer's square and compass. What oriental splendor must have been in all this proud show to kindred insects, whose eyes magnified still more than my solar microscope! I doubt not, that the fortunes and movements of this mite inspired as much interest and curiosity among its fellows, as the journeys of our presidents and cabinet ministers among us.

If a certain species of butterfly, whose head is crowned with thirty-four thousand six hundred and fifty eyes, perceived the images presented by vision with each eye, in separation, what a multiplicity of pictures would be painted on the brain of the insect! * Every morning a prodigious number of suns, preceded by as many twilights would shine for it, and its day would show as many dazzling suns as our night presents stars. You may easily imagine, that there are philosophers among these butterflies; and that they devise beautiful systems touching the worlds and light. But it is more profoundly, during night, that they theorize upon these high subjects. The thirty-five thousand moons which rise together and trace their paths along the azure of the firmament, in which the stars are multiplied to infinity, occupy no doubt all their astronomical speculations, present to them spectacles of splendor, of which we can form no adequate idea, and suggest to them thoughts not yet dreamed of in our philosophy. To operate all these prodigies, nature only took occasion to deck the head of the butterfly with a prism, and puncture it with a sufficient number of apertures.

The eyes of fishes would suffice to offer us a mass of considerations of the same character. For example, the fish called the sea-devil, a kind of ray of the gold coast, has received two eyes, of which the one is placed on the back, and the other under the belly, in such a manner, that it sees at the same time the fishes playing in the depths under it, and the stratagems of the birds that skim the surface of the waves. This observation will apply in some sense to most of the fishes of our lakes and rivers, that see objects to their right and left at the same moment. Their optic nerves are separated, and convey two distinct images to their brain.

While the eagle, whose eye is a telescope, plunged in an orbit like a tube, throws a piercing glance through the far depths of space, he discovers, perhaps, the satellites of Jupiter, and the seven glittering moons of Saturn, of whose existence men were so long ignorant. The moon is seen by him, not as by us, a globe of luminous ice, but an aerial isle suspended in space, which has mountains, volcanoes and seas. He embraces in his broad ken the whole of our world, and, while lost to our view in the clouds, he casts down a lofty glance upon humble mortals, creeping along the surface of the earth, and disputing for the possession of its little nooks, that they call empires; while he, free king of the air, soars majestically in a sky, whose miracles are all unfolded to his vision.

Two microscopes modify the view of the horse to such a degree, that objects are painted in immense magnitudes upon his retina; and the child, that guides him, seems to him of colossal size. Nature, in submitting him to our power, has caused him to view us under an illusion, which conceals our weakness from him. By a phenomenon of another kind, the dog, of which man has made a friend, neither discerns, nor chooses by sight. His eyes, being comparatively useless, he sees no difference between men; and it is by smell alone, that he knows his master. If we could annihilate the air between him and those he loves, he would not know them, and would bark at his master as soon as at a stranger.

But man is as much alone among all other terrestrial beings, in regard to vision, as to his other faculties. Light, before it brings to our soul the image of objects, paints, colors, varies them, softens their shades, and only presents them in their richest vesture. This azure vault over our heads, this carpet of flowers, which unfold under our feet all these wonders of nature, are seen in the highest perfection by man. It is thought, which contemplates and enjoys them, and imagination, which joins her creative prodigies to the miracles of the universe.

LECTURE XXIV.

REFRACTION. NATURAL EXPLANATION OF SPECTRES.

THERE exists between light and all the bodies of nature a very sensible power of attraction, which gives birth to an infinite number of remarkable phenomena. Light bends out of its direct course, in passing through a transparent body. Philosophers call this property *refraction*, and the body through which the light passes, a medium. Descartes was the first, who made known the precise laws of refraction, laws sought for to no purpose by Galileo, Kepler, and the other sages of former centuries. However contended for by Snellius and others, this discovery belongs entirely to Descartes, the noble rival of Newton in many branches of physics, and who remains alone in his comprehension of most of the sciences, in which the genius of Newton had not found scope.

Light forms an angle in passing from one medium into another. Such, as I have already remarked, is the cause of twilight. The first rays of the sun, passing through the rarer medium beyond into the denser medium of the atmosphere, are inflected by it, and cause, that the dawn precedes the sun in the horizon.

A staff, placed obliquely in the water, appears to our eyes as if it were broken; because the rays from the immersed portion of the staff pass obliquely from the water to the air; and in this way give an illusive aspect to it. Aristotle, of whom, as a philosopher, the world talks so much, was ignorant of the cause of this phenomenon. You have the advantage at present of knowing more than Aristotle.

Suppose the basin in the midst of a garden drained dry, your vision would directly strike the centre of that basin. Fill it again with water. The rays from your eye would no longer reach the same point; but, in entering the water, would change their direction downwards towards a perpendicular, and would reach the bottom of the basin at a point less distant from you. The exact contrary would happen, when the rays passed from the water into the atmosphere, that is to say, from a denser to a rarer medium. They then diverge from the perpendicular, incline towards the air, and change the apparent position of objects in the other direction. Those rays, that follow a perpendicular direction, experience no refraction, as we can see by the experiment of plunging a staff perpendicularly in the water.

The discovery of the precise laws of refraction enables us to account, in a natural manner, for many seeming mysteries, on which various superstitions are based. Apparitions may, in this way, have had their cause in nature. The Scotch may thus have seen ghosts wander in the thick fogs of Lego. The superstitious of the past days, and of all countries, may in this way have encountered phantoms, whom their fears and imaginations enlarged to superhuman dimensions. Their own images, reflected from the water in peculiar states of the atmosphere, may have been the ghosts they saw. More than one person, not believing in ghosts, walking at evening twilight amidst the misty air of marshes, has seen a shadowy form walking near him, and keeping pace with him.

Father Chasles, a jesuit, relates, as an eye witness, that he saw at Besançon a man of extraordinary stature, who walked in the clouds, and brandished in his hand a sword, with which he seemed to threaten the city. The people were all in alarm; and it was difficult to calm them, even when convinced, that this phantom was only the reflected shadow of the image of a saint placed upon the summit of the dome of a belfry. A thrilling story of the appearance of what was called the white army, or a multitude of spectres seen in the air, some years since, in New Jersey, attested by many people, may in this way be accounted for, without supposing, as most people did, that the whole was an idle fiction.

Certain bodies have the natural property of reflecting light and objects. You comprehend that glasses or mirrors have this property in the most remarkable degree. The rays, which proceed from all parts of your countenance, strike the mirror, which, being coated on the opposite side, with an opaque amalgam, returns your exact image to your eyes. Milton, in painting celestial joys, disdained not to express the surprise and delight of the first woman, when she perceived herself in the crystal of the waters. Ancient history, too, speaks of the mirror of Ptolemy Euergetes, which, elevated upon the Pharos of Alexandria, represented with precision all that passed in the level circumjacent country.

I shall say nothing to you of the mirror invented by Archimedes to burn the Roman fleet. Descartes refused credit to this historical account. Buffon composed a similar one, to prove that the mirror of Archimedes was possible. By this surprising invention, although we can neither seize, nor agitate, nor inclose, nor transport the rays of the sun, we can manage, and direct them upon a given point, and acquire with them a new power. In the hand of nature, light gives harvests, perfumes, colors; in the hand of man, death.

An Englishman, after a profound study at a lady's toilette, conceived the happy idea of substituting mirrors, as instruments of death, to guns, cannon and bombs. Every soldier was to carry a mirror, which he was so to direct in the faces of the enemy, as to dazzle, blind, and conquer them with the rays of the sun. For the whole apparatus of war, it would only be necessary, that each soldier, on the day of battle, should seize the looking-glass of his mistress, and march to combat with the same arms, which gave victory to beauty. A little address and a clear day would be all the postulates. The most accomplished beau would be the most terrible warrior; and instead of announcing the result of battles by the number of dead and wounded, it would only be, to state the number of the blind, and persons who had their mustachios scorched. The science of tactics would then be to learn, how to combine the different effects of convex and concave mirrors, to produce the greatest possible ravages. Newton had learned, that the intervals, which separate the colors of the rainbow, are the same with those, which form our musical scale. Imagine then a harpsichord with a scale of colors following the diapason of the musical scale. It is the ocular harpsichord of father Castel. Instead of audible, we here have visible harmony.

Upon this harpsichord painters can execute sonatas, and the deaf give concerts. The art can be carried even to the imitation of the movements of the passions. The eyes hearken, and colors sing. It is like the language of flowers, invented by oriental lovers. This beautiful harpsichord, which would enable the ladies to set their toilette to music, and certainly to blend colors, in the embellishment of the person, according to the laws of harmony, would not be unworthy to be played upon by the Graces.

LECTURE XXV.

COLORS.

In this lecture, I shall touch upon the theory of colors and the rain-bow. The opinion, which seems most generally adopted at this time is, that light is a real emanation of the molecules of luminous matter, emitted from all points of luminous bodies with inconceivable force. This hypothesis was received by the most eminent philosophers of antiquity, particularly by Democritus, Epicurus, and the poet Lucretius, who propounded it in beautiful verses. Newton is its most illustrious advocate among the moderns. But such great difficulties have been found in the way of this theory, that other philosophers of great name, have regarded it as inadmissible. The most distinguished among these are Mallebranche, Descartes, Huyghens, and, more than all, the illustrious Euler, one of the most profound scholars and geometers of any age.

These adversaries of emanation believe, that all space was filled with a subtile fluid, all the molecules of which were contiguous to each other, in such a manner that the vibrations communicated by the action of luminous bodies to the molecules nearest them, propagated themselves to infinite distances. According to them, light is nothing more than the result of the vibrations of this fluid, in the same manner as sound is the result of vibrations of the air.

Objections have been raised, and sustained with great subtilty of reasoning, against each of these hypotheses; but, to go into the details would require an extent and abstruseness of investigation, which would carry me beyond my purpose. The most obvious objection to emanation is, that the sun and stars, darting for so many thousands of years so great an abundance of matter, perpetually renewed so as to fill a sphere almost without bounds, with light, must long since have experienced a visible diminution of their volume. But the sun is not perceived to be either smaller, or its supply of heat diminished. 'It has not then,' says the objector, 'lost any thing of its substance, and is not, therefore, an emission of luminous matter.'

It seems, also, as if, upon either of these suppositions, the luminous rays would be deflected from their course by various circumstances. But nothing ever causes the slightest aberration from the unchanging laws of the onward march of light. So unvarying is this phenomenon, that it seems to contradict the axiom that matter is impenetrable.

All the uncounted millions of suns in the heavens, fill, each one for itself, a space almost infinite with luminous rays. All these masses of light, continually pouring into space, cut, cross, and penetrate each other in all directions. All move with a rapidity surpassing thought. All are impelled by a power beyond imagination. All exercise, the one upon the other, a reciprocal attraction. They cross each other's course in every direction. They are all subject to the attraction of the immense celestial bodies which they pass on their course, of which the number must be so nearly infinite, that the celebrated geometrician, Lambert, sustains, that in our solar system alone, there are at least five hundred millions of comets. Notwithstanding all these causes for derangement in the course of the luminous rays, we see not the slightest aberration from their perpetual law; and they move on with as much ease and regularity, as though there existed nothing in space, but the single and unimpeded sphere of these rays. All these difficulties attending any theory of light, considered as a corporeal substance, caused Newton to express a doubt if light was matter.

I cannot pass over another idea of Newton's, beautiful for its sublime simplicity. It is that, probably, there may exist in the universe but this single and unique substance, whose molecules, by the sole difference of their mode of aggregation, have produced all the bodies which exist. Light must be capable, therefore, of being transformed into every body, and every body reciprocally again resolved into light. Hence it appears, that Newton considered light the original principle of all things. In Genesis, it is affirmed, that light was the first result of the great work of creation. It was on the first day, that the Eternal pronounced the word, *Let there be light.* According to the theory of Newton, this command ordained the original principle, whose varied forms, combinations, and modifications, composed all the things and beings of this visible universe.

But to leave these high speculations, and return to humbler facts which belong to 'this visible, diurnal sphere;'—a ray of light, however subtile, is but a bundle of an infinity of rays proceeding from the sun, each of which has a different color. They are red, orange, yellow, green, blue, indigo, and violet. These colors, perfectly blended, form the color of light. Newton discovered that this ray was of a nature to break into different angles in passing from one medium into another, of different density; for example, from air into glass. He called this phenomenon refraction. Violet rays are the most refrangible, and red the least. This law of refraction, by means of the prism, separates the rays into their primitive colors.

All bodies have a certain disposition, in the texture of their molecules, which compels them to reflect a particular color. The rose reflects rays of rose-color, and absorbs all others. It is, probably, by this law that a blind man distinguishes colors by the touch. He founds his judgment upon the particular disposition of the molecules of bodies, which he is able to perceive by the exquisiteness of its touch.

Air and water appear blue, because they reflect the rays of azure, and absorb all the other colors. I need scarcely add, that white is the union of all the reflected rays, and black the privation of reflected light, or the absorption of all the rays. That white is the seven rays united, is proved by a beautiful experiment. A wheel is painted with all the prismatic colors. When turned with rapidity, the colors, confounded by the circular movement, form a circle to the eye of pale white.

White, the most vivid of all colors, is then composed of seven simple colors. If you retrench one, as for example, red, the union of the rest no longer gives white. It is calculated that the seven colors of the prism, may be combined in a hundred and twenty-seven different manners, to form all the colors of nature. Add to this, the infinite shades of the greater or less intensity of each color in the combination. For example, if we form green with yellow and blue, mixed, it is obvious that in augmenting the quantity of yellow rays, as in diminishing that of blue, we shall have a clearer green.

At Rome, the artists in Mosaic, employ stones of seventy-five thousand colors. In the tapestry of the Gobelins, where the colors are still more perfectly blended, the shadings of colors in the threads, are still more numerous and diversified.

Thus, when an object appears white, understand that it reflects all the rays which the prism decomposes; when it is red, that it absorbs all the prismatic rays, but red, which it reflects; and, finally, when we see it black, that all the rays are absorbed. I offer a single application of these rules to the toilette, simply remarking, that a whole system of the influence of colors upon each other, might be predicated upon these views of the analysis of light. If you wish, for example, that your blue dress should not appear greenish at a ball, or at a public spectacle, choose a blue of a ground color extremely bright; otherwise, the rays of azure mixed with the yellow rays, which the dress will receive from the lights, will cause it to appear green.

Thus the sun is the eternal reservoir of colors. It is from him, that they incessantly emanate. It is only requisite to render them visible, that the Creator should slightly vary the proportions of the molecules of bodies. Whence is it, that the rays of a planet a million times larger than the earth have such surprising harmonies with the paintings of nature? Whence is it, that the atoms of bodies can decompose the light of a globe distant a hundred millions of miles in space? These mysteries are not less astonishing, than the wonderful relations which exist between these different properties and the eye, between the eye and thought, and between thought and the Creator of all these wonders.

I conclude this long lecture, by explaining one of the most brilliant spectacles presented by light,—the rainbow.

The dark thunder-storm has past away. The trees and flowers are dripping, and the birds are singing the songs of refreshment and deliverance. What a magic circle of gorgeous splendor bends over the black cloud that has gone by! It is as if emulating a radiance of glory worthy of embellishing the diadem of nature. Yet drops of water, in which light is broken into different angles, are the entire materials of that superb arch. The falling rain performs the offices of a prism; and the colors, according to their refrangibility, show themselves in prismatic order. If you will pause to observe the fact, every morning dew-drop will present you its rainbows. Cause water to fall in mist between your eye and the sun, and you can make rainbows for yourself. Stand below the tremendous mass of falling waters at Niagara; and, when the sun shines, you will always see the space above the gulf resplendent with the most beautiful rainbows. This spectacle, henceforward, will not appear less glorious to you, because disenchanted of the supernatural and marvellous. It is for the simple inhabitants of Etea, in the South Sea, to adore this spectacle as a God. It was for the pagan Mexicans to mould a golden rainbow on the front of their temple of the sun. Enlightened as to the cause of this splendid spectacle, you will no longer think to grasp the glorious arch on the summit of the hill, upon which it seems to rest. You see it to be a philosophic illusion, created by a little water divided into drops in the air. But the pageant will assume a new grandeur in your eye, as you admire the severe and sublime simplicity of the means by which the Creator spreads the most magnificent spectacle of nature, his bow of peace, upon the clouds.

LECTURE XXVI.

THE EYE.

I HAVE already touched upon the mechanism of the eye. Were I able to detail the physiology and philosophy of this wonderful organ, admiration of the wisdom and contrivance of the Creator could not but ensue. Among the most beautiful remains of antiquity is the discourse of Socrates, as preserved by his disciple Plato, in which he elegantly illustrates the design of Providence, as manifest in every part of this astonishing contrivance. That must be a strangely constituted mind, which could for a moment believe that the formation of the human eye was the work of chance. Let us note a few of its most obvious marks of astonishing art and contrivance.

Its complicated structure is fitted up with lenses, microscopes, and telescopes, of such admirable construction, that human art can do no more than imperfectly imitate them in the same sort of mechanical contrivances, to answer all the different requisitions of vision. Then its different humors have different refrangibilities, arranged to meet all the various accidents of color. Though the organ is double, it is so contrived that the picture in the mind is single. Though the physical properties of light and the eye, paint external nature inverted on the retina, the organ has a rectifying power, by which the mind perceives the images erect. It is placed where it should be, as a watch-tower in the forehead; and exquisitely sensible and delicate, as its complicated structure must be, it is walled round on every side with a firm parapet of the most inflexible bones of our frame. The arching eye-brows defend it as a curtain, guard it from the access of dust, and arrest the descent of the moisture of the forehead, which would corrode it by its saline properties. The eyelids, as the shutters of the window of the soul, open and close with the rapidity of thought, with a spontaneous and apparently conscious, though involuntary perception of its necessities, excluding too much irritation of light, lubricating, wiping, and defending the orb from all external annoyance; and, by frequently covering it, preserving it from fatigue, as well as shielding it from the access of light during the period of repose.

I need not indicate the uses of the graceful eyelash, the most perfect of screens, and the most delicate of brushes, nor of the lachrymal moisture, answering the various purposes of shielding it from the friction of the eyelid, and causing it to glisten with the expression of compassion and sympathy. I say nothing of its wonderful and indescribable power of representing the infinitely diversified thoughts, passions and emotions, as they arise in the soul, and look forth, and become visible to the beholder. Such an investigation would unfold to us a new universe of wonders; but too remote and complicated for my present discussion.

Among its more obvious physical harmonies, you cannot but admire its spherical form. If it were a plane surface, it could not receive, perpendicularly, any object, larger than itself. The rays, which fall upon a transparent, spherical body, all converge towards the centre of the sphere. By these means the vast picture of the universe is painted entire on a globe no larger than the eye. Four transparent substances, each with a different power of refraction, compose this globe, and serve to bend the rays towards a focal point, and to unite them upon the retina, which receives the image of objects. The rays of the sun, as has been seen, are composed of rays more or less refrangible; that is to say, which diverge more or less in passing from one medium into another. If the eye had contained but a single humor, the light, in passing through it, would have experienced such different refractions, that we should have perceived only confused images, invested in prismatic colors. It was necessary, then, that light and the eye should be in harmony, that the rays with different powers of refraction should pass through many transparent substances in the eye, which should possess different powers of refrangibility, so as to carry all the rays to one point, and invest the object in a uniform color. All these refractions have but the single object of transmitting the seven rays united to the retina, and to find even in their divergence the means of uniting them.

Observe how admirably this little sphere is suspended in the socket, so as to enable it, as quick as thought, to glance from heaven to earth, to turn obliquely in any direction so as to grasp in the scope of its vision a whole hemisphere. Neither can we mark without admiration, that the pupil possesses the power of dilatation or compression; and of acquiring more or less convexity, according to the greater or less degree of light, in which we see objects. When the sun culminates in brightness upon a glittering surface of snow, the extreme irritation of the light contracts the pupil, and almost closes the eye. If in that conformation we pass into a room, the eye, not instantly losing the conformation fitted for the dazzling light abroad, admits so diminished a portion, that we are at first unable to discern objects; and in the common phrase, are snow blind. But this wonderful organ, as if itself endowed with intelligence, soon regains a form, fitting it to see clearly in the new position.

Observe, too, the harmony of external nature with this wonderful organ of vision. Were external nature painted black, the eye would be strained to unnatural expansion, to embrace sufficient rays to render objects visible. Were the creation all white, it would suffer still more from the excessive irritation of light. But green and cerulean are beautiful mixtures of black and white, softly intermediate shades, which the eyes contemplate with unwearied gaze, and are neither too much expanded nor compressed. To meet this structure of the eye, nature paints the earth in green, and the sky in cerulean.

A circumstance, equally wonderful, is the infinite delicacy of the visual nerves, which, notwithstanding that extreme sensibility, that fills the eyes with tears by a passing thought of grief or tenderness, is enabled to sustain a constant flood of a fluid, so subtile and penetrating as light, darting with a rapidity, to which lightning is slow, without inconvenience. Such is the incomprehensible structure of that little sphere, by which we become acquainted with the situation, figure, movement, size, and infinite diversity of shades in the color of bodies at a distance! Such is the astonishing contrivance necessary to converse with external nature, and indispensable to the most ample, instructive and delightful of all the enjoyments of the senses. What a divine workmanship is this structure! What a web of infinitely delicate and sensible constituents! What contrivance, short of that of a God, could have established such relations between an immense luminary, a hundred millions of miles from us, and the eye, a little sphere, shining in the forehead of a moving atom!

Had I space to pursue this theme further, an anatomical dictionary would be requisite, to name all the constituent adjuncts of vision; and yet without those names and an explanation of their uses, you will find it difficult to conceive the complexness of the wonderfully ramified web of nerves, necessary for the communication of the perceiving power with the objects of vision. The particles of mist in the ocean would sooner be numbered, than the rays of light, that pour from a single object of vision upon the visual nerve of the eye. We might extend these remarks in a degree to hearing, smell, taste, and, more than all, to touch; an inconceivable sensibility diffused over the whole frame, which seems to operate the concurrent result of millions of souls, enabling the single conscious being to receive information from every pore. Then, imagine the power within us, still more mysterious than all, knowing every thing but itself, sitting behind the curtain of invisibility, and taking cognizance of every thing conducted to it by these millions of instruments of sensation and thought.

To keep all this machinery in living action, besides all the infinite complication of the apparatus of the senses, the heart is required to give ninety-six thousand strokes for every twenty-fours of health, to propel the vital fluid through its almost innumerable canals. During the same time, the lungs must expand and contract twenty-eight thousand times, to imbibe the requisite portion of oxygen from the atmosphere. Add to this, the web of constituents necessary for digestion in the stomach, of absorbents and lacteals for the assimilation and incorporation of nutriment with the frame, and the simultaneous movement of the countless millions of vessels of the capillary system of the surface, necessary to throwing off noxious accumulations by the pores; and all this to qualify us for a single sensation!

To these I add the larger and more palpable organs of life and motion. Two hundred and forty-five bones are numbered in the human frame. Each has forty distinct intentions, nearly eleven thousand in all. There are also four hundred and forty-six muscles of motion, each with at least ten intentions, or four thousand five hundred in all. All this is but commencing with the history of the human structure; and most of those movements are in unconscious progress in our frame, during every moment of our lives. Truly said the Hebrew poet of inspiration, 'We are fearfully and wonderfully made!' Who would ask for other proofs of a God?

If we descend from man to animals, we must be equally struck with the precaution of Providence, in giving to the lower orders of being a vision appropriate to the position it inhabits, and the pursuits, by which it subsists. The chamois, the wild goat, the gazelle, which roam high mountains, and require an extended vision to reach the deep valleys, are *presbytes*, or see better at a distance than near, which enables them to discover their enemy afar off. Looking at the structure of their eye, we discover, on optical principles, that it ought to produce this result. On the contrary, the sluggish and heavy moulded races, that inhabit the plains and valleys, such as swine, tapirs and sloths, whose vision is naturally bounded by hills and forests, are *myopes*, or see better near at hand, than at a distance.

The ocean, lakes, streams, all collections of water are inhabited with forms of life, as various as those on the land. It is the remark of mariners, who have been in all seas, and have had opportunities to observe all the varieties of animals that live in the water, that there is no form of animal on the land, that has not its corresponding counterpart of resemblance in some animal of the water. In the mer-men and mer-women of the sea, they have seen, or imagined, the resemblance of our race. These strange water-dwellers inhabit an element, which has, as we have seen, a very peculiar effect upon the transmission of light. They, moreover, glide through the waters surrounding them on every side, in contact with their organs of hearing and vision as completely, as air is with ours. It is obvious, that to fit them for life, motion and enjoyment in this element, they must have organs essentially different, and provided with a widely different apparatus for producing sensations similar to ours, of sight and hearing.

As we might calculate, nothing more forcibly unfolds the foresight of the Creator, than the striking difference which exists between the eyes of birds and fishes. We have remarked, that the first substance, found upon the front of the eye, and which serves to refract light, is called the *aqueous humor*.

Birds, destined to move in the medium of a very rare atmosphere, and which has but little tendency to refract the rays of the sun, have a great quantity of the aqueous humor, that the light, strongly refracted in entering their eyes, may bring distinct images. Thus birds at heights, where they appear to us only as points, perceive the smallest reptile concealed under the grass. But, as *presbyte* animals do not distinguish objects when brought near, nature has provided for this difficulty, which occurs when they descend from the heights of the air to seize their prey. To provide for this emergency, they have a membrane, by means of which they remove the crystalline lens from the retina; and, thus changing the power of their eye by changing the focal distance of objects, as we do with spectacles, they never lose sight of their prey, whether in the air or on the ground.

But this great quantity of aqueous humor, so necessary to birds, would be useless to fishes that live in an element which considerably refracts the rays of light. The Creator, who bestows nothing in vain, has not therefore given it them. But, as the water which strongly refracts, serves them instead of the aqueous humor, they have been provided with a crystalline humor almost spherical, which, performing the operation of a burning glass, corrects the refracting power of the water, unites the dispersed rays, and concentrates them on the retina. We observe, too, that most of the classes of fishes have large eyes, a necessary circumstance to obviate the obscurity and density of the medium they inhabit. It was the examination of the structure of the eye which convinced the great ancient physician, Galen, that there was a God.

LECTURE XXVII.

COLORS.

I SHALL touch, in passing, upon the harmony of colors in the different climates. The sun paints the universe, as Raphael painted his pictures. Nothing is done in this work by chance. Every arrangement is not only in harmony with the vision and the wants of man, but even with the seasons and climates. The first flowers of spring are white. The apple-tree, pear-tree, wild-plum, crab-tree, dog-wood, and the prevalent flowering trees of our climate, show summits as white in their flowers as their recent snow-wreaths. This color is no caprice, but a wise foresight of nature. We have seen that white surfaces have the property of retaining heat, which easily escapes from colored surfaces. Thus nature supplies the warmth of the sun in the yet cool and uncertain temperature of the spring.

In proportion as summer advances, spring loses its snowy vesture of flowers; and the prevalent colors are blue, golden, and crimson. The shades change to brownish purple; and the flowers clothe themselves, if I may so say, in their summer dress. Apply this remark to climates, and you will have under your eyes, the painting of the tropical countries of America and Africa, of countries which the sun inundates with his light; where we see the red flamingoes, the sparkling humming birds, the insects of gold and fire. Here we have the gorgeous spectacle of these rich shades in the midst of a gigantic nature, beside rapid streams of almost the breadth of seas, shading their shores with the lofty columns of the palm.

While the first spring-flowers of our temperate climates are of a brilliant white, those which grow in countries condemned to almost perpetual winter, on the contrary, are painted with the most glowing colors. The learned Patrin, who journeyed seven years in the dreary forests of Siberia, relates, that, one day as he was descending from the frozen summits of the mountain Altai, and as he reached the last bench which rose over the plain, watered by the majestic river Ob, he was struck with the most magnificent spectacle he had ever seen. He had left arid cliffs as old as the world, and snows and ices which were incessantly melted and renewed. On all sides, these desolate mountains were environed with storms, clouds, and snows. On a sudden an immense plain opened before the illustrious traveller, *resplendent* with the most vivid colors. Three species of vegetables entirely covered the surface. Not the least verdure was seen. The purple flower, of the iris of Siberia, formed the ground of this magnificent carpet. It was embroidered, in all its extent, with groups of hemerocalles, with flowers of gold and anemonies, with the narcissus of silvery brilliance. Sometimes the breath of the zephyr creates gentle undulations upon all these stalks. The varied colors are then so mingled and confounded, that the eye only sees waves of gold and purple which undulate under the brilliant sun. No hill, in the distance, bounds this rich plain. It spreads to the horizon, and seems to unite the sky and the earth with brilliant garlands.

In these frozen climates, many of the animals at the approach of winter gradually change to the color of snow.

This contrast between the color of vegetables and animals is another proof of the divine foresight. As it was necessary that the plants should be seen from a distance, they were pointed out, by their striking colors, to allure the animals that feed upon them. It was equally essential to the feebler animals that have a crowd of enemies, that, in procuring their food, they might glide over the snows confounded with them in the same color. Such is the case with the rabbits, the hares, and, in some countries, the squirrels and rats, and in the northern portions of Canada and New Britain most of the animals clothed with fur. The ermines of Siberia have no other defence than this change of color, and their caravans set forth in security by the light of the Aurora Borealis; while the foxes, bears, and wolves, are entirely black, brown, or blue.

St Pierre, in his Studies of Nature, avows that the reason of this contrast is unknown to him. Strange that this interpreter of nature had not divined, that nature has blanched the rabbits, partridges, and quails, only to conceal them from the eyes of their ferocious enemies; while the foxes, brown bears, and black wolves, armed with terrible teeth, resemble stalking shades, wandering, in strong contrast of color, upon the surface of the snows.

The colors and the forms of vegetables have exercised, even upon men, an influence equally pleasant and powerful. This influence is especially noted upon the Chinese. Their dress, buildings, and ornaments, are assimilated to the shades of coloring in their flowers, and the forms of their birds and animals. Their tents are modelled to the form of the inverted corolla of the tiger-lily of Japan. They have imitated the red and blue bells of the Faschia in their dress; and they wear bonnets, whose forms are borrowed from the campanulas of their meadows.

A fact equally remarkable, is, the harmony which existed between the ceremonies, the manners, and religion of the Peruvians, and the colors appropriate to the climate which they inhabited. It was natural that this simple people should worship the sun. The earth there yields gold, and the planet of day shines with a radiance of glory. The flowers emit flame, as the capuchin; or assume the image of the sun, as the turnsol; or open only during the night, as the perfumed mirabilis. These observations extend even to the colors which adorn the sky. A green carpet is spread under our feet, an azure veil shines over our heads. The sun is also the painter of the clouds, and varies their aspects at every moment, changing them according to temperature and climate.

The sky of the highlands of Scotland shows inflamed clouds of a livid and copper color. The aspects of the firmament are stern and savage, like the heaths and mountains, and sombre as the genius of Ossian.

The horrible mythology of the Scandinavians seems to have been inspired by the sterility and harshness of the climate, the gloom of the sky, and the misery of the inhabitants. Every where the earth was ungrateful, and man was gloomy, and thirsted for the blood of man.

Between the tropics, the sky is of gold and flame. Mountains of green and rose-colored mist seem to tower in the firmament, and are seen shifting their gorgeous-colored folds, and opening to view the varied play of light in the blue infinitude beyond. The sun, in his burning march, seems to create palaces in which to repose on his way.

Thin clouds, transparent vapors, and a pure sky cover the superb ruins of the Roman empire. Nothing can surpass the splendor of a summer evening in the American climates, when the sun is descending in his glory behind his towers of brass and his pavilions of purple. That would be a book at once of poetry, eloquence, and instruction, which should treat of the influence which the colors, and the varied aspects of the earth and sky, had upon the mythology and opinions of the ancient races of men. We should find the Olympus of Homer in the sky and plains of Greece, and the Elysian fields of Virgil in his own beautiful retreat in the vicinity of Naples.

LECTURE XXVIII.

OPTICAL ILLUSIONS.

You may consider this lecture an episode, in which I shall touch upon mirage, lands of mist, ærial illusions, and clouds assuming the aspects of animals, buildings, and works of art. 'I have observed,' says the traveller Patrin, 'in the sandy deserts of Asia and Africa, a phenomenon rendered singular by the illusive appearances which it presents. The traveller, in the midst of arid plains, imagines that he sees, at the distance of a few hundred steps, a vast extent of waters, whose shores sometimes appear covered with trees and verdure. Charmed with this agreeable and unexpected aspect, he presses onward in the hope of finding that refreshment and repose, which, in this scorching climate, he so greatly needs. But as he approaches in the direction of the object, it still retires before him, and finally vanishes.'

This phenomenon, which has been called *mirage* and *looming*, has been observed by modern travellers in Egypt, and was formerly perceived by the army of Alexander in the deserts of Sagdiana, to the east of the Caspian sea, as we learn from the history of that conqueror. Quintus Curtius thus describes this appearance: — 'When the fierceness of the sun heated these deserts, it might have been said, that the whole country assumed the aspect of a general inflammation. The sky was darkened by the vapors which arose from the burning soil, and the sandy plain had the appearance of a vast and profound sea.'

At the commencement of the last century, an English traveller, on his route to Pekin, who found himself, about the middle of October, in the sandy desert which separates Siberia from the frontiers of China, witnessed the same spectacle, which he describes in the following terms: —

'Sometimes, in the morning, I was agreeably surprised to see before us, at a little distance, what appeared a broad and beautiful river, bordered with ranges of fine trees. It was no more than an optical illusion, occasioned, as I imagine, by vapors which so magnified objects, as to transform the bushes, spread along the desert, into large trees.'

When the French troops entered the deserts of Egypt, they witnessed the same singular spectacle of mirage. Instead of an arid and sandy plain which really spread before them, they imagined that they saw a vast lake, in the midst of which were islands, with villages built upon them.

Mariners and travellers have presented us innumerable instances of these optical deceptions from mirage, or looming. This spectacle is no where seen more frequently, or in greater perfection, than on the drier prairies of the Upper Missouri. A man seen through the fog, in certain aspects of the sky, seems as tall as the mast of a ship; and sand-hill cranes, walking on the grass, might be mistaken for buffaloes.

Mariners at sea are often deceived by an optical illusion, which may be viewed as a sort of reverse of land mirage. This creates a sea in the midst of sandy deserts. The other shows in the wide wastes of the sea, lands, where are seen in the clearest manner shores, rocks, mountains, ravines and trees. The illusion is so complete, that often the most experienced mariners and the most enlightened philosophers have been completely deceived. The vessels have been directed to make for the land, which fled before them, and finally entirely disappeared. The name of fog-banks has been applied to them.

The great navigator Cook was often deceived by these illusions, familiar as was his experience with all the phenomena of the seas. He was seeking to make the isle of Pepys near the straits of Magelhaens, in forty degrees of south latitude. He judged that he saw land; and he coasted along the supposed shores two hours and a half. He then discovered that the seeming land was only a phantom. This was not the fog of winter; for it was in the height of the summer of the southern hemisphere. Another time he was deceived in the same way, in a clear and pleasant day, to the south of the Indian Ocean. Still a third time he was led astray by the same deception to the south of Africa. These three deceptions were all experienced in the southern hemisphere; and in the middle of the summer of that portion of the earth. How strong the illusion was, is proved by the circumstance, that Cook had with him the most enlightened of observers, who shared this error with him.

The great French navigator Peyrouse was completely deceived by these fantastic apparitions, as well as the learned philosophers and naturalists who accompanied him. He thus describes a deception of this sort. He was in latitude forty-four near the shores of Tartary. 'At four in the evening,' he remarks, 'the most beautiful sky succeeded to the thickest fog. We imagined we saw the continent; and in the south a great country, which appeared to join Tartary to the west, leaving between it and the continent an opening of about fifteen degrees. We distinguished the mountains, the ravines, in short all the details of a land view. We could not conceive how we had entered into this strait. In this position, I ordered the vessel to be directed towards the south east, and this supposed land. But soon the hills and ravines disappeared. It was a fog-bank, the most extraordinary I had ever seen, which had occasioned this error.'

What surprises me most is the singular contrast between the mirage and the fog-banks. In the first instance, a parched and desert country presents the aspect of a great and beautiful lake, or a wide river; and the surface of the open ocean shows rocks, lands, mountains, and all these appearances so seductively visible, as to deceive the most experienced eye. I know no theory, which explains these appearances in a manner perfectly satisfactory. Quintus Curtius supposed that such illusions were caused by the burning vapors of the sands of Sagdiana. But a French traveller, as we have seen, had the same view in the sandy deserts of Siberia, when the air was so cold that the caravan hastened its march, through fear of being delayed by snow. It is not then, as Quintus Curtius supposed, burning vapors, which present to vision a vast sheet of water in a desert of arid sands. What is the true cause of this singular phenomenon? I only remark in reply, that it is seldom remarked, except in sandy and dry plains; and that the fog-banks, with their rocks and mountains, are never seen, except on the open sea.

There are other aerial phenomena, which produce very singular optical illusions. Among them none is more striking, than that, which is seen from time to time, upon the strait, which separates Sicily from Calabria. Swinburne, the English traveller, quotes father Angelluca as describing one, of which he was an eye witness. 'The sea,' he remarks, 'became suddenly as if in flames, and appeared, in a line of ten miles extent, like a chain of mountains of an obscure tint, while the waters of the shores of Calabria were apparently united, and appeared like a highly polished mirror leaning against a curtain of hills. Upon this glass was seen painted a range of many thousands of pilasters, all alike in height, distance, and degree of light and shade. A moment afterwards these pilasters were transformed into arcades like the aqueducts of Rome. Upon the summit of these arcades was a sweeping line of cornices, surmounted with a multitude of castles, which immediately after transformed themselves to towers. These in turn became colonnades, then ranges of windows, and finally pines and cypresses all of equal elevation. Previous to seeing this spectacle, called in the language of the country *Fata Morgana*, I had regarded the description of it, as a mere tale.'

The phenomenon of figures seen in the air is an optical illusion so general, that almost every country has its own.

One of the most singular is that described by Diodorus Siculus, which was observed in that part of Africa, which extends from Tripoli to Barca, opposite the gulf named by the ancients the Syrtes of Africa. This desert country is at present inhabited by the wandering Arabs.

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This author tells us, 'That in all seasons, when there is no wind, the air appears full of figure of animals, of which some seem motionless; and others to have the power of voluntary motion. They appear of an extraordinary size, and nothing is more capable of affrightening those, who are not habituated to this strange spectacle.'

Patrin relates, that he has remarked hundreds of times in northern Asia, in those vast plains, known by the name of Steppes, which are bare of trees, and bounded only by the horizon, corresponding exactly to our prairies, in autumnal evenings, when the air was perfectly calm, a belt of clouds elevated from fifteen to twenty degrees above the horizon. These clouds, seemingly thick, although the dome of the sky was perfectly clear, were mixed with lights and shadows, like a design in India ink; and always represented human figures in different attitudes, oftener naked than clad; and of a size beyond the proportions of nature. 'The imitation at times appeared so perfect,' he remarks, 'that I began to fear that they were the phantoms of my own imagination. To satisfy myself on this head, I asked my guides, and the inhabitants of the country, what they saw in the clouds, and the answers of these simple people described appearances precisely similar to those I saw myself.'

LECTURE XXIX.

COLORS. LUMINOUS ANIMALS.

I RESUME my theme of the harmony of colors, and speak in this lecture of luminous animals. Nature has multiplied the species of these animals. The waters have their luminous fishes, and the air its insects glittering in the darkness of night. In some of the tropical regions the inhabitants use them as torches. They attach the insects to their heads and breasts, and walk amidst the darkness by their light. These flies have sufficient brilliance to enlighten a bed chamber, a work shop, or a parlor. By the light of these insects Mlle de Mèrian composed the designs of her beautiful work upon the butterflies of Surinam.

On a beautiful evening a traveller was rowing ashore, to land on one of the islands at the mouth of the Ganges. On a sudden the trees on the shore all became colored with a kind of bluish light, and seemed to be full of crystals and transparent fruits. These crystals passed through all the shades of the rainbow, and appeared successively azure, purple and rose-colored. Sometimes they were at once extinguished, and the whole isle was in darkness. In the next moment, sparks flashed again from all sides. They seemed to flow from the trees, and to fall in a rain of gold; and then to rise again in sheaves of azure and opal, or to unfold in the air, like masses of fire works. Motionless with surprise the traveller imagined himself transported to fairy-land. His oarsmen destroyed the illusion by informing him, that these phenomena were repeated every night at that season of the year; and that they were produced by winged insects, which nature in sport had been pleased to clothe with light.

These luminous insects, which are of a size and brilliance to illumine the dark forests of Brazil, some parts of South America, and the West Indies, are a beautiful spectacle in a summer evening in many parts of the United States, particularly in the month of July, and the sultry, and still, dark evenings, which precede nocturnal thunderstorms. I have seen a meadow show, as if on fire with them.

Even in the bosom of the dark forests, which environ the higher points of the Alps, these phosphoric swarms arise, multiplying like the sparks of a conflagration. The snow is covered with them. They illumine the icy peaks, as it were an arch of light, whose moving undulations are lost in infinity.

The phosphorescence of the sea water has been the subject of much investigation by philosophers. In one place the surface of the ocean shines in its whole extent like a sheet of silver, which has been made electric in the dark. In another point the waves offer the aspect of a plain burning with sulphur and bitumen. St Pierre has described stars, which seemed to flow by thousands from the bottom of the seas. Other naturalists have spoken with admiration of those inflamed masses, which roll under the waves, like so many enormous red hot cannon balls. Cook, Labillardiére and Banks have observed in the sea pyramids of light, serpents of fire, and dazzling chandeliers. They have seen meteors of flame arise over the waves, roll off into the air, and become compounded in the horizon with the stars. These phenomena have been successively attributed to bitumen, phosphorus and electricity. Their real origin is still more surprising. They are caused by organized beings, whose innumerable families people the abysses of all the seas from the poles to the equator.

Peron, in his voyages to the countries of the southern hemisphere, is the first naturalist who has carefully described the variety of their habits, the singularity of their forms, and the richness of their shadings of color. He borrows the diction of poetry to paint those animals called velellæ, which, like pirogues surmounted by a transparent sail, manœuvre upon the surface of the sea, into which they dip thousands of azure oars. Sometimes he shows us heroes transparent as crystal, and which decompose light. They are seen moving their fringed limbs, which are painted with all the brilliance of prismatic colors. They then appear, as if enveloped with a multitude of undulous rainbows, which multiply, and enlarge at every movement, and the gaiety of whose colors no pencil can seize. After them the physiphoxi unroll upon the waves their garlands of rubies, and opals, supported by aerial globules; while the stephanomia unfold their transparent limbs like the foliage of ivy. In noting the gentle balancing of their stems, shaded with rose and blue, you would say it was a garland of flowers opening to the breath of zephyr. But if the appropriate prey of the animal happen to fall into the snare, instantly the apparent plant becomes animated, envelopes, and seizes it. Thousands of tongues dart from under the delicate foliage, which served to protect them. In this way live the glaucus, the pyrosoma, the cuvieria, and the loligo. All these kinds, adorned with a thousand colors by day, assume that of flame on the return of darkness; and the sea, when moved, exhibits the spectacle of an immense conflagration. During the delicious nights of summer, when the vessel gently glides across these luminous waves, the pilot, often superstitious, contemplates with terror the flames, which flow around him, and which he sees, in his imagination, like those of hell, prolonged down the unfathomless depths.

An ancient traveller has drawn so charming a picture of these phosphorescent lights, that I cannot forbear giving you the outline. He relates that he has seen, upon the coasts of Guinea, tribes of blacks who wander continually upon the shores of the sea. As the twilight of day declines, the young girls collect to fish. By the light of the moon, they throw themselves into the sea, their heads adorned with beautifully plaited rushes, and carrying in their hands a reed to detach shells from the rocks, or to spear the fish. After they have sported their assigned period in the waves, they return with songs to their houses, and appear all resplendent with the phosphorescence of the sea. Some bear lobsters of prodigious size, and formidable thorn-backs. Others empty on the turf baskets filled with shell-fish, which sparkle with a thousand fires. They dance afterwards in front of their rustic cabin, environed with these flames, at once their only vesture and ornament.

Thus nature has kindled fires in the waters which the sea cannot extinguish, which shine without warming, spread without destruction, and burn without ever wanting fuel; and its prodigality scatters rays of the sun upon the body of a humble insect.

But nature in casting these singular animals from her hand, has not abandoned them. On the contrary, she seems to have exhausted upon them her most vigilant maternal intelligence of foresight. For example, the cuttle-fishes, a kind of naked molusci, to escape the pursuit of their enemies, dart away in water which they have blackened by an ink, which they have shed into it to obscure it; while the medusæ, by an instantaneous fusion, melt into a transparent fluid, like the water that surrounds them. Having become thus invisible, they dart upon their prey, and having seized it, kindle to their former appearance like coals brightening, or becoming extinct at will. They do not appear to be possessed of any muscular system, and yet they execute rapid evolutions. They possess an active respiration, yet the seat of this function cannot be discovered.

Nature only uses fire with a provident benevolence to embellish creation. She has diffused it in the sky, upon the earth, and even in the waters, and it is everywhere an exhaustless source of fecundity. Through its benefits, man becomes monarch of the earth, and the inhabitant of all climates. Such is this benign power in the hand of the Divinity. But, as soon as man applies it beyond its original uses, in his hand it becomes terror and death. Some particles of nitre, united with sulphur and charcoal, give him this terrible application of the power. The epoch of this invention was that of levelling the strong with the weak, and rendering war a science of money and stratagem, rather than of personal heroism. The illustrious Bayard disdained the fatal invention, a power which rendered valor useless. He still grasped the sword and the lance of chevaliers, as the arms of his choice. The hero fell by the invention he abhorred.

LECTURE XXX.

FIRE.

Fire fills all nature. We may well consider it a miracle, that the earth does not kindle to inflammation. It flows in sparks from the hardest stones. It circulates in the water, which owes to it movement and fluidity. Plants, animals, the air itself, all are impregnated with fire. Hanging in the transparent ocean above us are thousands of flaming stars, from the glittering meteors which dazzle us a moment, stream along the air and expire, to comets and suns. The heaving bosom of the earth evinces, in the terrific explosion of volcanoes, that she feeds central fires in her unexplored depths. Along with the refreshing shower, poured from the clouds, comes down the irresistible shaft of lightning.

But this same element, which, in one form, destroys whatever it touches, is the chief instrument in the creation and regeneration of all animal and vegetable life. It animates, colors, embellishes, and gives life to all. Nature awakens with its light. As soon as its source disappears, every animal seeks its retreat, and the eyes of man become heavy. Most of the plants, too, at the approach of night, give themselves up to sleep with all nature. In the absence of its vitalizing warmth, the trees are stripped of their foliage. The birds fly to warmer climates. The power of the sun returns, and brings spring with it. The face of the universe is renewed. Thus we owe every thing to a globe of fire, placed at an immense distance in the sky, which forever burns on without consuming.

How did the first men obtain fire, and learn its uses? You are acquainted with the fable of Prometheus, who is supposed to have stolen fire from the Divinity, importing probably that he was the first who knew the use of it. Even this discovery has not been diffused over the whole earth. When Magelhaens debarked upon the Marianne islands, the inhabitants did not know the use of fire. When the ship's crew first kindled it, these simple beings regarded it as a kind of animal, which consumed whatever came too near it. What a difference between that people and the people of civilization, who change it to the most faithful and useful of servants, and avail themselves of its power to produce, during the severest frosts of winter, the temperature of summer!

In speaking of fire, it is impossible that we should not be disposed to ask, what is the nature of that immense globe, the sun, which operates all the beneficent wonders of sustaining the worlds? Nonè can reply in a manner altogether satisfactory. What are the spots of the sun? Some have made them rivers, others mountains, others caverns, and some clouds. Leibnitz, wishing to render the science of physics agreeable to the ear of queens, wrote to the queen of Prussia, that the spots of the sun were patches, which he put on to embellish his visage. Cyano affirmed, that he had discovered the sun looking through the spots of the moon as windows, to see the vagaries perpetrated by the inhabitants of the earth in his absence.

A law of physics, which requires our first attention is, that the rays of the sun only impart warmth to those objects which do not afford them a free passage. Ice can be formed into a convex lens, which will kindle a fire where its focal rays fall. But these rays pass powerless through the ice. The warmth which we feel is not from the air, but reflected from the earth. In proportion as we rise above the influence of that reflection, we ascend to the regions of frost. This explains the cause of the cold in the elevated regions.

The city of Quito, in Peru, almost directly under the equator, would seem to have an almost insupportable temperature. But, as it is situated upon table-land, higher than the summit of the Pyrennees, and has a very rare atmosphere, which gives free passage to the sun's rays, the temperature is cool and delightful. The town of Antisana is the highest inhabited spot on our globe, being nearly fifteen thousand feet above the level of the sea. There the shepherd, almost under the vertical rays of the sun, pursues his flocks amidst sleets and snow-storms which assail every month in the year. He has the further disadvantage, roaming among frost and ice-banks, to behold, contrasted with his dreary abode, countries under his feet, where the trees are always green, and where buds, flowers, and fruits, all succeed each other on the same tree. Thus the Creator, designing to render the burning zone habitable, has there reared the loftiest mountains on the globe, and has spread out, on their table-summits, cool and agreeable climates.

We remark, in this law of physics, an admirable foresight of nature. If the air had not afforded a free passage to heat without becoming warm itself from the transit, if heat had diffused warmth through the extent of the sky, the glaciers of the Alps, of the Pyrennees, the Cordilleras, and the Himalaya, had not existed. No river, no stream, had flowed from the mountains. No changes of temperature had given birth to condensation and rains, and the universe would have been a ruin.

Yet this same inequality of temperature has inspired certain philosophers with bitter complaints, and even the denial of Providence. One half the globe, according to them, is scorched by the sun, and the other half buried under ice. A superficial view of things saddens and discourages, and smatterers become unbelievers. But, in proportion as we profoundly investigate the phenomena of nature, the mind changes to admiration of the wisdom and foresight of Nature, and raises adoring conceptions of its Author.

For example, the fires of the equator, and the ices of the poles, have been alike the foundation of a charge against Providence. All beings below would perish, however, if this same Providence had not arranged things as they are. The poles in chilling the air, and the torrid zone in heating it, are the cause of the different currents which preserve the purity and the freshness of the air. Without them, no wind would have brought us clouds and rains; no zephyrs would have swelled the buds. Our harvests would have failed, but for the sources of storms placed at the extremities of the world. It is at the poles, and under the equator, that are generated those mighty causes which take up the evaporated waters from the bosom of the ocean, and transport them to the mountains in the interior of continents, to be condensed in rains, to descend in mountain-torrents, to meander in rills, to roll in rivers, to water whole countries, and to return whence they sprung.

Specious objections vanish before the most simple and obvious reflections. We have only to cast a considerate eye upon creation, to be convinced that a divine harmony, a celestial foresight, presides over all these seeming inconsistencies. Apparent disorder is unknown order; and, in every accusation against the Author of nature, time, study, and experience, will unfold an act of ignorance as well as impiety.

One word respecting the central fires, an invention of the ancient philosophers, honored by being adopted by some of the moderns, will close this lecture.

They called by the name of central fire, the interior warmth of the globe. This warmth serves to explain the vegetation that takes place under the snow, the boiling fountains of Spitzbergen, the astonishing hot jet d'eau of Geyser, the high temperature of deep mines, and, generally, the volcanic character of whole chains of mountains.

According to Whiston, the earth before the deluge was much more populous and fertile than at present. Human life, too, was longer in proportion to the greater internal warmth, or central fire. But this same fire, in augmenting the strength of the human body, unhappily mounted into the head, and turned the brain. Men became proud of deceiving innocence, and of killing their friends in duels. They boasted of not believing in a God, and wrote admirable books about the power of nothing to create something. The animals even, with the exception of fishes that inhabit a cold element, felt the effects of this mischievous influence, became criminal and deserving of death. This universal death was inflicted, according to our philosopher, one Friday, on the twenty-eighth of November, by an unhappy meeting between the earth and the tail of a comet.

LECTURE XXXI.

CALORIC.

In those ancient days so much boasted by the moderns, when the philosophers were content with believing that the sun was a fiery cloud of a foot in diameter, or at most no larger than Peloponnesus; one of the most renowned sages, in the midst of the gardens of the Academy, was theorizing with great confidence and power. He was explaining, in brief terms, how all the worlds which roll in space, were created. A young disciple of Plato, accustomed to reason by proposing questions, as is the fashion with some of his modern disciples in a part of our country, thus addressed him: — 'O sage! condescend to enlighten me upon these mysteries; how it happens, that the rays falling upon wax causes it to drop in threads of gold, while the same heat, applied to moist clay, changes it to stone? Or that man, moving under the full ardor of these rays, is covered with sweat, while the same heat dries up the fountains and streams? Or, that the same light reddens the rose, stripes the tulip, blanches the lily, and browns the shepherd girl? Whence is it that the same cause operates such opposite effects?' The disciple of Plato ceased; and the sage world-builder not being able to resolve the questions of a scholar, touching the most obvious matters of daily observation, retired overwhelmed with shame from the academy.

In these more fortunate days, we have in our ordinary schools young doctors of sixteen, and fair Euclids at twelve, who, standing at the black-board during an examination, are able at least to discourse learnedly upon these points of philosophy, if they cannot satisfactorily explain them.

The great agent of these seemingly contradictory results, is a subtile, invisible fluid, of which I have already spoken, called caloric. The effect of the presence of this fluid to the perception of a sentient being, is warmth. It is supposed to expand bodies by penetrating between their molecules. In this way, a bar of red hot iron becomes perceptibly longer than when cold. A still greater quantity of caloric would have caused this bar to melt and flow, like a fluid. Whoever visits the mint will see gold and silver, by this action, become as liquid as water. Caloric, entering into the particles of water, dilates them first into steam, and then into invisible vapor. Remove this power, and the transparent fountains change to a substance like glass. To this element air owes its fluidity. The atmosphere itself would become a solid body, if caloric did not expand the molecules which compose it. It is affirmed in these days, that philosophers have succeeded in compressing air, so as to render it twice as dense as water.

Although caloric and light are frequently found in union, it is not uncommon to find them in separation. We have seen that sea-water, and many insects, offer us the brightest light without a particle of heat; and we can heat a great number of substances without rendering them luminous. It is natural to suppose, then, that caloric and light are two different bodies, which have a great analogy the one with the other, though many modern philosophers confound them.

The most remarkable property of caloric is to expand bodies; that is to say, to augment their volume in gliding between their molecules. This effect, as I remarked at the commencement of these lectures, is directly opposed to that of the attraction of aggregation, which draws the molecules of bodies towards one another. There is, therefore, a continual war between these two forces; and from this war results all the varied forms of matter, from the state of a solid to that of a liquid, and still further to that of an æriform fluid.

A certain quantity of caloric, added to a solid body, changes it to a fluid. If we add still more caloric, it separates the molecules of the fluid so far from each other, that their attraction of aggregation is entirely destroyed, and the liquid is transformed into vapor or steam.

When I touch a warm body, the caloric which is perpetually tending to an equilibrium, passes from this body into my hand. On the contrary, when I touch a cold body, the caloric passes from my hand into that body, and I experience a sensation of cold. To the property which caloric thus has to pass from one body to another, we owe the invention of the thermometer. The heat, in expanding the quicksilver, increases its volume, and causes it to ascend in a small cylindrical glass vessel, marked with circles at equal distances, called a graduated scale, by which the increase of the heat is noted.

There are bodies which the heat penetrates only with difficulty. They retain their caloric, and grant it a difficult passage. They are called bad conductors. On the contrary, bodies which give a free and easy passage to their caloric, are called good conductors. If you raise the wick of a lamp with a pin, the heat is immediately communicated to your hand. Metals are good conductors. You burn a match, on the contrary, until the flame almost touches your hand without giving you the sensation of heat. Wood is, therefore, a bad conductor.

A little girl went into the study of Mezerai, the celebrated historian, to get fire. Having forgotten to bring a vessel in which to carry the fire, she put some ashes in the bottom of her hand, and, to the great astonishment of the philosopher, put the burning coals upon the ashes, and carried off the fire in her hand. Experience had taught the child, that ashes were a bad conductor of heat.

The warmest bodies are bad conductors. Such a substance is a woollen dress. It keeps off the cold, not as some suppose, by imparting warmth, but in hindering the warmth of our bodies from escaping. Hence, when the air is warmer than our bodies, a woollen dress tends to keep us cool.

Most of the animals, by an admirable contrivance of the Creator, are covered with wool, fur, hair, feathers, all substances among the number of bad conductors. They are clothed by the hand of Providence exactly in conformity with their wants, and the nature of things. Their dress accommodates itself to the heat of summer, and the cold of winter. It falls, and becomes thin in the former period, and grows thicker during the winter. The aquatic birds have a species of very warm down, which only covers that part of their breast exposed to the water, which is varnished with a bland oil, and is at once fortified against cold and humidity.

Nature carries her foresight still further. The same animal acquires a different fur in different climates. The northern frosts impart to the goat, rabbit, cat, and sheep, a thick and furry vestment. The same animals are almost entirely deprived of hair in the burning regions of Senegal and Guinea; while in Syria, according to the expression of a naturalist, they are covered with a long, light, and silky vestment, like the robe of the Orientals. The wants of all beings have been calculated with such an exactness of benevolent justice, that the animals which live in valleys where they enjoy a milder temperature, are more thinly clad than the animals of mountains, that wander in the midst of storms and snow.

We might trace the same wise arrangement, even in the conformation of vegetables. Their flower-buds are destined to multiply and perpetuate the species. They contain, at the same time, the seed, the fruit, and the coming tree. Nature, neglecting nothing that could tend to preserve so important a change, has fenced the bud with scales, overlaying one another like tiles; bristled them with hairs which defend them from insects, and lubricated them with a light varnish, over which the water glides without leaving a trace of humidity.

As animals are more warmly clad by nature in proportion as their climates are colder, so, as we approach the warm countries, these scales which envelope the germs diminish by degrees, and end by disappearing entirely. In the torrid zone, the light buds of flowers are naked, like the savage that dances round the tree which bears them. Transfer this vegetable to our climates, and you will see nature take care to clothe and defend it by numerous scales. This is her process of acclimation.

Every thing perishes in the universe only to be renewed. Nature incessantly struggles against destruction; and her wise and benevolent foresight maintains the equilibrium between life and death. What admirable precaution has she taken to assure the reproduction of the humblest plant! During the close of summer, she covers the ears of our maize with husks, more or less thick, according to the mildness or severity of the winter that is to follow. The naturalist discovers this provident care in many of the coverings of the fruits and grains. The savage counts the number and thickness of these coats, and is forewarned for what severity of winter he has to prepare; and, unread in the lore of our books, in reading this beautiful book of nature, he is enabled to regulate his labors, his hunting and fishing in the desert.

I hope you have seen that the study of nature is full of charms. In proportion as you investigate her secrets, the wisdom of Providence is continually disclosed, and your views become more broad and delightful, and all dryness disappears from the pursuit of knowledge. You enjoy such a pleasure as the traveller experiences, who has finally toiled to the summit of a mountain. The prospect of boundlessness opens before him, and the heavens surround him on all sides.

LECTURE XXXII.

ELECTRICITY.

Electricity, galvanism, meteors, and thunder, will be the subject of this lecture.

Is the subtile fluid of electricity diffused through nature? Is the terrestrial globe the inexhaustible source of it? Is it analogous to caloric, or identical with galvanism? We know little of this strange element, except some of its more obvious properties. Glass, resin, and amber, as we have seen, have the property of retaining the electric fluid between their molecules. Rubbing detaches it; and metallic points draw it off, and are called conductors. When the machine is in operation, and you touch a conductor brought near it, the sparks flow off. Certain bodies have the property of opposing an almost impenetrable barrier to the escape of the electric fluid. Glass is of the number of these bodies. A person standing on a glass tripod, and holding to the conductor when the machine is in operation, is said to be insulated; that is, he is no longer a conductor, and the person who touches him receives a shock. It is a common jest, practised upon a person unacquainted with the intended experiment, to place a lady on the stool, and invite him to salute her. As his mouth comes in contact with her cheek, he receives a shock that causes a revulsion of terror. Another holds to her a vessel full of ether. The contact of her finger sets it on fire. Whoever approaches her, experiences something more than poetic darts and flames. Her hair stands erect. Sparks fly from her eyes, and she gives forth real fires.

Shooting stars, the meteors that wander over swamps, morasses and church yards, by the name of Jack-o'-lantern, the fire of St Elme, and perhaps the Aurora Borealis may be referred to electricity, as their cause. Their bluish light exactly resembles the color of the electric spark. To this cause we clearly assign those luminous tufts, which, Cæsar relates, were suddenly seen to play about the points of his soldiers' spears. Innumerable appearances of the same kind are recorded to have been seen at different times and places. Officers have remarked them at the points of their swords on nights of thunder storms. They have been seen about the metal points on the rigging of vessels. Travellers have perceived their hands, their whips and the ears of their horses stream with a bluish, brilliant light. These phenomena are all the product of accumulated electric fluid; and the history of these appearances probably led

Franklin to meditate his electric rod, as a protection from the effects of lightning.

Can we credit the fact, that the appearance of these meteors has, more than once, settled the destiny of kings and nations? The history of the phenomena of nature would be the history of human superstitions and follies. The pontiffs of ancient Rome, after a great storm, ordered religious festivals to reconcile heaven and earth. The Huns, after a destructive storm of rain, dethroned their king. The Spartans deposed their prince, if during the tenth year of his reign, a shooting star, or a wandering meteor of a particular aspect were seen. The fierce Thracians ranged themselves in order of battle, during the uproar and thunder of a tempest, adored the god Zamolxis, and discharged their arrows into the air. Froissard describes a storm which played no unimportant part in French history. Edward of England held king John prisoner, and encamped in the plains of Chartres, threatening to invade France. The kingdom seemed on the verge of ruin, when a tempest saved it. One so dreadful had never been known in the memory of man. The earth was enveloped in a darkness like night; and magazines of fire seemed to inflame the sky. For some hours, France had no other light than the glare of lightning. The English army encamped upon the plain was awe-struck, and believed itself the object of the wrath of heaven. Edward, affected with the common terror, turned towards the spire of Chartres, which shone in the midst of the inflamed clouds, and made a vow to return to England. The age, which would not have pardoned him the slightest emotion of fear in the field of battle, forgave his being frightened by a storm. He accomplished his vow, and a peace ensued.

The identity of lightning with the electric spark was discovered by Franklin. He raised a kite with a wire, and held it by a silken cord. His heart palpitating with hopes and fears, he went forth alone into the fields, during the passing of a thunder cloud, to test his supposed discovery. One cloud passed by, and gave no sparks. But his delight may be imagined, when, during the passing of another, his string gave out abundant sparks. The fact assured him, that his discovery was real and complete; and inspired him with the joyful consciousness, that his name would descend to posterity, as the author of a great and beneficial discovery. More than one person, imitating his experiment, was struck dead, for not taking the precaution to hold the wire, while the thunder cloud was passing, by some proper non-conducting substance. Every one knows, that this discovery led Franklin to the invention of the electric rod, by which the electricity of thunder storms passes harmless to the earth.

The ancients, when imagining Jupiter invested with his sublimest attribute of power, armed him with thunderbolts. In fact, there are few spectacles presented by our world, sublimer than a great thunder storm. The clouds are seen gathering, and condensing, as they acquire a gloomy darkness. Whilst white clouds pass in all directions across the cerulean magazine of lightnings, as if to announce, as coursers, the approaching storm. Huge masses of vapor of a brassy whiteness are rolled in unspeakable grandeur about the external borders of the cloud. Hollow sounds of the mustering winds are heard in the centre of the advancing blackness. At length the storm pours in mingled sheets of wind, rain and hail. Crash after crash follows the glare of lightning, as though the artillery of heaven made war upon the earth. The forests bend. The cattle fly to their coverts. Even the beasts of the forests, and the fowls of the air seem awe struck. Too often it happens, that man, capable of reason, and of sustaining himself by a calm courage, and a manly and confident reliance upon the wisdom and benevolence of the ordinations of Providence, shows fear unworthy of his rational nature. The most timid women act below their dignity, when they utter cries, and attempt to hide themselves from the shafts.

If we could observe the deportment of the different people of the world, while the storm is over their heads, we should see vast numbers of all the christian communities pale with terror. We should behold the native Brazilian contemplating the heavens with a sigh, under the impression, that a malignant spirit was about to strike him. In the midst of the profound darkness, and by the glare of the unremitting flashes, we should see the greater number of the savage nations prostrate upon the earth, waiting for the storm to pass away; while in Circassia, we should note the beautiful young girls issuing from their houses, lute in hand; and instead of manifesting terror at the formidable spectacle, commencing their gayest dance in presence of their aged parents.

The effects of lightning are surprising for their singularity. It has been seen to melt metals, in which gunpowder was enclosed, without firing the gunpowder. It is not uncommon, that persons, who are scathed with the stroke, survive; while those, whom it had not visibly touched, are killed. The mother has fallen lifeless, and the infant in her arms has remained unharmed. From the dryness of our atmosphere, thunder storms are frequent, and many fatal accidents from lightning annually occur. The surest mean of resuscitating a person from the effect of a lightning stroke is, to strip the body, and pour upon it great quantities of the coldest water that can be procured.

There are simpler means of security than even shielding the habitation with an electric rod. It is only requisite to sit in a chair with glass feet, to cover the head with a silk veil, and to abstract from the person all ornaments of gold, silver, steel, or other metals. With these precautions, the person is more secure from the effects of the most violent of these tempests, than was the terrified Roman emperor, who prepared a profound cavern, in which to hide himself.

I beg to cite in this place the proposed improvement of an English philosopher; which was to erect an electric rod from the hat crown of our fine ladies, and to add to the ornaments of their head a chain of metal. This chain would ward off the lightning, by causing it to glide safely over their hair, which, like amber and resin, is a non-conductor. 'It would produce,' says the inventor, 'the same effect, as conductors raised above the summit of spires, which are so frequently struck with lightning, only because their vanes expose points of metal, like the wires and pins of the head dress of ladies.'

There are countries even in the warmer climates, where thunder is unknown. Parts of Upper Peru may be mentioned, as examples. It seldom rains, or thunders at Lima. Moisture is supplied by copious dews, and the purity of the air preserved by the fresh breezes of the Andes. This climate is one of the most lovely in the world. Again, there are other portions of our continent, where it thunders almost every day. Nature still intends kindness, in sending these formidable tempests. These countries are covered with dense forests, and often with stagnant waters, containing prodigious masses of decaying vegetation, which, brought into action by the high heats, would cause the atmosphere to become so charged with noxious miasms, as to be uninhabitable from insalubrity, were it not for such a powerful agent in purifying the air, as thunder.

We have observed, that we are wholly unacquainted with the nature of electricity. But we have recently had a chance to become conversant with a modified form of it, which has taught us, that it sustains many interesting relations with chemistry. This form is called galvanism. Doctor Galvani first observed in 1764, that the nervous and muscular organs of animals, brought, in particular circumstances of contact, with different metals, experienced an irritation, which was manifested by sensible movements. If we bring two pieces of different metals in contact upon a blister, or incision on the body, a sharp pain is experienced, when they touch. If we put a piece of zinc under the tongue, and a piece of silver above it, and bring the pieces of metal into contact, we experience a decidedly acid taste. If we place one piece of metal against the internal angle of the eye, and the other between the lower lip and the jaw, we see at the moment of contact, a flash nearly resembling distant lightning. It was thought at first, that this was a new element, which acted only on the animal organization, and therefore ought to be termed *animal electricity*. Among the numerous philosophers, who investigated this new form of electricity, for such it was soon proved to be, Volta was the most distinguished; and to him we owe most of the important discoveries connected with the subject.

He discovered a method to augment the galvanic energy, and exhibit it in a convenient form for observation. His apparatus for this purpose is called the Voltaic pile. It consists of plates, or pieces of dissimilar metals, arranged with paper or cloth moistened with brine or a weak acid between them. When these alternate layers of metals are brought in contact by a conductor, the metal most easily oxidized is always positively charged, and the one, least easy to oxidize, negatively. When from five hundred to a thousand double plates are thus arranged, brilliant and striking effects are produced, if the opposite poles are properly united by conductors. The wire, that forms the union becomes magnetic. If a piece of charcoal, united with the negative wire, be made to touch another piece, united with the positive wire, a brilliant spark and intense ignition ensue. When the metals and other inflammable bodies are placed in this arc of fire, they burn with great brilliancy; and those, which are most difficult of fusion, give evidence of the intensity of heat by instantly melting. Many earthy and other bodies, infusible by any other methods, are liquefied. The shock to the animal frame is painful and dangerous. When bodies are under the influence of this electrical decomposition, their usual chemical powers are suspended, and new and curious phenomena are observed in their place. If the wire be made to communicate at one end with the zinc, or positive part of the pile, and the other with the copper, or negative part, it is rapidly oxidized, where it communicates with the zinc. Water, brought between the points of the wire, is decomposed, and oxygen gas is liberated at the positive end, and hydrogen gas at the negative point. The water, surrounding the positive wire, becomes slightly impregnated with acid; and that around the negative wire with alkali.

It was with a pile of this sort, that Sir Humphrey Davy performed his celebrated series of experiments upon the fusibility of metals. In this way, he produced those famous decompositions that have convinced the age that the alkalies, and some of the earths, have metallic bases. In this way, he discovered the existence of various metals unknown before. Experiments resulting from the analysis of bodies, and the production of acids and alkalies, may be multiplied by this apparatus without end.

Its effects in exciting the nervous irritability of animals recently killed, still affect the multitude with astonishment. Applied in a certain way to frogs, muscular action is renewed to such a degree that the animals seem about to leap again. The head of an ox recently killed, and strongly galvanized, had the appearance of life. The tongue was thrust from the mouth; and a noise, like that of bellowing, was heard. Bodies of hanged convicts, under the influence of galvanic action, it was thought, might be restored to life. Sanguine calculations were made in regard to its expected efficacy in resuscitating drowned persons, and others in whom life had been suddenly suspended from any violent cause, that had not deranged or destroyed the organs of life. Much expectation in regard to its influence upon many forms of disease, was raised from witnessing its extraordinary effects upon the animal organization. It has achieved much more than was expected from it as a chemical agent, and much less as a curative application to the human system. Those who wish to become acquainted with all that is known of the galvanic fluid, will consult treatises expressly upon the subject; among which, those of Volta, Haüy, Davy, Pfaff, Hare, and Brande, stand conspicuous.

LECTURE XXXIII.

ELECTRICITY OF THE POLAR REGIONS.

In this lecture, I shall touch upon the beautiful compensations of nature in balancing advantages and disadvantages; and I shall present some of the phenomena of electricity as the supposed origin of Aurora Borealis.

We have seen that torrents of light from the sun, give birth to the beauty and grandeur of the vegetable kingdom. Their agency electrizes all animated existence, and imparts energy to the universal principle of love. The sun disappears. The streams, chained in ice, cease to murmur. The foliage of the trees first changes to hues of orange and purple, and then falls. Nature wears an affecting aspect of sadness and decay. Man, ceasing to find comfort and pleasure in the open air, retires to a new form of existence around the sacred hearth.

What is the destiny of the inhabitants of the frozen North? Are they abandoned by Providence to their storms and ices? In their inclement and dreary region, how can they subsist without warmth and without harvests? Providence has taken thought for all; and its wisdom always furnishes ground for admiration, precisely at the point where ignorance begins to seek cause of complaint. A quadruped, a tree, a bird, the reindeer, the eider-duck, the whale, and innumerable fishes are found in those regions; and these simple gifts of nature originate for them joy, abundance, and satisfaction. For these people, the reindeer seems to unite all the qualities of the useful animals; the fleece of the sheep, the milk of the cow, the force and swiftness of the horse, the docility and attachment of the dog, and the sobriety and patience of the ass. A little moss satisfies this excellent servant that attends the inhabitants in the midst of their snows, as the camel serves his master in the midst of the sandy deserts.

If the reindeer has rendered the northern regions of the globe habitable, the birch-tree furnishes materials to conquer it. From the first, the Laplander fabricates vessels, cordage, clothing, and the long shoes with which he glides like an arrow, over the frozen summit of his granite mountains. The bark of the second furnishes canoes, and a covering for his roof like tiles, a kind of flower which nourishes him as bread, a fragrant oil, and a beer or wine like that of the palm. In fact, as the reindeer is the camel, the birch is the palm of these regions. The feeble Laplander, whose form and movement might seem to indicate want of courage, forms a light skiff of the bark of this tree, and throws himself fearlessly upon the tumultuous bosom of the sea, in pursuit of the huge whale floundering among the billows. Nothing can exceed his calm courage and address in this formidable encounter. Sometimes he seems swallowed up between the mountain-surges, but is soon seen floating again on the abyss. The enraged animal strikes with irresistible force with his semi-circular tail. But, as agile on the water as a duck, he evades the blow, and ceases not to make war upon the huge monster, until he is seen towing the insensible hulk to the shore. His friends line the strand with acclamations of joy, and the whole tribe is enriched with the spoils of a single fish. With the thick skin, the Laplander constructs the roof of his cabin. The flesh furnishes him food; the membranes of his intestines, a linen softer than cotton; his fat, an oil that gladdens his cabin in the long, dark nights; the tongue, articles of clothing impermeable to the rains and cold; his bones harpoons, arrows, and knives, which serve him to destroy other whales, or pursue the game of his forests, or take the fish of his rivers and seas.

Scarcely has the season of his fishery passed, before myriads of wild geese, swans, and ducks, light in the lakes of the rivers. The number of these fowls is so great, their ranks so close, their white plumage so brilliant, that when they raise their wings to fly, the whole lake seems to swell like a sea of alabaster. Divesting themselves of their down for the purpose, they cover the rocks and ices with their nests, and lay innumerable eggs which will not hatch until the frost is past, and only in such a manner that the young are launched from the ices into the waves. In this way, Providence sends every spring to these countries an ample harvest of fowls, eggs, and down; as she gives wheat and maize to our fields, and fleeces to our flocks. Thus, these men, who seem at first view abandoned of nature, have neither to toil, plant, nor spin, but receive all from the hand of Providence.

But what shall compensate them for the departure of the sun, and the absence of that light which is the life of creation, and perhaps the element of worlds? What plastic and reproducing fire shall awaken love, and replace the glorious star of day in these regions of darkness and frost? A provident and maternal nature, overlooking nothing, providing for all, has given them a diffusion and power of the electric fluid which almost compensates the light of the sun. 'I have seen,' said an old Siberian, 'the hair on the heads of my children rise only by my passing my hand over it.' The air is electric to such a degree, that the slightest rubbing of the furry hair of the animals causes the sparks to fly as from an electric machine. Philosophers have remarked, that electricity powerfully favours the rapid development of vegetation. We may therefore conclude, that the great abundance of this fluid in the polar regions, is intended to replace the beneficent action of the sun.

Electricity is the sun of the poles, like that planet imparting light and animation to the atmosphere and the earth. Under its influence, as if fostered by the solar ray, plants acquire hardihood, life, energy, and enjoyment, and the blood a rapidity of circulation which prevents the inclemency of the climate from being felt. Earnest, vigorous, full of life, the native exults amidst his whirlwinds of snow, joyfully breasts the keen air, 'and carols as he goes.'

Every one knows that the polar year is composed of but one day and one night. The sun ascends the sky at the vernal equinox, and holds its revolutions above the horizon for six months. It then slowly disappears; but a long and beautiful twilight softens the gloom of its departure as it preceded its coming. As soon as all traces of the glorious planet have disappeared, innumerable varying luminous spectacles kindle in the sky. Flames of a thousand hues, glittering globes and scarfs of light flash across the extent of the heavens. These meteors silently traverse the celestial spaces, uniting in the zenith, where they form porticos, arches, and gulfs of fire. One wide conflagration seems to fill the heavens, where Aurora Borealis reigns the superb ærial meteor of the ascendant.

Philosophers have done no more than conjecture the cause of this phenomenon. M. de Mairan supposes it to result from the contact of the solar and terrestrial atmospheres. Others have advanced the extravagant opinion, that near the poles there are magazines of nitrous gas, whose red vapors rise to these immense heights in the air and spread over the polar heavens. The more probable conjecture is, that it is the accumulation of the electric fluid which is always found in the greatest activity in the clear cold sky of the frigid zones, precisely where the boreal phenomena are most striking and abundant. Thus all the arrangements of the universe, and all the apparent accidents of nature, are distributed by weight and measure.

Such is creation, that beautifully perfect work of the Divinity. Confidence in his wisdom, goodness, and power, fill my heart as I contemplate it. My being enlarged and prolonged, becomes identified with the immortality of thought, remembrance, and love, and I see through the veil of darkness the twilight of a life to come. The docile and diligent student of nature, as Columbus divined from noting flowers floating on the sea as he approached the sunny isles of the west that he was nearing a new world, assures himself that the spirit in harmony with all these innumerable adaptations of God's universe at the close of this brief sojourn, touches on a world where life is without death.

LECTURE XXXIV.

VOLCANOES.

NATURE has reserved mountains as the machinery for putting forth her sublimest spectacles. Her most imposing mysteries are accomplished among the snows and storms that envelope their summits, while the central fires that burn beneath their roots, have been contemplated in all time as the most terrific manifestations of her power. As we mount these ancient piles, majestic solitudes, a purer air, fresher vegetation, flowers of more brilliant hues, the enlargement of the horizon, the expansion of mind, and thoughts more serene and meditative, seem to whisper us that, in climbing the domes of the temple of nature, we are approaching the throne of the Eternal Being, who fills nature with his presence.

The seers and sages of every age have delighted to fix their cells on mountains, that, above the low passions and pursuits of earth, and abstracted from gross and terrene thoughts, they might yield their minds to meditations worthy of the nature of truth, and their own undying spirits. Here the early Christians retired from persecution, and the more dangerous assaults of earthly temptation. Here the imaginative poetry of heathen fable assigned the mansions of the muses and the gods. A common propensity of the Oriental nations, impels them to desire that their sepulchres may be upon mountains.

The more closely we scrutinize the details of these grand structures, the more clearly we shall discover, that no circumstance which appertains to our globe has been arranged by chance. The place of every rock is designated with intelligence. Even the forms of mountains are only varied to meet the intention of their use. Some, like immense obelisks, rear their heads in solitary grandeur to the sky, to collect the clouds, to condense their moisture, and to foster the fountains, that leap down their cliffs, till they wind in beneficent calmness through their green meadows. On others perpetual ice and snow glitter in the sun's rays, and become the nursing reservoirs of rivers, that water whole countries on their way to the ocean.

In the torrid zone mountains are commonly steep and almost perpendicular. These forms cause them to project vast shadows, which shield the plains, plants and animals, from the burning ardors of the sun. On the contrary, in northern climates gentle acclivities reflect the sun's rays, and give origin to the beautiful verdure and the splendid flowers of Alpine plants.

A high mountain is an epitome of the physical world. On some belt of it we may enjoy all seasons and all climates, and pass through the temperature of all the degrees of latitude from the equator to the poles. In traversing the Alps or the Andes, nothing is more surprising than to note the prodigious power of vegetation, which raises brilliant flowers and rich strawberries in the immediate vicinity of a snow-bank, and clusters of grapes in view of unmelting ices. Perhaps a ravine appears close at hand, which, disclosing the ruins and organic remains of a former and by-gone world, forces the thoughts down the dim traits of the unknown ages of the past.

In ascending mountains, none of their spectacles afford more pleasing food for reflection, than the accurately defined belts, which bound the peculiar habitation of each tribe of plants. Having assigned them their limits, nature has interdicted their escape by enactments of her own peculiar code. At the foot of the tropical mountains we find palms and bananas. In the next belt the cultivator discovers the sugar-cane at home. Still higher he notes the most vigorous cotton and the most luscious figs. Thus far no oaks are seen, and the diseases of tropical climates prevail. In the next belt the temples are fanned by a purer air. Oaks, the emblem of strength and health, raise their vigorous trunks. The sweeping pestilence of the cities below will not germinate in this atmosphere, lustrated by the rustling of oak leaves. Here we see wheat fields, the cherry, peach and apple. The hardier pear tree takes a higher place along with rye, barley, peas, and the nutritive potatoe. The wind next sighs through the evergreen tops of the terebinthines, pines, cedars and hemlocks. Still beyond this belt is the region of the myrtle, and a wilderness of beautiful shrubs and bright Alpine flowers. Farther onward are the blue petals of the gentian, and the juniper with its innumerable berries. Nature here begins to assume a sterner aspect at every step. The humid turfs are rendered soft by a silky moss. The small round slender plants have flowers as dry as paper. It is the vegetation of Lapland and Kamtschatka. The naked rocks soon sustain nothing but here and there a lichen, and organic nature expires amidst the ices of the poles.

There is a house in Swedish Lapland, in which the inhabitants retire to sleep on a certain night in the year, in the unmitigated inclemency of winter. They are awakened in the morning by the bright sun of matured spring.

They dwell in a valley bisected by prodigious elevations of perpendicular rocks. The portion of this valley that opens to the south, receives the sun eight hours of each summer's day. The other portion opening to the north, and sheltered by rocks and mountains, lies buried in shade three months after the other section exposed to the light unrolls to the eye an immense carpet of verdure, decked with saffron, violets and primroses. The shepherds are then seen driving their flocks to the pastures, and the gay chirping of birds is heard. The section deprived of light all the while presents the sad spectacle of the snows of winter, trees bristling with icicles, whilst the frequent noise of avalanches is heard. The summit of the peak, which separates these two divisions, has a width of but a few feet. The sun, still mounting the horizon, begins to touch the summit. The shadow diminishes, and spring finally enters the northern valley. This change is accomplished in a single night.

With this picture of icy mountains, I contrast one of mountains of fire. Even amidst the terrific spectacles presented by this scene, we shall be able to discover the paternal care of Providence. If the earth is indebted to the former for its fountains and streams, its freshness and fertility, the ocean is, probably, indebted to the other for the purification of its vast masses of water. The chain of volcanoes extends through the two zones contiguous to the equator, and is prolonged towards either pole. The craters of some thousands of volcanoes, that are now extinct, still indicate the position of their former action; and a thousand more of these prodigious furnaces are still in operation. Well may the imaginative ancients have deemed them the mouths of hell.

It would not be difficult to produce volumes of theories by different philosophers, to account for the origin and action of volcanoes. I do not propose to perplex you with details of their conjectures and reasonings. The theory that seems to me most probable, contemplates in them one of the greatest benefits of nature. A great mass of collected facts is produced, which lead to the belief, that they feed upon the impurities of the ocean, which, without this grand lustration of cleansing, would become a vast infected sewer, which on the earth, and in the waters, would produce the destruction of every thing that has life.

The phenomena of their eruptions, it is true, are often accompanied with great disasters. But nature, always full of maternal kindness, gives forewarnings of the formidable catastrophe, which is preparing. Alarming subterranean noises were heard, three months before the terrible eruption of Vesuvius in 1779. Livid flames, streaming aloft from the crater, illumined the air. A volume of thick smoke was soon after emitted, which separated into strata from the summit. These layers, of a dazzling whiteness, resembling bleached cotton, formed in a few days an aerial mountain, four times higher than the volcano, the summit of which inclined in sinister folds towards the city below. At intervals impetuous winds dissipated this fantastic mountain of smoke, and raised above the crater glittering clouds, in which the blazing interior of the gulf was reflected, as on a mirror. Sometimes by an effect like that of a copper ball brought near an electric tube, a cloud propelled upon the mountain became instantly covered with lightnings, in forms of tufts, zigzags, and rockets of fire. These prodigies, repeated three months, gave ominous note of warning to the inhabitants in the vicinage to escape. That term elapsed, it burst, and threw into the inflamed atmosphere pyramids of fire eighteen thousand feet high! The mountain presented the aspect of an immense ignited ball of fire, whose blood-colored reflections glared below upon a wide circle of ruins.

There are few considerable districts of the earth, which do not exhibit traces of volcanoes, either in action, or extinct. The prodigious masses of hot water, thrown into the air by the spouting spring of Geyser, in Iceland, and generally the existence of large hot springs, seems to be evidence of volcanic action. Throughout the Atlantic, Pacific and Indian Oceans, the greater number of the islands are of volcanic origin. In the Azores alone there are forty-two; and in one range of the island of Java there are thirty-eight large volcanic mountains. They exist through the zones immedately parallel to the equator, and diverge into the arctic circles. The whole immense line of the Andes shows volcanic mountains at frequent intervals. Under mountains clad with masses of ice and snow that never melt, is seen the astonishing spectacle of central and everlasting fires.

History and observation abound with facts, that serve to convince us, that a connection exists between volcanoes and the sea, and that they thus have a common centre of communication, in an element diffused over three quarters of the globe. Explosions at one point appear to communicate an influence to another at a great distance, like an electric shock. Earthquakes and volcanoes seem clearly to have a common origin; and the former manifest contemporary results across oceans, through whole continents, and in some instances, over a whole hemisphere. The earthquake which destroyed Lisbon was more or less felt all over Europe, across the Atlantic, in North America, and along the shores of our great lakes. The destruction of Caraccas in South America, in 1811, and the terrific phenomena of the earthquakes at New Madrid were coincident.

Another fact establishes the point, that volcanoes act in concert, and at immense distances from their craters. The volcanic mountains clearly are not themselves the store houses of the volcanic matters ejected; but merely the funnels or spiracles of their escape. Volcanic mountains, that have generated regular eruptions at intervals from time immemorial, have poured out more lava at a single eruption, than the whole solid mountain would have formed, had it all liquefied, and flowed away. But this process has been going on from age to age, without at all diminishing the volume of the mountain, from which the eruption takes place.

A striking proof of the number of ages, in which these phenomena have been in operation, is found in the fact, that Cumea, founded twelve hundred years before the Christian era, is built in the crater of an ancient volcano, which had been so long extinct, that the time of its existence was not matter even of tradition. The streets of Herculaneum and Pompeii, ingulfed in lava in the year 79 of our era, are discovered at this day to have been paved with lava, the eruption of periods beyond traditionary record.

Another analogous fact to prove that the mountains do not themselves furnish the matter of their eruption is, that water and mud are, perhaps, as often ejected in eruptions, as lava. These volcanic explosions frequently take place in the very bed of the ocean, throwing islands from its fathomless depths, that appear awhile, and sink back, leaving no soundings in their place. All these facts seem to speak one language; and to declare, that volcanoes have a common origin in the sea, and derive from its impurities the matter of their eruption. For this purpose, on this illimitable mass of waters, which would else become bodies of poisonous miasm, are kindled eternal fires, of sufficient power to raise islands from the depths of the sea, and to cover extensive regions with lava of impenetrable depth, upon which cities rise, measure their dynasty, and are whelmed in their turn in liquid fire.

The most extraordinary volcanic eruption recorded in history, for the extent and power of its explosion, was that which took place in Sumbawa, one of the Molucca islands, in 1815. It is described in the history of Java, by governor Raffles. Its report was heard, and its tremulous motions extended, over a circumference of a thousand miles from its centre. At Java, distant a hundred leagues, it seemed awfully present. The sky at noon day was so overcast with clouds of ashes, that the sun was enveloped in an atmosphere of palpable density. The circumference to which the cloud of ashes was so carried as to produce utter darkness, must have had a diameter of 700 miles! When we have such a recorded historical fact, need we ask for a more powerful lever with which nature may raise one region and submerge another; and, in fact, produce any of the changes which the surface of our globe exhibits?

I add to this brief sketch of volcanic history, by quoting from the journal of Mr Ellis, a missionary, an account of a volcano of a new and extraordinary character, which he visited in the island of Hawaii, in the South Sea. It is called Kirauea: —

'After walking some distance over the sunken plain, which sounded hollow under our feet, we came suddenly to the edge of the great crater, where a sublime spectacle presented itself before us. Astonishment and awe for some moments deprived us of speech. With our eyes riveted on the abyss below, we stood, like statues, fixed to the spot. Immediately before us, in the form of a crescent, yawned an immense gulf above two miles in length, a mile in width, and from 300 to 1000 feet high. The bottom was filled with lava, and the southwest and northern parts of it were one flood of liquid fire in a state of terrific ebullition, rolling backward and forward its surges of flame. Fifty-one craters, of various forms and sizes, rose like so many conical islands from the surface of the burning lake. Twenty-two of them constantly emitted columns of gray smoke or pyramids of brilliant flame, and many of them ejected from their ignited mouths streams of liquid lava, which rolled in burning torrents down their black and indented sides into the boiling mass below.

'The sides of the gulf were perpendicular for about 400 feet, where appeared a wide horizontal ledge of solid, black lava, of irregular breadth, but extending completely round the crater. Beneath, this black ledge sloped toward the centre, which was 3 or 400 feet lower. The gray, calcined sides of the great crater, the fissures which intersected the plain below, the long banks of sulphur on the opposite side, the numerous columns of vapor and smoke, the steep ridges of rock rising in some places 400 feet, presented an immense volcanic panorama, the effect of which was greatly augmented by the roaring of the vast furnaces below.

'Between nine and ten at night, the dark clouds and heavy fog, that, since the setting of the sun, had hung over the volcano, gradually cleared away, and the fires of Kirauea darting their fierce light athwart the gloom, unfolded a view at once sublime and terrible. The agitated mass whirled tumultuously, like a flood of molten metal. The flame that danced on its undulating surface, tinged with sulphureous blue or glowing with mineral red, cast a glare of dazzling light on the indented sides of the insulated crater, from the mouths of which, at regular intervals and with loud detonations, shot up masses of fused lava or ignited stones.'

To this vivid picture, I add that of the volcanic Peak of Teneriffe. Imagine a mountain rising so high from the bosom of the sea, as to lose its summit in the clouds. Two celebrated naturalists, Humboldt and Bonpland, passed a night at the foot of this volcano. Although in the middle of summer, and under the tropical sky of Africa, they suffered severely from cold. The moon struggled at intervals through the vapors which the north wind collected about the mountain, and her disc appeared of a deep crimson on a ground of blue. The aspect of the volcano, which rose so high above them as almost to hide its summit in the immensity of the air, gave a majestic character to the nocturnal scene. Sometimes the Peak was entirely concealed behind the mist, and then emerged to show itself in terrific proximity, like an enormous pyramid, projecting its shadows upon the clouds which floated beneath.

In the morning they directed their course towards the summit of the Peak, and were extremely surprised to find scarcely space enough upon which to sit down. A circular wall of porphyritic lava concealed the crater from their view, and they were able to descend into the smoking mouth of the volcano only by making a breach in the wall.

Having sated their curiosity in the survey of the internal structure of this ancient crater, they returned to the Peak, and sat down to the tranquil view of the scene before them. Above was a pure sky, while at vast depths beneath, masses of vapor perpetually agitated by the wind, rolled round like the waves of the sea. Sometimes a current of air suddenly rent these misty curtains, and through their fissures, the forests, the villages, the port of Oratava with its vessels at anchor, the vineyards, and the gardens with which the city is surrounded, showed as by enchantment, and the view was lost in immensity.

The travellers enjoyed the contrast which presented between the bare and rugged sides of the Peak, its steep declivities covered with calcined rock, and the smiling aspect of the cultivated lands below. They remarked that the vegetation of the mountain was divided by zones, according to the temperature and degree of elevation. Below the lichens which bordered the summit, flourished a species of violet, forming a carpet, which was interspersed with tufts of the *rhetania* full of flowers. Still lower was the region of ferns, bordered with that of arborescent heaths. A forest of laurels, of *rhamni*, and arbute-trees, separated the *erica* from fruit trees. Below all, a rich carpet of verdure extended from the zone of the alpine plants to the groups of date-trees and the banana, at the foot of which the ocean was breaking. From the height of these sterile regions, they could survey the sky, earth, and sea, the tempest, and the calm, the plants of all seasons and climes, and all forms of physical grandeur and beauty. An epitome of the whole earth was under their eye. The grandeur of such a scene inspired profound meditation, and an energy of thought, calculated to fit them for large and instructive discourse with nature.

Those surprising phenomena, called water spouts, spirals of ascending water, which at the same time appear to touch the sky and the sea, have perhaps the same origin as volcanoes. Six of these immense whirlwinds of water and fire surrounded the two discovery ships of Captain Cook at one time. The sun poured upon them the most brilliant light. Storms raged in their bosom. Their movements, causing the whole sea about them to boil and whiten, were furiously rapid. In a moment, like the fallen angel touched by Ithuriel's spear, they seemed to dart up to the clouds and to form colonnades around the ships, interdicting all escape. Storms and thunder are sure to follow this phenomena.

There can be no doubt that these terrific phenomena of earthquakes and volcanoes have a utility, on a scale of importance corresponding to their power. Still the question will return, what is their cause? The fable of the heathen poets replies, that Vulcan is forging under Etna thunderbolts for Jupiter. The philosopher of India became insane while attempting to investigate these refractory movements of his great sensitive animal, the world. Empedocles threw himself into a volcano, because he could not comprehend the cause of it. I present a brief outline of the theory of M. Patrin, which presents a solution of the cause of these great agents of nature, and which to me seems the most probable of all.

Italy is covered in its whole extent with lava and volcanic ashes of such an enormous thickness, that if there existed under it the subterranean hollows from which these immense masses had been ejected, Rome, Naples, and Capona, would have been long since ingulphed in the abyss. Etna alone has thrown out lava more massive than all Sicily. The adjoining earth then cannot have furnished the matter thrown out by these volcanoes. Eruptions so ancient, sustained and multiplied, could not have been supplied with materials by agents which drained their resources without renewing them.

Different gases, according to M. Patrin, inflamed by the electric fluid, form the lava and other matters which the volcanoes emit. Therefore they are inexhaustible. Observe further, that the greater number of volcanic mountains are in the vicinity of the sea. It is thence, they draw the materials which furnish fuel to their fires. These fires are extinguished, or are never kindled, in proportion as they are further from the sea. Their fuel are the gases of which air is composed; that is to say, water and salt. Volcanoes then are springs on a vast scale, whence continually blows a gaseous fluid, incessantly renewed. Part of this gas is inflamed and consumed in the atmosphere. The other part condenses in lavas. The stony matters are instantaneously formed by the contact of air, like a certain gas which changes instantly to quartz by the contact of water. This experiment is shown by the siliceous, fluoric gas.

Probabilities seem to me to unite in favor of this system. You are aware, that vegetables are nourished by the gases which they decompose. A forest then is no more than air rendered solid and visible. Volcanoes are nourished by the gases which are drawn from the sea and circulate in the depths of the earth, as vegetables by the gases which incessantly play round their leaves.

The fact that great quantities of salt are decomposed by volcanoes, on this supposition seems to derive probability from a beautiful and singular observation. The Mediterranean loses, by evaporation, incomparably more water than all that is supplied by the rivers that flow into it. Buffon remarks, that to preserve this equilibrium a strong current flows from the Atlantic through the straits of Gibraltar. These waters bring an immense quantity of salt, which of course never evaporates. The basin of the Mediterranean would long since have been filled with a solid mass of salt, if the volcanoes of the two Sicilies had not been placed in the midst of it, as prodigious laboratories to operate the decomposition of it. Admit this theory, and there is nothing strange or mysterious in the formation of meteoric stones in the air. That showers of such stones have fallen from the air, is no more to be questioned than that we witness showers of hailstones. In the ærial ocean, suspended over our heads, are all the matters in solution of which meteoric stones are found, on analysis, to be composed. Why is it more strange that they should form, by the contact of the gases of which they are composed, than that hailstones, formed in the same way, should fall?

In all ages volcanoes have been the subject of reflection and astonishment. Many philosophers have been the victims of a curiosity to investigate their phenomena. Every one has read the affecting narrative of the death of Pliny from an eruption of Vesuvius. What a sublime and yet simple picture does it convey of the accumulation of all that is awful in nature; thunder, earthquake, darkness, the mountain pouring forth rivers of fire, the profound obscurity only illumined by the crimson glare, that opened to view cities ingulfed in a moment under a liquid torrent of molten rock! The eye only could discern sights of horror, mothers, children, the young, the aged, the sick and imbecile, all making the efforts of terror and despair to fly. In the terrible momentary pauses of the uproar of nature, the ear only caught the shrieks of these fugitives; some, in self abandonment, calling for those dear to them; and others, in ignoble selfishness regardful of none but themselves. We see the son struggling onward, sinking with the weariness of bearing his aged father upon his shoulders. He falls in exhaustion, and expires. We note the philosopher, calm, magnanimous, fearless, his heart tenderly alive to the keenest sentiments of friendship, anxious for others, forgetful of himself, inculcating self-possession by his voice and example, still pausing, and turning with eager curiosity, at each renewed explosion of the mountain, to investigate the formidable phenomenon. He falls the victim of piety, friendship, and philosophic curiosity; having lived without fear, and dying without pain. Three days afterwards, the darkness and smoke giving place to a kind of fearful twilight, the body of the philosopher was found with a calm countenance, as if he had fallen asleep upon the ruins of a world.

LECTURE XXXV.

POISONS. HABITS OF ANIMALS. STRATAGEMS OF INSECTS.

Few have taken the pains to study and class with sufficient care the relations which exist between man and other beings. Whoever will so study the universe, cannot be guilty of the impiety of denying a wise and beneficent Providence. A plant is found to be poisonous and noxious. The unbeliever at once infers, that it can have none other than an injurious relation in the abstract. Because it is poisonous to him, he overlooks the tribe of insects, that rear happy families and communities among its leaves; or the flocks which feed upon it. A reptile stings him, and he murmurs at the Creator, as though it militated with benevolence, that he should create beings, that are not directly subservient to men. Why should not other beings have their measures of enjoyment, as well as man? Millions of happy creatures exist in the deserts, and in the isles of the sea, where no man is, or has been. Happiness is for every thing that is capable of sensation, as well as man. Naturalists have classed more than thirty thousand species of plants, and only two or three hundred of the number are of any direct utility to man.

There are plants that have been formed for man, and others for animals. From the cups of the kind, most poisonous to him, the bee culls a honey, as sweet and salutary, as from the perfumed rose. The deadly hyoscyamus is devoured with impunity by the swine, on whose flesh man feeds; and, what would be a mortal poison to him, assimilates in that animal to the most delicate of meats. The goat browses in health upon hemlock and milk thistles, and the poisonous juices produce that salutary milk, which we give to the pulmonic patient, as a restorative diet. The bustard is eagerly sought by epicures for its delicate flesh, and yet it feeds upon the seeds of poisonous plants. Most of our domestic fowls feed upon noxious insects and venomous reptiles, wherever they can find them. Observing nature in this way, we shall begin to discover the links of that chain, by which poisonous plants and animals are thus circuitously related to the existence and enjoyment of man.

It is a remarkable fact, that in cold climates there are neither poisonous plants, nor venomous animals. Noxious plants even lose their mortal qualities by being transplanted from the south to the north. The illustrious Haller remarks, that the aconite, with the juice of which the Gauls poisoned their arrows, is less poisonous, in proportion as it grows further north; and that it is even eaten in Sweden as a salad to create appetite.

Nature has given birth to the greatest number of poisonous plants and venomous animals on the borders of pestiferous marshes. May they not be placed there, to absorb the poison from the air, putting in operation the machinery of life to lustrate it? It is a well known fact, that in humid and unhealthy districts, during the greatest heats, the atmosphere germinates the greatest number of insects, and that serpents are then the most poisonous. Wherever corruption reigns, nature begins to put forth a vigorous vegetation, and to scatter flowers to conceal, or neutralize it, and to create vast numbers of noxious insects and animals, probably, by absorbing the miasm to restore the air to purity.

At the same time it has been arranged, that the venomous animals should warn man to avoid them, by their ugliness, their frightful noises, and their sinister hissings. God has not thus labelled the nutritive wheaten sheaf, nor the perfumed flower. He has not thus distinguished the laborious ox, the superb courser, or the *agami* of the desert.

It is obvious, that in the burning countries, the rays of the sun more promptly develop corruption, that the decomposition of bodies is more rapid, and the principles adverse to life more vivid and dangerous, than in the temperate regions. In these climates are found the most violent poisons. It is my hypothesis, that nature avails herself of them to purify the atmosphere. Such, in this view, is the ministry of the musquito among insects; toads, vipers, the hooded serpent and the rattlesnake among reptiles; and the mortal vegetable poisons of Java and Surrinam. The innumerable hissings, croakings, and indescribable sinister and revolting noises and cries from the southern swamps, during the high heats of summer, yield instruction, while prompting us to caution. In the ear of him, who receives this theory, these revolting sounds not only warn man to fly these regions of miasm, but cheer him with proofs, that these loathsome animals are finding their own enjoyment, while, assigned a ministry by Providence, they are operating a work of beneficence to man and nature. Were it not so, the winds would become charged with poison, and sweep the country with desolation.

I add, as facts corroborating this theory, that if the sultry countries produce the greatest numbers of poisonous vegetables and noxious animals, it is from them that medicine derives its most salutary remedies. If we find these myriads of annoying insects, their bounds are generally assigned in burning sands, or insalubrious swamps and marshes, not destined to become the habitation of man. By a beautiful adjustment of the providential scale of compensations, here, in the greatest abundance, grow those aromatics and perfumes, which purify the air. In return, if the inhabitants of cold climates are deprived of the rich fruits, aromatic vegetables, and the effeminate and luxurious appetites of warm countries, they have not only sound nerves, great elasticity and vigor of health, but a small number of dangerous plants and animals, and fewer sources of pollution to the atmosphere.

We cannot fail to be interested in another observation. There are plants that incline to grow in single isolation, and others, which have gregarious habits, and grow only in society. These latter are the ants and bees of the vegetable kingdom. We can readily perceive, that the isolation of the one and the union of the other is the arraugement of the foresight of Providence. Almost all the gregarious animals of society are destined to the necessities or enjoyment of man. Such are the horse, ox, sheep, goat, and the domestic fowls. The carnivorous animals, whose forces if concentrated in union would become destructive, such as the lion, tiger, hyena and leopard, the eagle and vulture, live in loneliness, and suffer no companions or rivals to share their solitudes, or their repasts of blood. The same beneficent law classes the vegetable tribes. The cereal and papilonaceous seeds, such as those of potatoes, dates, palms, bananas, and the grains, have the habit of growing in families, and of covering entire fields with their harvests. The greater number of the poisonous plants, on the contrary, grow up in unenclosed fields, in humid swamps and desolate places, and seem to be restrained to multiply their kind only in formidable singleness. Does not this arrangement seem to be settled by a kind of instinct in the one class, and in the other, which has relation to the necessities of man? Does it not seem a link in the great chain of adaptations, without which every thing would perish?

I do not conceal from myself, that this hypothesis, in relation to poisonous plants and venomous animals, may easily be met by specious objections. Should these views prove on trial unsound, at least they are not dangerous. To admit it, is to see new beauty and fitness in the most doubtful arrangements, in the midst of which we are placed. Of this fact I am convinced, that he, who finds most wisdom and fitness in the arrangements of nature, will invariably be her most faithful and accomplished interpreter.

Have you never felt disposed to admire how it happens, that the frailest and most delicate flowers sustain unharmed the fury of the tempest, and the ardors of the sun? Have you never felt disposed to inquire, during the fierce driving of a storm, how the delicate and unfledged young of birds, abandoned in their nests to the wind and rain, could survive the exposure? The ornithologist will excite your surprise, by indicating the various ways in which Providence has foreseen, and provided every thing requisite for their preservation.

The trees of the temperate climates have leaves of delicate fabric, taper form, and light tissue of down, easily penetrated by the sun's rays. On the contrary, the trees of the torrid zone, in Asia, Africa and America, are of gigantic size, and, covered with broad, thick and firm foliage, form a deep and humid shade, alike to protect the flowers and the traveller from the burning heats of the sun. In the same manner the vegetative force of plants is proportioned to the dangers that surround them. Nature has given flexibility to the reed, and strength to the oak, as she has given stratagem to insects and vigor to lions. This remark is so just and universal, that a naturalist, at the single aspect of a vegetable, divines the climate, which it inhabits. For example, the stems of the heath of the Cape of Good Hope, have an elastic power, as if they were made of steel. We see, that they were formed not to receive injury from the shaking of fierce winds. Nature has placed it in a country, which is the home of perpetual storm. All the vegetables of these climates enjoy a life so energetic, that Thunberg, having carefully laid a plant on a stone, found it after three years in fresh vegetation, and having gained three inches in length. The moisture and coolness of the stone had supplied it with the requisite aliment. In this way we see the vegetable power, the form and thickness of the foliage, vary according to the heat, tempests and dangers of the climate.

There are climates, for example that of Jamaica, where the grass dies, the soil cracks into chasms and hardens under the fierceness of the unclouded sun. Nature seems to come to the aid of the sear and parched earth, and employs a mean to shelter it, which evidences another provision of Providence. It covers the parched soil, which refuses to produce a spire of grass, with a kind of tree, *brosimum alicastrum*, whose leaves have the property to multiply under the fires of the sky, as others have to grow in the dew.

The more burning the sky, and the more arid the earth, the more vigorously its leaves unfold. The flocks find in its foliage, a healthful and abundant pasturage. It becomes a sort of fresh meadow in the air, at the period when all other meadows are withered and sear. Still further, these meadows more prolific than those fostered by the dews and showers, conceal delicious fruit which ripen as food for man.

The temperate climates offer examples of the solicitude of nature no less striking. The *nigella* inclines its head, as if it were withered, to avoid the heats of the day. It rears its re-animated cup, as soon as the evening brings its refreshing coolness. Other flowers, as the *carlina* and *meadow trefoil*, shut up their cups at the approach of a tempest. The *quinque-folia* extends its golden petals, in the form of a tent, to cover itself from the rain. As soon as the storm is past, its leaves are again unfolded. Under the same circumstances, the umbelliferous flowers expand their umbels; and the infundibuli-form reverse their funnels; the rosaceous incline their petals ; the liliaceous hang down their corollæ, and the carophylli incline their heads. Every flower seems to foresee its peculiar danger, and to avail itself of the means supplied by nature to avoid it.

I have noted under another head, that the varied movements of flowers, their working, sleep, and sensibility, gave Linneus the idea of a clock, and a barometer of Flora. His garden regulated all his movements. The aspect of different plants announced to him, when there would be fair weather, and when storms. The study of flowers furnished him data, on which to predict the phenomena of the sky. The observing shepherd has only to cast his eyes upon the fields to receive lessons from nature. While the philosopher in his study confides to the uncertain presages of a tube filled with mercury; the laborer says, 'a storm is not distant ; for I have seen the vernal trefoil gently fold up its leaves. There will be a tempest this evening; for the carlina of the vale has been shut up since the morning.'

Neither let us be solicitous about the tender young of the birds. We shall discover that their nests are protected by a thick foliage, branches, straw, wool, and the aperture intrepidly closed by the body of the mother that never abandons her nest. We shall remark, that nests upon the summit of trees are entirely roofed, and have only a little opening on the side opposite the winds that bring rain. All these diminutive, but beautiful specimens of art, are of the color either of the foliage or trunk of the tree on which they are built, that they may escape observation. Some suspend their nests, like hammocks, allowing them to swing at the pleasure of the winds. Some weave their nests firmly in the form of a globe. Others divide a great nest into many apartments, and form a kind of common Spartan city. The humming bird plunges into the scarlet corolla of the bignonia, and there makes its voluptuous nest. It is at home in this splendid flower, for its own glittering plumage challenges comparison with its hues. Its little head glistens with the most vivid colors. Its plumage is a changeable lustre of sapphire, emerald, gold, silver, and flame. It seems to have sprung from the breath of the zephyr; and, nestled in its scarlet chamber, shows as a flower lying in a vase of ruby.

The Abbe Pluche gives a touching picture of a Canary bird. They had given it hay to make itself a nest. For want of cotton or silk, to preserve the temperature necessary to the eggs which the mother was about to lay, she had recourse to a surprising expedient. She put herself to the task of stripping the breast of her male of all his plumage; and he seemed to consent to the operation, by making no resistance. With this down, she effectually lined all the interior of her nest.

Is it not evident that the strange formation of the camel is a provident arrangement for their long journeys through burning deserts of sand? Do not the long legs and beak of the ibis announce to the observer, that it was formed to inhabit the muddy marshes of the Nile? The tortoise, with its slow movement, cannot escape pursuit by flight, and is therefore covered with the impenetrable buckler of its shell. The rabbit is feeble and defenceless, and has no security but in its speed. The ferret, its most formidable enemy, is condemned by nature to an almost perpetual sleep. The *doripedes* and *dromi*, species of sea-crabs, spread sea-weed and sponge upon their backs, and thus crawl securely on the bottom of the sea, as if sheltered under a mountain; while the Surinam eel strikes his enemy with a lightning-stroke, and the caustic sea shell-fish sails, like a vessel, upon the waters of the sea, and leaves upon all the fishes that touch it an impress as of burning coals.

The habits and stratagems of insects, clearly announce a similar arrangement of foresight. Here is a caterpillar dwelling under a tent of silk. Further on are chrysales, suspended by long threads, gently waving in the breeze. Some insects, enveloped in a strong coat of mail, but without other means of defence, counterfeit death to deceive their pursuers. There is a species of caterpillar that frightens its enemy, by menacing it with a long double tail. The thundering-crab, inert and without arms, spreads terror around, by discharging a salute of little cannon, followed with a train of blue smoke.

I shall pass the history of bees, because Virgil has given it so beautifully, that he alone ought to be their historian. The ants of the isle of Bancan are scarcely inferior, in skill and industry, to bees. These little insects raise pyramids twelve feet high, crowned with so solid a roof on the summit, that the wild bulls cannot overturn them. The interior is divided into a labyrinth of apartments. Some are filled with provisions. Others inclose the numerous children of the nation. A multitude of galleries lead to all the stories of this wonderful edifice, inhabited by a king, queen, and an immense people of operatives, masons, carpenters, and soldiers. A species of ichneumon attacks the caterpillar, pierces the body with its dart, and deposits its eggs in the wound. By an inexplicable foresight, it takes care not to kill the insect outright; because it is necessary, that the living body should serve for a cradle and food to the young enemies concealed in it. The larvæ, thus secure, spin little cocoons of silk, and lodge quite at their ease. They seem to divine, that the prolongation of their own life is identified with that of their abused host; for they avoid devouring any of the organs necessary to its existence. The caterpillar continues to move about without appearing to suffer, and it is only at the moment when the larva have attained their growth, that they cut through the sides of the animal and kill it to escape from prison.

These few specimens may stand, as a general example of the universal results of profoundly studying nature. Who would afterwards be seduced by those arrogant spirits, who find cause for exultation, in attempting to disprove the wisdom of the Creator? Instead of admiring the light, they rejoice in darkness. Instead of aspirations towards heaven, they desire to dig in the earth and reduce every thing to a tomb. The weakness of man furnishes them ground to deny his greatness. The sublime thoughts of genius for them are illusive hopes or falsehoods. Diogenes exclaimed, as he threw into the midst of the academy a cock plucked of its plumage, 'Behold the man of Plato!' Produce before such minds a mass of clay. It is the man of the impious.

LECTURE XXXVI.

WATER. DEW. THE COURSE OF SPRINGS.

Water, next to air, the substance most essential to man, is profusely distributed over the whole earth. It floats invisible in the air. It runs among the hills. It flows to the sea in rivers. It fills the vast basin of the seas. It is the world of an infinity of organized beings. Reduced to vapor, it forms clouds, and is the cause of dews and rains. Its caloric being insensible, it hardens to ice. It is composed, as we have seen, of two invisible gases, oxygen and hydrogen.

You are aware, that the most beautiful part of the ancient mythology is that, which, in the version of the poets, has transformed the rivers, springs and fountains into divinities of the Neptunian family, nymphs and tritons, each inhabiting its favorite fountain. As a symbol, that water is the prolific element of all things, they represent Venus, the goddess of love, and the maternal source of all animated nature, to have sprung from the sea.

The inhabitants of a village of Cerigo, formerly Cytherea, have neither wells nor springs; and supply themselves with the necessary fluid by cisterns. Water is there held in almost the same estimation with which we regard choice wines. When one of these villagers marries, his most important preliminary step is to sound the depth of his cistern; for water is the most precious present, he can bestow upon his beloved. The more water is drunk at the wedding, the richer the new married couple are estimated. The prodigality becomes the theme of scandal, which is whispered about the village. An envious jealousy fabricates falsehoods, and predicts the ruin of the prodigals. The unmarried girls envy the lot of the happy spouse, who has been able to furnish such a sumptuous regale of water.

For other cities the coolness of this beneficent fluid has as many charms. The inhabitants of Cumana in South America meet every evening, not for a promenade, or a cotillion party, but to bathe. The ladies and gentlemen of the first society have a particular place, where they assemble. Here they discuss politics, modes, and the thousand important nothings of fashionable society. They arrange and derange marriages, make and unmake reputations, and the hall of assemblage is a bath in the river.

Kepler tells you, as I have hinted, after the Pythagoreans, that the world is a vast animal, marching in urgent haste, and at a prodigious gait through the sky. Pythagoras has assured you, that this vast creature perfectly understands music, and that his very movements constitute a splendid sonata, called the music of the spheres. Campanella, in a book upon the subject, asserts, that his hands are rays of light, which emanate from his substance; that his feet are the atmosphere of the planets, and that his eyes are the stars of the firmament. To complete his body, we must suppose his muscles, sinews and bones the solid earth, the waters the substance of his flesh; and as phrenologists, we may presume the mountains to be his cranial protuberances, phases indicative of the extent of his understanding and passions.

To sketch an outline of this grand animal, the painter ought to be seated under a canopy of clouds, at a sufficient distance in the immensity of space, whence he could distinctly note the vast creature, shaped like a ball flattened at the poles, whirling in its immense orbit round the sun, that envelopes it in a flood of light. He should be able to notice the influence of this rotatory movement upon the seas in their profound beds. He should be able to trace the meandering streams from their cool spring fountains, bearing onward the tide of vegetable refreshment and life to the sea, as the arteries and veins propel the purple fluid from the heart to the extremities, and thence back to the heart.

A nobler sentiment would pervade his spirit, as he beheld the wisdom of nature in the distribution of waters. The adjustment of this distribution to the watering, fertilizing and embellishing of the whole earth would present a beautiful spectacle. The seas of the north would be seen standing in equilibrium with those of the south, the Atlantic and Pacific separating the two worlds, bathing their shores, furnishing their rains, and interposing their vast abysses between the fierce and jealous passions, that generate revenge and war, at the same time, that they furnish the means of connecting the nations by the golden chain of commerce. Far away in the blue outline, he would note the high chains of mountains so admirably arranged, that the torrents and streams, that roll down their sides, as soon as they reach the plains, commence their grand function of irrigation, filling the horn of plenty on their whole course from the hills to the sea.

How many isles would be arid and uninhabitable, had not nature taken the precaution to place in their centre high mountains, where are fostered those springs and fountains, which fertilize the plains. Such is the isle of Scyros, which contains hills of an elevation to attract the vapors, that impart verdure and fertility to the plains. Such is the isle of Nevis in the seas of our hemisphere, the centre of which is a mountain covered with trees, that are always enveloped in clouds. Such is the Isle of Pines, and such that of Tinea, a very fertile island of the Grecian Archipelago, in which the ancient mythologists placed the cavern of Eolus, on account of the north winds, which incessantly drive against its steep rocks.

A recent traveller in the deserts of Nubia has presented one of these striking manifestations of the foresight of Providence. In the bosom of a sea of burning sands, he discovered a battlement of rocks forming, as by enchantment, the enclosure of a lake fringed by a belt of perennial verdure. The burning temperature would soon evaporate the waters of this lake, if there arose not on the southern shore high cliffs of green marble, protecting it from the fierceness of the sun's rays, and covering it with perpetual shade. To animate these solitary wastes, nature conducts to the delicious spot clouds of aquatic birds, which find here at the same time an asylum from the snares of man, and the dangers of tempests.

All the readers of the Bible know, that the most soothing and delicious images of that Divine Book are drawn from still waters in green pastures, cool and refreshing fountains, and the Jordan flowing in full banks. The most impressive representation of the absence of the favor and inspiration of Jehovah is to be exiled to sandy deserts, in a dry and parched land where no water is.

In India and Arabia, from time immemorial, the eulogy of the greatest benefactors is recorded in the fact, that they cleared out a fountain, dug a well, shaded it with trees, or constructed a tank, a perennial reservoir of water for the refreshment of the thirsty pilgrim, who, reclining his weary limbs in the shade, and quaffing the cool element, finds water and shade the most grateful gifts of Providence.

Another beneficent gift of nature is the dew. It is generated by spring, and born of the zephyr. Who, at the twilight of a summer's morn or eve, has not felt the delicious coolness, with which it fills the atmosphere? Who has not admired the white veil of mist, which nature draws aside from her face, when, fresh with dew, she receives the gaze of the sun, shaking her pearls into the cups of the flowers?

To conceive clearly of the formation of dew, it is necessary to understand, that air has the property of containing water in suspension, in the form of invisible vapor, and so much the more, as the temperature of the air is higher. When the sun retires, and the sky is clear, the earth, and the whole vegetable creation, all bodies, in a word, lose their heat by radiating it into space. The air, circulating round these cooling bodies, shares their temperature, and precipitates, or condenses a portion of its water, so as to part with it by its losing that caloric, which was necessary to give it a gaseous form. On the contrary, the atmosphere, in becoming warmer, is charged with a cool and vivifying vapor, which the increased caloric raises from the ground, in the form of evaporating dew.

Dew is appointed to supply the want of rains in the parched and arid climates. Hence the plains of the torrid zone are moistened by an imperceptible distillation of dew. In Arabia Felix, where it seldom rains, the dew alone is sufficient for the sustenance of those exquisitely aromatic plants, with which the earth is covered. In some portions of Europe, in Languedoc and Provence for example, districts abundant in odoriferous plants, rains are rare. But, as has been already noted, it is more than all, on the table plains of Peru, that Providence has bestowed this benevolent compensation for the want of rains, in the abundance of the dews. Light mists fill the atmosphere, moisten the valleys, and deck them with verdure and flowers. The dews are so gentle and imperceptible, that they scarcely damp the dress, and yet are sufficient to refresh, and fertilize the fields. It is because a fleecy tissue of fog at prodigious heights in the air so intercepts the rays of the sun, as to prevent their absorbing these vivifying vapors.

The alchymists made dew the basis of their supposed liquor of immortality. More than a hundred years before the Christian era, Ven-Ti, a Chinese emperor, seduced by the promise of some charlatans, ordered a palace to be constructed of odoriferous wood. In the midst of this palace arose a copper tower four hundred feet high, terminated by a grand tunnel, destined to receive the dew from the sky. A certain number of pearls of great price dissolved in this dew were to impart the ultimate efficacy to the tincture of immortality. We can easily divine, that neither the credulous emperor, nor his impostors are now alive to testify to the success of their grand elixir.

It is an interesting fact, that an urn of glass, or China ware exposed to the dew will soon become covered with drops. Place a silver urn near them, and the dew seems to avoid it. You may even bring the three vessels in contact. The earthen vessels are still covered with drops, while the silver one remains dry.

Pythagoras, with his doctrine that every thing in nature is sentient, would have been at no loss to explain the phenomenon. He would have attributed the modest preference of the dew to the favoritism of some sylph, who would in this way indicate her preference, and at the same time inculcate, as a moral, a contempt of riches. In this way, a celebrated genius explained all the phenomena of nature. According to him, the air is peopled with sylphs, the sea with goblins, the fire with salamanders, and the earth with gnomes. This theory was once so stamped with the impress of fashion, that every lady was supposed to have her attendant sylph, whose office it was to pay her a complaisant visit, in the absence of her lover or husband. But these lovers so slender, subtle, and at the same time mischievous, soon passed out of fashion. Count Gabalis and Paracelsus sustained this theory in seriousness. Pope has conferred immortality upon their ludicrous imaginings, in the splendid irony of the Rape of the Lock.

Experience proves that all bodies have a tendency to part with their caloric, but all with different degrees of facility.

Black, tarnished, rough, and oxydized surfaces part with it most readily. Polished and white surfaces retain it with more tenacity. The polished and shining surface of the silver vase retains its caloric. The air, that plays round it, is not sufficiently cooled by the contact, to condense and precipitate the water which it holds in solution. The earthen vessels, on the contrary, rapidly radiate and lose the heat from their less polished surfaces. The air coming in contact with them is cooled, and condensing a part of its water, covers them with drops of dew.

To account for the well known fact, that most rivers and streams have their sources in mountains, Descartes supposed that the waters of the sea are conducted there by prodigious subterranean passages to immense cavern-reservoirs, situated in the bosom of the mountains. They had previously parted with their salt by evaporation. In these caverns the waters are condensed, and issue forth in torrents, fountains, and rivers. The more exact views of the processes of nature subsequently attained, would probably have changed the whole theory of this philosopher. Had he lived in this age, he would have seen, that nature has no need of subterranean passages, nor distillatory apparatus, nor mountain reservoirs. The streams have their sources in the sky, and we need not search for them in the caverns of the mountains.

We have already remarked, that the air has a property to hold water in suspension in the form of vapor. It is from these suspended vapors, continually condensing in the elevated and cold regions of the air around their summits, that mountains derive the sources of their rivers. This permanent and perpetually equable source of supply would be adequate to fill the urns of these fountains, even if the summits of mountains had no tendency to attract clouds and vapors. But that they have this tendency is matter of universal observation. The cone shaped, and often metaliferous summits of mountains, in many instances, are electric needles. Whenever the electric fluid is in play, the floccules of mist begin to hover round the point of action. The wood-covered sides of mountains are seen enveloped in mist. Condensation and attraction, in this way, concur to render mountains the nursing parents of streams. You cannot but have observed in the morning, when the dew is disappearing before the sun's rays, that it rolls in beautiful white folds up the acclivities towards the peaks. It is a lesson in physics, in which you are taught the origin of rivers.

What a spectacle is presented by the ocean, the grand reservoir, where all the rivers have their source! Sublime image of immensity and eternity, who can imagine the wonders of thine unfathomable depths, of thy incessant flux and reflux, of the resistless power of thy wrath in storms! Yet illimitable, perfidious, unfathomable, and thy bed whitened with the bones of thy victims, to thee we owe forests, fruits, verdure, flowers, every thing that gladdens spring or autumn. From the vast surface of every sea is continually steaming, in invisible vapor, the whole amount of the rains that fall, and the rivers that run over the whole earth. Ascending into the higher regions of the air, it is borne by the winds towards the mountains. In the magazines of hail and snow, it condenses, falls in rains, which fill the urns of innumerable mountain-sources, which unite to form rivers that roll back in majesty to the sea, where they are vaporized anew and raised once more into the air. In this eternal circle, I see the rivers rolling over my head in this transparent mist. I see trees, plants, and flowers, in the form of ærial vapor. In contemplating this perpetual circle of transformations of air into water, of that into vapors and clouds, and of rains into the substance of the innumerable tribes of vegetation, to be decomposed and to return to air and water again, who would not be inclined to believe with Thales, that water was the only element of the universe?

Compared with this magnificent apparatus, so powerful, and yet silent and invisible in its operations, to water the whole earth, how trivial appear those boasted hydraulic machines, which men have contrived for the irrigation of a few vineyards and fields? That is a proud work, by which one of our most beautiful cities is supplied with water by machinery which the water itself puts in motion. A river is made to exert its own power to raise a part of its superfluous waters high in the air, whence, by its own laws, it conveys itself to the multitudes of the city. A power still more vást and artificial is raised from water itself in the form of steam, in which form it is subservient to raising water to elevations, whence whole cities may be supplied. But how insignificant are these proudest triumphs of art and human effort, compared with the sublime water-works of nature! The same rays of the sun, which, in their temperate culmination, cheer and brighten every thing, and in their fiercer ardors menace to destroy every thing, silently and invisibly pump up the vapors, which temper the burning brightness by a veil which the sun in this way draws over his own face.

I close this lecture, by presenting you the superb picture of the formation of clouds in the equatorial regions, as drawn by the powerful pencil of St Pierre. The trade winds from the northeast or southeast that constantly blow there, card the clouds through each other, like so many tufts of silk; then sweep them away to the west, crossing and recrossing them over each other, like the osiers interwoven in a transparent basket. They throw over the sides of this chequered work, the clouds which are not employed in the contexture; roll them into enormous masses as white as snow, draw them out along their extremities, and pile them upon each other like the cordilleras of Peru, moulding them into the shape of mountains, caverns, and rocks. They grow calmer towards evening, as if afraid of deranging their own workmanship. When the sun retires behind this magnificent web, you see a multitude of luminous rays transmitted through each interstice, of the most superb tinge of gold and orange. Divergent streams of light, radiating up the zenith from the sun, clothe the undetermined summits of this celestial barrier with fringes of gold, and strike with the reflections of their fires the pyramids of collateral ærial mountains, which then appear of silver and vermillion. At this moment of the evening are perceptible, amidst their reduplicated ridges, valleys stretching away into infinity. Those celestial valleys present, in their different contours, inimitable soft shades melting into each other. You see, issuing from the cavernous sides, tides of light precipitating themselves in ingots of gold over rocks of coral. Here it is a gloomy rock pierced through and through, disclosing beyond the aperture, the pure azure of the firmament. There it is an extensive strand covered with sands of gold, stretching over the rich ground of heaven, poppy-colored, scarlet, and green as the emerald.

The reverberation of these colors diffuses itself over the sea, whose azure billows it glazes with saffron and purple. This sublime spectacle presents itself at the still and silent hour of evening prayer. The sailors lean over the gunwale and admire these ærial landscapes, which, by their grandeur, invite them to lift their hearts with their voices to heaven. The shifting colors, and the varying forms of these clouds, no pencil can pretend to imitate, and no language can describe.

LECTURE XXXVII.

IMMENSITY OF THE WATERS. TIDES.

How many countries are buried under the barren brine! How many cities might have been reared, how many men might have subsisted, where reigns a single, sterile, illimitable abyss? Why submerge two-thirds of the globe? Such are the questions, with which the impious have dared to attack Providence. The views which we have taken of nature, cannot but have convinced us, that where, in the arrangements of our world, we cannot at once trace the analogies and relations of things, and discern the intent of Providence in them, it is owing to our ignorance and feebleness of vision, rather than to the want of design. Our arrogant ignorance may propose the question, why it rains on the ocean, and does not rain on the Sahara of the African desert? Were we able to trace all the relations of one arrangement in our system to the other, and the mutual influence of all upon each, we could probably be able satisfactorily to resolve questions more inexplicable than this. As far as we can trace these relations, all is the harmony of the most perfect adaptation. God dwells in a light that may well dazzle our perceptions. We are still abundantly warranted in believing, that not one of the phenomena of the physical universe is without its capacity of exposition, and without its utility. Between the lily of the valley, in the interior of a continent, and the ocean, distant hundreds of leagues, there is an admirable and invisible correspondence. The life of the one is identified with the laws of the other. From this immense abyss, so barren and useless in the eye of the unbeliever, proceed the elements of all life. Exhalations from this mass of brine, are wine in the delicious grape, flavor in the peach, apple, orange, anana; blue in the violet, gilding in the marigold, silver in the lily, purple in the piony, and verdure in the foliage. Thales affirmed, twenty centuries since, that water is the principle of all things. It is because this element is so indispensable, that it is diffused in such abundance. Therefore it flows from the hills and winds among the vallies, and is every where so accessible. But we have seen, that the circumambient air is the principle of water. May not light be the principle of air and the universal element of all things?

Instead of viewing the sea as a sterile waste in the kingdom of nature, let us sit upon its shore, and in the pauses of its resounding billows, let our hymns of gratitude to the author of nature be heard. As I strain my eye along its blue profound, as I inhale its humid air, as the waves whiten, and burst upon the shore, to be perpetually renewed, a throng of reflections upon the grandeur of God, and the immensity of this abyss, the image of his own greatness, rush upon my thoughts. What imagination can descend to its unsounded depths? I mark the billows, lashed by the winds, swelling, whitening, bursting, to be incessantly renewed without a moment's repose. Measured by this image of eternity, how fleeting a thing is life, which like ocean-bubble rises, bursts, and is lost in the bosom of the sea!

But while we contemplate this mass of waters in its ceaseless fluctuations, we note another phenomenon. The sea has retired from its shores. Where, a few moments since, the waves dashed, we now discover the strand laid bare. But the ocean is not emptied into space, nor will it, continuing to sink, show us the mysteries of its bed. In a few hours it will return, retire, and return again, in the same unchanging intervals to the end of time.

You might comprehend in advance, that these great movements would cause the descending waters of the rivers to recoil, and move back towards their sources. The mighty current of the Mississippi is thrown back more than a hundred miles by the comparatively small tides of the Gulf of Mexico. What a powerful reflux in the impetuous St Lawrence, the vast Amazon, the broad La Plata, at whose estuaries the tides run high!

The scanty knowledge of the ancients, in relation to the science of physics, prevented them from bringing forward any thing like a plausible solution of the causes of the tides. The philosopher of Stagira, Aristotle, following Alexander into India, was so astonished at seeing the ebbing and flowing of the tide, which does not take place in the Grecian seas, that he is said to have drowned himself in despair, at not being able to explain the phenomena to Alexander. Historians have taken pleasure, in painting the astonishment of that conqueror, when, in descending the banks of the Indus, he saw that great stream flowing back towards its source. Anxious to penetrate the causes of such a prodigy, he left his warriors, and stood in profound meditation upon the shore of the sea. Admiring the regularity of its movements, and affected with a sense of his own weakness, at the view of such a mighty and unchanging power, he admitted, that it was an empty illusion for him to impose himself upon the world, as a god.

Cæsar, when about to invade England, was equally surprised with the spectacle of the tide, and for a while dared not attempt the narrow passage. Observing that the phenomenon was regular and periodical, the intrepid warrior soon resumed his courage, pitched his camp on the sea shore, and accustomed his soldiers to witness the regular retreat and return of the tides. Familiar with the spectacle, they were soon brought to embark, and cross the strait, which separated them from the country, where centuries afterwards, *he* was to be born, who has given the solution of this phenomenon. Discarding the theory of Newton, some modern philosophers have attempted to account for the tides, by offering instead of it, ingenious fictions. The eloquent St Pierre imagines the poles covered with immense glaciers. Their periodical melting and freezing, according as their summer or winter prevails, by augmenting or diminishing the mass of the waters is, according to him, the cause of the tides. The celebrated Kepler, who believed the earth to be a living animal, supposed the flux and reflux of the sea to be the effect of his respiration; as Blackmore, in verses intended to be sublime, describes the eruptions of Etna, as the result of a fit of the colic in the bowels of the mountain.

Descartes led the way to the theory of Newton, by remarking that the elevation and depression of the waters varied in correspondence to the movements of the moon. This thought was seized upon by the learned, as furnishing a clue to the solution of the phenomenon. Newton, who seemed to have been born to divine the laws of the universe, at last convinced the age, that the tides are caused by the attraction of the sun and moon, but chiefly that of the latter; and that this planet exercises this influence, during the six hours, in which her course is perpendicular to the bosom of the sea, where the tide is created. All the succeeding observations of mathematicians and astronomers have tended to confirm this ingenious solution. Yet Newton, as modest as he was profound, only proposed this solution in the form of an hypothesis. Some time before his death, the great philosopher remarked, 'I know not how I shall appear in the eyes of the world. But when I estimate myself, I seem like an infant, who, without daring to cast its eyes upon the extent of the sea, plays upon the shore, where it collects some beautiful shells and brilliant pebbles; while the vast ocean of truth appears outstretched before me, leaving me powerless to sound its depths.'

Such is the avowal of the greatest philosopher who has lived. It reads us a lesson of modesty. His system, it is true, has been often contested. The theories of his antagonists, however, are forgotten, or only remembered, as being opposed to his. It is something to be sheltered by so great a name. If you wait, before you abandon the Newtonian theory, until some mind more profoundly versed in physics, than this scribe and interpreter of the laws of nature, shall produce one that will supersede it, you will probably be a Newtonian to the end of your days.

LECTURE XXXVIII.

THE NEW WORLD, OR THE DISCOVERIES OF SPALLANZANI.

I HAVE mounted no hippogriff; neither have I sailed upon the clouds. How I arrived, I know not; but I find myself here in the centre of a new world. Such sights are before me, as neither Cyrano, Pæquilon, Gulliver, or any other traveller, ancient or modern, has recorded. However incredible they may seem in the recital, they are too real to be a dream. I entered a forest, of which the strange looking trees were covered with long tufted flowers. I passed thence through meadows still more wonderful, and like enchantment. The surface, divided into valleys and mountains, was carpeted with a green turf beyond the reach of vision. Lakes, rivers, a wide ocean divided all these paintings. Yet the whole of this wide spread continent raised the impression, that three steps would encompass it, and seemed rather like the illusion of a panorama, than the spectacle of actual nature.

I perceived on the shore of the sea a strange animal of a green color and globular form, rolling rapidly onward, by revolving on its own axis, like the hoop snake of the southern part of the United States. It was so perfectly transparent, that you could clearly perceive its internal structure and vital movements. What a charming study it presented for the anatomist! In the bosom of this green living globe I counted thirteen other globes, included the less within the greater, forming a nest of globes, and containing apparently thirteen globular generations, to be evolved in succession. In the utmost astonishment I raised an exclamation of enquiry, What sort of reptile this might be? An unknown voice, perhaps the genius of the place, hushed me, and cautioned me to give no offence, intimating, that, what I thus degraded by the name of reptile, might appear in the end to be a nymph or a goddess of this new world; at the same time admonishing me to recollect, that Fontenelle has informed us, that nothing in the other planets resembles what is seen in ours. It may be so, I answered with due respect; for a green globular goddess, trundling upon her own axis, has not a shadow of resemblance to the Venus of Medici!

I had scarcely ceased speaking, when a new spectacle, not less extraordinary than the first, attracted my attention. I perceived a tree, instead of foliage, covered with little bells, as transparent as crystal. Suddenly one of these little flowers, dropping from its stem into the water, began to swim most gracefully. Others followed the example, and in a short time they all changed into little trees, covering themselves with bells. These trees began to divide, or rather multiply into pairs. From this strange sort of plantation my attention was diverted to an animal, that perpetuated its kind by destroying itself in a manner most surprising. Its stomach, at first transparent, became afterwards opaque, and began to swell like a bubble. Soon after, it gave birth to a new family, by bursting into a hundred pieces, as though exploded by gunpowder. The newborn young, thus discharged into light, appeared not to have suffered from the explosion in the slightest degree.

I was drawing near the shores of the ocean. From it arose a burning vapor; and the thermometer indicated that the water was boiling. The peaceful inhabitants appeared not to be incommoded in the slightest degree. Some travelled slowly, and at their leisure; and others ran with a swiftness, which they never intermitted. Some threw forth from their own body a kind of twine, availing themselves of this contrivance to make prodigious leaps, as on a tight rope. Others continually rolled over, like the oriental bonzees; while others near them hung perpetually suspended and balanced.

In irrepressible curiosity I exclaimed, 'I am anxious to know, if the strange beings of this new world are endowed with the power of thought!' 'Why not?' replied the unknown voice, that had responded to my first exclamation. 'In fact some grave philosophers have written books to prove, that these little balls, these bells, these trees have a soul more perfect than many other animals. They have even attributed to them such passions, as wrath and love.' It was impossible to suppress a smile, at hearing it gravely advanced, that these handsome green globes, trundling upon their axes, had souls, and made love and war. 'Long live the philosophers,' I cried. 'They are the people first to create prodigies, and then explain them.'

Suddenly another spectacle caught my eye, and I began to imagine, my unknown instructor might have reason, at least in deeming these strange beings subject to the amatory propensities. I was convinced, that a number of young swains with their beloved were impelled by sentiments precisely like those, which gave birth to love-making in our world. They paired off to promenade in their groves. Marriages were the result, and so rapid was population, that families were reared under my eye.

While I lingered upon the survey of this picture of rural felicity, the scene was changed, and the country became involved in the horrors of war. An army of giants appeared on the plains marching to combat. They defeated their enemies, and then devoured them, striding onward with the still palpitating limbs of their feeble enemies in their mouths. I discovered that these cannibals, like the warriors of our earth, respected no law, but the right of the strongest. Infancy and age, male and female, the sick and defenceless, as well as the strong and resisting, fell beneath their blows. I saw them swallow down their unfortunate victims whole and alive, still struggling for a long time, in the transparent stomachs of their gluttonous and revolting devourers. Death, desolation and blood soiled these gloomy and accursed shores; and I saw that war was the same detestable pursuit as in our world.

I was satisfied with what I had seen in a single nook of this new world. Turning in loathing and disgust from the carnage of these cannibals, I raised my eye from a compound microscope, and the world, the inhabitants, the ocean, and plains all vanished. I was alone, and saw nothing before me, but an almost imperceptible down of mould, and a drop of water, in which some plants had been infused.

There are then millions of inhabitants, that think, love, hate, caress and devour each other, and all in a drop of water. Spallanzani, a new Columbus, discovered and conquered this new world, and I have been giving you the result of the survey of the animalculæ in a drop of water. The microscope unfolds countless millions upon millions of animated beings, where the naked eye can descry nothing but brute and dead matter. What a history is that, which Spallanzani has written of the new world, which he has discovered!

Each one of these animalculæ which are a million of times less than a particle of dust, has its head, mouth, eyes, and the eyes their complex contrivance and visual nerves; its fibres, muscles, veins, nerves, arteries; these veins their blood, these nerves their nervous fluid, this fluid its particles, these particles their pores, these pores their reticulations, subdivided still further, and each preserving its peculiar form. All these numberless parts, of which no power of thought can imagine the diminutiveness, concur to form a living and animated being of the most exact proportions. This being feeds upon its appropriate aliment, has its chyle, its solids and fluids, the trituration of its food, the circulation of its blood, its digestion and generation, and, what is more, its alternations of sickness and health, its pleasures and pains. Yet these diminutive beings are no nearer the ultimate molecules of matter, or the end of its capacity of subdivision, or mere nihility, than the largest organized beings. It is not inconceivable, that still minuter animals, insects in relation to them, may germinate on them, and live upon their body!

Leuwenhoeck, a naturalist equally industrious and intelligent, was the first who discovered that the tartar of human teeth is full of animalculæ. 'I determined,' says the distinguished naturalist, M. Sulzer, 'to satisfy myself as to the truth of this assertion with my own eyes. I availed myself of a most powerful microscope, and put myself to the examination of that matter which our food leaves upon our teeth, notwithstanding the most careful cleansing. I followed exactly the process indicated by Leuwenhoeck. I discovered not only that his account and description of these animals was just, but, after many experiments, I arrived at the result of an exact knowledge of the figure and size of some of the smaller of them which he was unable to obtain. The greater division of their body is round, with a short tail attached to it, resembling the spring-formed tadpoles of stagnant waters. They appeared to me to compare in size with a grain of gunpowder of the smallest dimensions. As my microscope magnified some millions of times, it is clear that on the surface of a grain of gunpowder, there could exist millions of these animalculæ; a circumstance as true in my eyes, as it may seem incredible to the thoughts of others.'

How much more sanguine and assured would Pythagoras have been in his persuasion that every thing in nature is sentient, had he been acquainted with these discoveries of the microscope! There are few, who would not hesitate about pronouncing this doctrine extravagant and ridiculous after reading these facts. The deep purple that forms the downy surface of the plum, is animated life. The orange or vermillion of the peach is life. May not the attraction and repulsion of chemistry be the result of organic action? May not the sapidity and flavor of all the palate recognizes in tastes, be the result of life in the minute molecules of food? May not the theory be true that contagion, miasm, and the pestilence walking in darkness, are the result of animalculæ floating in the air, and inhaled by the breath? May not the universe be an aggregation of animals, living the one upon the other, life within life, from the great animal, the globe, down to the animalculæ that inhabit the tartar of the human teeth?

It may be asked, what would be the fruit of admitting this doctrine? What are the interests and passions, the wars and loves of animalculæ to us? I answer, nothing is great or small, except by comparison. The earth is but as the mould and the drop of water in immensity. What are our wars, our passions, our glory, in the view of superior existences? What are all in the eye of the Divinity? What a lesson might mad ambition learn from the discoveries of Spallanzani! Happy the unambitious disciple of benevolence and peace, who aspires to be remembered only by the benefits he has diffused, and who, in acts of love and wishes of kindness, waits the call of his Creator to visit that unseen world, where thousands of the mysteries of this earth shall appear, in beautiful simplicity, in the light of truth!

LECTURE XXXIX.

ICE AND SNOW.

Imagine a palace of diamonds. Its immense façade is transparent as water. Its portico, enriched with superb sculptures, is elevated high in the air. Rows of diamond statues adorn its entrance. The palace of the gods, as reared by the genius of Homer, was scarcely more brilliant. Crystal columns supported transparent arches, which radiated and multiplied the brilliance of the sun. The trees, landscapes, and animated scenes which the eye discerned through the walls, seemed so many paintings executed by the hand of a skilful artist. Six crystal cannon and two mortars, and their carriages and wheels, all alike of crystal, guarded the entrance. A cannon ball discharged by gunpowder did not break them. This is no delineation of a fairy palace. Menzikow, the favorite of the first Catharine of Russia, married adverse to her wishes. The empress ordered the construction of this palace for the bridal night. It was of solid ice, and seemed admirably calculated to reduce the feverish ardor of her former favorite.

We have contemplated water in the form of invisible vapor, steaming from the surface of the lakes and seas. We now behold it changed to crystal. How admirable, and yet how simple are the phenomena of nature! A little addition of caloric renders water as invisible as air. A slight subtraction condenses it, and causes it to fall in rain. A still greater diminution converts it to a solid crystal. Reflect upon the relations between the wants of nature and these various forms of water, and you will see the necessity that it should be crystallized by cold at the summits of mountains, and condensed into rains by the higher temperature of their declivities; that it should trickle from their roots, to be vaporized and taken up by the air, and carried back to the mountain-tops again; and you will comprehend another link in the chain of the arrangements of Providence. Take from water its properties of vaporization, condensation, and congelation, and the whole harmony of nature would be reversed.

The clouds are composed of infinitely comminuted floccules of vapor. The cold seizes them in the higher regions of the air, and they are congealed in a kind of striated or star-shaped crystal; and this, when it falls, is snow. If the clouds are convolved and driven compactly together, the starry crystal accumulates by dropping through a thick stratum of clouds, in which the nucleus of snow is constantly growing by the contact of added particles. The accumulation is hail. The same cloud, according to its compactness and temperature, sends down rain, snow, or hail.

Snow is to great portions of the globe, what the waters of the Nile are to Egypt. Like a fleece of wool spread over the surface, it covers the earth like a garment, and shields it from the severity of winter. It prevents the seeds of plants, and the germs of vegetation, from perishing. In Canada, and the northern parts of the United States, during a winter of ordinary severity, if it commence before the earth is covered with snow, the soil freezes to the depth of four feet. On the contrary, if a deep snow falls before the ground is frozen; protected by the snow, it remains unfrozen through the winter. Snow fertilizes the soil, and quickens vegetation, like a manure. Upon the declivities of Mount Atlas, in the month of April, the green points of wheat are seen making their way through the dazzling surface of the snow. The inhabitants of Savoy and Switzerland, regard it as the best source of their wealth. On the return of spring, as soon as the snow melts away from their pasturage, which it has preserved fresh and green through the winter, they drive forth their flocks upon the verdant declivities of their mountains, blessing Providence that has provided such a warm covering for the earth to preserve it from the frosts of winter.

Even the severest frosts bring their benefits, in fertilizing the soil. The surface deeply frozen is raised some inches by the expansive force of the frost. During this process, the frozen earth cracks in chasms, sometimes miles in length, and to the depth of some feet. These chasms cause an explosion not unlike thunder when they are formed. This bursting of the ice of lakes and rivers, of the trees and the earth, is one of the most common, and yet to the inhabitant of a southern climate the most surprising phenomena of cold countries. It sounds in his ear, as a continued succession of thunderclaps. But by this operation of being raised by the frost, and sunk on the return of spring, the adhesiveness of the soil is broken, its particles rendered friable and comminuted. With the admission of air, light, and warmth to the pores of the soil, a kind of fermentation seems to take place, and an effect like that of ploughing has been wrought upon the fields by the mighty agency of frost.

I might here present experiments, touching the expansibility of water in the act of freezing. From this property becoming specifically lighter than water, it floats on its surface. Being filled with water, which is suffered afterwards to freeze, cannon that have been strongly stopped at the mouth, have been burst by the expansion of the water contained in them, as it passed from its fluidity to a state of ice. Most of the accidents of the breaking of glass vessels, and implements of steel and iron, that are used in a frozen state, when their temperature, and of course the relative position of their molecules are suddenly changed by being brought under the influence of heat, occur from their rapid expansibility in passing from the temperature of frost.

The phenomena of the formation of rain, snow, hail, and of consequence, springs and torrents, are best observed and classed upon mountains. We have seen that philosophers, sages, and recluses, have chosen to study nature and nature's God, upon mountains. Orpheus descended from Mount Hemus to civilize the Greeks. Thales passed his days upon Mount Mycale, near Miletus. Anaxagoras, of Clazomene, to pursue the contemplation of divine things, ascended Mima, a mountain of Ionia. High and holy thoughts have been naturally fostered in the cool and serene air above the grossness of earthly passions.

Let us ascend with them above this dim, dull spot, whose atmosphere has so much pollution mingled with it. Here let us contemplate the streams in their origin, in the midst of ice and frost above the clouds. In these apparently desolate realms of winter, it is, that a beneficent nature invisibly prepares the verdure of spring, and fills the horn of plenty. It will elevate and enlarge our spirits, from the height of these summits to look abroad upon nature and divine the grand scheme of Providence. The soul, disengaged from the miserable and perturbing passions of earth, here drinks in sublime sentiments, as if, in approaching heaven, man divested himself of his terrestrial ideas, and resumed the consciousness of his native grandeur.

It would belong to this sketch of the formation of snows and ices upon mountain-tops, to describe an avalanche. From the height of a cliff, you contemplate one of the deep valleys among the Alps. The cattle are seen ruminating in their pastures, and the smokes stream aloft from the peaceful domestic hearths. You behold heaped above you, hills upon hills, the accumulated snows and ices of ages glittering in mid air in the sun-beams. Overcharged by their own weight, or undermined by a new-formed mountain-torrent, a fearful noise, announcing in advance the doom of the vale below, gives warning that an avalanche has broken from its deep foundations. The rocks, the ancient battlements of the mountains, the soil with its trees, are borne along in one sweeping and irresistible ruin. The villagers in the fields have only time to fly to the embrace of their wives and children before all is whelmed in the common destruction! The fair valley, lately the abode of peace and love, is buried a hundred fathoms deep with snows and rocks and ruins.

LECTURE XL.

THE NATURE OF WATER.

I have already spoken of many gases, the invisible instruments of nature in creation. At present I dwell a moment upon the nature and agency of hydrogen, so called, from a Greek compound, importing that it is the parent of water. Its most remarkable property is, that it is extremely inflammable, and that when fired with oxygen gas, water is the result of the combustion. This gas often arises from church-yards, burning fountains and deep marshes. It shows itself in these cases, in the form of blue or red flames, and has caused a thousand superstitious terrors.

To effect the decomposition of water, Lavoisier took a porcelain tube, into which he put iron filings, exposed it to the action of fire, and passed water over it in the form of steam. The water was decomposed; that is to say, its oxygen having more attraction for the iron than its own hydrogen, combined with the filings, and the disengaged hydrogen passed into a glass retort. The most beautiful part of the experiment is, that the increase of the weight of the filings, added to the weight of the hydrogen gas, precisely equalled the weight of the water employed.

These gases, when accumulated in great quantities, possess a terrific power of explosion. That of gunpowder bears no adequate analogy. We must seek for a comparison in the power of detonating gold and silver. Great caution must be used in firing the minutest quantity in a glass globe; otherwise the glass will be shivered by the explosion. A certain philosopher has imagined, that the Creator formed the waters of the ocean and the earth, by uniting the oxygen and hydrogen of space, and igniting the gases in union by a thunderbolt! Inflammable air, or hydrogen gas, plays a great part in the phenomena of nature. Its extraordinary lightness causes it to ascend high in the air. From these elevated regions, it presents spectacles the most brilliant, and sometimes the most terrible. When the electric spark kindles it, we have thunder showers. At other times, it is the origin of those luminous meteors that stream along the sky, filling the inhabitants over whom they pass, with awe and terror.

Hydrogen is a considerable component in certain well known and much used vegetable products. For example, sugar can be formed with carbon, oxygen and hydrogen.

Although this gas is of such specific levity, Gay Lussac, having submitted to analysis, air taken from a great height in the atmosphere, has proved, that, in the highest strata of the air, there is no hydrogen. It appears, beside, from the experiments of Dalton, that gases, which differ most widely in specific gravity, mix rapidly, and become combined in the atmosphere. We must not imagine, that these phenomena of the decomposition and recomposition of air have been mere useless experiments. A thousand beneficial discoveries in medicine, chemistry and the arts have already resulted from them. The gas in question is so prepared as to yield a cheap and most brilliant light, which is already employed in various ways to illumine churches, theatres, public buildings, light houses, and whole cities. It is gaining general adoption in American cities, as the cheapest and most brilliant light with which they can be lighted.

Nature seems to take pleasure in encouraging discoveries of this kind ; for she has created sources of carbonated hydrogen in many places in the earth, in sufficient abundance to light whole cities. Beside many well known places in the old world, where fountains of hydrogen gas are discovered, there are numerous and abundant reservoirs in Western New York. One of the villages on the line of the grand canal is already lighted with hydrogen gas, conveyed in pipes from the fountain, whence it flows, to the lanterns of the streets. Most magnificent fire works might thus be exhibited, by conducting the gas to the highest dome or eminence of the town. These spouts of flame might be thrown out in alphabetical or other forms, so as to convey telegraphic information to a whole country.

By means of this gas confined in a large silken globe, so varnished as to retain it, the aeronaut ascends into the air, and soars with the eagle above the clouds. These daring experiments have been made at different times by various intrepid individuals, who have ascended to the regions of perpetual congelation, and traversed distances of many leagues in the air. Among these adventurers, not a few have been females. The names of no aeronauts are more distinguished, than those of Montgolfier, Pilatre de Rozier, and Blanchard. In the United States different individuals have ascended in balloons from New York and New Orleans.

It is, perhaps, not too much to hope, from the astonishing progress of modern chemistry, our more perfect acquaintance with the components of the air, especially those of the higher strata of the atmosphere, the more extended application of steam, as a propelling power, and the use of gum elastic in forming the body of balloons, that the art of guiding them in the air will at some future period be carried to some practical and useful degree of perfection, possibly to the extent of using them as vehicles of conveyance, especially in time of war. We do not consider it visionary to hope that, in the generations to come, the aeronaut will be able to guide his balloon through the air, as the mariner steers his vessel over the seas, casting his anchor in space, or hoisting sail, and emulating the course of the eagle in mid air.

I am less sanguine, however, than some have been, that our aeronaut will ever be able to sail to the moon. I fear, that his balloon, when it has ascended to the very rare atmosphere in the upper regions of the sky, will remain in equilibrium. Could he ascend to the centre of gravity between the earth and the moon, it may be apprehended, that he would remain suspended forever, after the supposed predicament of the coffin of Mahomet. Could the voyage be accomplished, it would be a consummation devoutly to be wished. What agreeable descriptions the first voyager would give us of the mountains, valleys, volcanoes, ladies and fashions, that change every month! There, too, would be found, with many other things not dreamed of in our philosophy, nor descried by our astronomers, the inspiration of many of our poets, schemers, politicians, inventors of perpetual motion, love philters, and the elixir of life.

LECTURE XLI.

HYDRO-VEGETABLE HARMONIES.

If we find water indispensable to the life of turfs, flowers, plants and trees, these in their turn exert a powerful influence upon the waters of the atmosphere, and the earth. We shall find, that districts, covered with forests, attract clouds, turn aside destructive winds, arrest electric meteors, and thus shelter and preserve the humble dwellers in cottages. Who is so destitute of taste, and admiration of the works of the Creator, as not to love beautiful trees? Who, that has one touch of poetry and the love of nature in his heart, cannot remember the hours of pleasant meditation, which he has passed under the greenwood shade, feeling the delicious coolness, imbibing the spirit of repose, admiring the ten thousand forms of the rustling leaves, and listening to the soothing hum of the insects, seeking their nectar on the foliage and in the flower bells! Who, but a barbarian, would unnecessarily apply the axe to these beautiful ornaments of the fields? Who, in cities, to subserve at once the purposes of shade, health, and beauty, would not put forth sufficient public spirit to unite his efforts with those, who would procure the streets, squares, and public walks to be lined with trees?

Cut down the forests of a country, and you change its climate. No country on the earth has offered such convincing proof of this fact, as ours. If our climate was originally too humid, cutting down the forests has so far ameliorated it, as it has clearly tended to render the air drier, and rains less frequent. Yet it is a fact, attested, as it seems to me, beyond all question, that the primitive settlers, who reared their cabins under the shade of the unbroken forest, were healthier than their successors, who lived in the cleared fields. The wide and general clearings among our vast forests has had equivocal and double results. In various portions of the Ohio valley, the air has become decidedly more salubrious, since the country has been opened to the sun and air. In other districts of the West, as along the lower courses of the Mississippi and Red River, the reverse has decidedly been the case.

A forest so dense as to prevent the free circulation of the air, and to screen its reeking vegetation from the sunbeams, is manifestly insalubrious to the inhabitants. But if trees had been left over the whole surface of our pastures and unenclosed grounds, at regular and proper distances, and especially if our whole road sides had been left shaded, and our whole country had been made to resemble the country, half forest and half pasture, which in the West is denominated a *barren*, what an exquisitely beautiful landscape, surpassing that of all others in the world, would the United States have presented!

The plains of Provence in France have been swept by storms unknown in former times. The change has resulted from cutting down the forests during the French revolution. The Cephisus, that bathed the gardens of the ancient Academy, has disappeared with the grove of Mount Hymettus. Travellers search in vain in Troas for the river Scamander. It has dried up with the destruction of the forest of cedars, which covered Mount Ida, whence it took its source. Italy, during the existence of the vast forests of the Tyrol, enjoyed a mild temperature. It has become a burning climate, since their destruction.

A thousand beautiful springs in our own country have disappeared since the forests have been cut down. A thousand streams in the West, that continued to murmur along their limestone beds, during the highest heats of summer, when they meandered through a deep forest, now, that the verdant screen from the Sun's rays is no more, are dried up every summer. Who of us, that have seen half a century, cannot remember cool spring sources in the deep shade, where we were wont to slake our thirst, and taste the coolness and repose of the forests, that are now dry and stripped of their trees? The barbarous axe has been plied in our country without taste or discretion. Would, that the disposition to spare the trees, could be infused into the ten thousand youthful adventurers, who are every year making their abode in our primeval forests.

It never rains in the sandy deserts of Africa, because their arid surface, deprived of all vegetation, reflects the burning heats of the sun. The mass of warm air, which always radiates from the scorched surface, hinders the aerial moisture from condensing, raises the vapors high in the air, and propels them towards the distant mountains. If the whole Sahara, large enough for kingdoms, were at once covered with the forests of America, can we doubt, that showers would form above them, that they would be watered with dews, and become the abodes of husbandmen, instead of retreats of the wild and cruel rovers of the desert?

Extreme dryness of the air sometimes produces dangerous diseases in the neighborhood of Quito. To arrest their progress, it is only necessary, that a few showers should temper the brightness of the sun. Nature has taken thought for all the physical inconveniences of the region, and has covered the valleys and the surrounding mountains with vast forests. From their bosom rise those grateful dews, which diffuse coolness through all the air.

The vast prairie plains, west of the Mississippi, are both hotter in summer, and colder in winter, than the forest country east of that mighty stream. These prairies experience rarer and more scanty rains than the valleys that are covered with trees. Over vast extents of them are spread dry, sandy deserts, like those of Arabia, where the traveller wanders for days without seeing wood or water. In the days to come, when these plains shall be inhabited, the shepherd and husbandman will plant trees, which will invoke the showers, and call down the rains and dews. Liberty, aided by peace and industry, will spread fertility over the sands, and exactly reverse that order of things, which has consigned the once fertile environs of Nineveh, Babylon, Tadmor, Jerusalem, Athens and Rome to sterility and desolation.

But these beautiful harmonies between the earth and the skies extend further still. The destruction of certain trees, the eradication of certain plants, is sufficient to destroy whole tribes of useful insects, birds, and quadrupeds which feed upon them, and with which their existence was identified. A Dutch naturalist relates, that an entire tribe of cormorants made their nest, and their abode, in the thick forest of Sevenhuis. The forest was cut down, and the birds were exiled from the ancient trees that sheltered them. They emigrated and established themselves on the sea shore, where they now build their nests among the reeds, offering, like Venice, the singular spectacle of a city built among the waves.

A celebrated modern traveller has remarked a similar result on the magnificent shore of Lorento, near Rome. This valley of the Tiber, which, according to Pliny, was adorned with more palaces than all the rest of the world, not only presents at this time a mass of ruins, but it seems as if nature had ceased to be fertile and beautiful in proportion as men have withdrawn from it. The domestic animals have disappeared with the shades, under which they formerly ruminated. Even the migrating birds no longer light upon the desert shores. Yielding to the mysterious indications of instinct, they divine the way to the new countries which liberty, peace, and industry, have rendered dear to husbandmen; and they are found in these new fields, demanding nature's tithe of the harvest. It seems a settled law of Providence, that the presence of man should cause ferocious beings to retire, and should attract those that are innocent and useful. The benefits of nature follow him in his journey over the globe, and abandon the places that he abandons. The sky and the sea of Lorento preserve their serenity and azure, but the shores are no longer cultivated by proud and triumphant hands. Sadness and desolation have gathered over them, and all that dwell upon them seem hastening to decay.

The ancients, without doubt, were acquainted with these beautiful harmonies between the vegetable kingdom and man. We cannot fail to admire the profound wisdom of portions of their religious institutions, which were predicated upon these harmonies. Every forest contained something like an oracle or temple, which inspired respect. Every tree, beneath its rind, concealed a nymph. Every flower was animated by a being of celestial origin, who, instead of suffering death and decay, had been changed to that beautiful form. Every spring-source had its Naiads, and every grotto its etherial inhabitant. These sentiments stood, as sentinels, to protect the sacredness of the solitude, and to preserve the free wildness of nature. The forests were guarded against the profanation of human avidity by the presence of gods. Even the sages, apparently aware of their purpose, seemed to respect and adopt these useful superstitions. The grave Cato prescribes the formula to be observed in cutting down a tree, and the pious invocation which should be addressed to the divinity before striking the first blow.

The Persians, victims of pestilential maladies which arose from their humid rice-plains, called to their aid the balsamic plane-tree. 'There is no contagion at Ispahan,' says Chardin, 'since the Persians have ornamented their streets and gardens with the plane-tree.' Here then is a tree with which nature has invoked us to shade and purify our naked marshes.

Who has not been inspired with regret, in seeing the hundreds of new villages that have sprung up in the recently settled parts of our country, unsheltered by a tree or a vine, under the influence of a sun that we may almost imagine pouring its rays with more fierceness on the soil, for having been so long excluded from it! The thousand remains of the trees, like the bones of the slain after a battle, instruct us how easily trees of shelter and shade might have been spared at intervals. The climate and soil alike invoke the inhabitants of these villages to repair the ravages of their want of taste and regard to health and comfort, by planting the plane-tree or Sycamore, the superb and odoriferous catalpa, the deep-green Pride of China, the peccan, alike useful and beautiful, and the cone-shaped sugar maple, so exquisitely rich in its fading autumnal foliage. In the south, the orange and fig-tree should be added, and the whole surmounted with the Isabella grape, so abundant in delicious fruit, so luxuriant in beautiful foliage, and so easily cultivated. With this foliage taste would interlace the splendid bells of the bignonia. With these would come bees, humming birds, the oriole, cardinal and mocking-birds, as invited guests.

LECTURE XLII.

GEOLOGY. THE AGE OF THE WORLD.

Geology is a Greek term, importing a discourse concerning the earth. The science is sometimes termed *geognosy*, which has an analogous meaning. This sublime and useful science, unfolding so many new harmonies between the earth and its dwellers, has hitherto been little studied and less estimated, in our country. This neglect may be traced partly to the recent date of our country, partly to the genius and pursuits of the American people, and not a little to the many barbarous and difficult terms in which the science has been hitherto involved.

To point out a single bearing of geology, its indispensable connexion with the true knowledge and advancement of agriculture, the nurse and common mother of us all, ought to be a sufficient answer to all those who question the utility and importance of the study. Metalurgy, in all its relations with the arts; building, in all its dependence upon clay, mortar, stone, and marble, depend for their perfection upon a due acquaintance with this science.

Were it otherwise, and a pursuit unconnected with direct utility, the liberal scholar would addict himself to it, as an occupation in itself ennobling and delightful. What kind of investigation can bring its own appropriate enjoyment, if it be not that of the geologist along the glens and valleys of the mountains, threading his way through the meanders of caverns, intently noting the strata of the ravines, winding his course down the sinuous beds of rivers which have changed their courses, or meditating the changes wrought by the ocean, as he walks upon its resounding shores?

The antiquarian is rapt in thought, and the poet pours his inspiration in dirges over the ruins of Thebes, Babylon, Persepolis, Tadmor, Athens, and Rome. The painter presents us mouldered towers and fallen columns, still grand in their ruins. Is the study of the geologist less inspiring, as he makes out the history of the changes which our planet has undergone, as indicated by the impressions of nature upon the cliffs and mountains, the depths of the earth and the sea, those enduring chronicles of the progress of creation? Will he not be led to indulge deep thoughts, as he finds every where such immense masses of organic remains, traces of a world that was and is no longer, and whose history is inferred from these monuments in everlasting stone?

This study will be found related to that of philosophy by another bond. Like the study of physics, astronomy, and natural history, it tends to piety. Where the common observer of the structure of the earth sees nothing but an inexplicable chaos of earths and stones in promiscuous confusion heaped upon each other, masses of *detritus* that seem to him without any clue to classification and arrangement, the geologist separates, arranges, classifies, labels, and assigns each to its family and local habitation. Wisdom and beneficence do not radiate alone from the stars or the green earth, or the animated tribes of creation. They light up the deep places of the earth, and are found in volcanic craters and the pathless beds of the seas. Those great changes, that result from the most formidable action of water and fire, earthquake, inundation, volcanic eruption, however terrible the history of the partial disaster and ruin caused by them, will probably convince the geologist that they are the irresistible agents of nature in operating general good, and acting on a grand scale towards the melioration of our planet, as tending to render it a better and happier habitation for man.

But has mere speculative geology any use? What advantage would result from knowing, whether the earth has been liquefied by fire or deluged by water? What would it benefit us to know, whether the world is six thousand, or six millions of years old, or that it never had a beginning? Are the cosmogonists by water or fire of the true school? Which is better, to become a disciple of Burnet, Hutton, Werner, Buffon, St Pierre, or Cuvier? Shall we assign the changes of our earth to fluviatile or diluvial action? Is our globe a scintillation struck off from an impinging comet, or its earth, rocks, and mountains, a deposit from a large globular ball of turbid liquor? Is brute matter capable of sentient life and voluntary motion? Had it beginning *de nihilo*, or is it as eternal as the infinite Mind every where diffused through its masses? Will it exist forever, or, having accomplished the temporary purposes of its Creator, will it be reduced again to its original nihility? I am ready to admit, that it is much more difficult to trace the relation of these much vexed questions with utility, than questions of practical geology. But all the sciences have a mutual connexion with each other and with truth. We can pursue no inquiry which tends to enlarge the mind and expand its conceptions, which leads to the investigation of final causes and the original intention of the Creator in the arrangements of nature, without deriving both pleasure and utility from the pursuit.

Were it even otherwise, man had an erect form assigned him that he might contemplate the heavens. The searching propensity of his nature, his 'thoughts that wander through eternity,' will have scope. There is inwrought in the very nature of the mind, an irresistible impulse towards the investigation of such operations, and especially the phenomena of the glorious mansion of its present habitation. Those appearances which indicate the sublime energy of nature, will arrest our attention. We cannot examine the structure of the earth which feeds and sustains us, and finally shelters our remains in its bosom, without feeling curiosity to learn what changes this, our common mother, has undergone and is to undergo. We cannot see belts of rocks circumscribing the whole earth full of the organic remains of what once had life, or dig up the enormous bones that are buried in the virgin soil of our forests and prairies, without an effort to imagine the time when the huge animals, to which these remains belonged, bounded over the plains. We may be sure, that He who stamped this impress upon the human mind, and gave it these aspirations to range 'beyond this visible diurnal sphere' into the invisible of the past and future, intended that we should satisfy them to the extent of our means of investigation.

How old is our world? This is one of the most obvious questions presented by geology. Of the numberless theories, which propose to answer the question, I only consider the two most prominent ones. The one is that, which is predicated upon the most generally received exposition of the Mosaic account of the Creation. It supposes, that Creation has resulted from successive exertions of the divine volition; that nearly six thousand years since, one of these volitions caused our world to spring from nothing, to accomplish temporary purposes of wisdom and benevolence; and that, after having accomplished them, it will return to that original nothing, from which it sprung. It is a part of this view to suppose, that there are worlds, which have accomplished these purposes, continually ceasing to exist. Some, it is conjectured, have perished so recently, that their light still indicates their places among the stars, as though they yet existed; and that other worlds, obeying the creative word, are emerging from non-existence, whose light has not yet dawned upon our world.

The other theory considers matter and mind to be alike eternal. It assumes, that a creation from nonentity involves an incongruity of ideas, which the mind cannot understand, and therefore cannot believe. If, say the disciples of this theory, there was a period in eternity, when the Deity existed absolutely alone, it would involve the necessity of the lapse of a precedent eternity, in which his attributes must all have slumbered for want of an object external to himself, upon which to exert them. We cannot conceive, that the Divinity, more than subordinate natures, can act without a motive. Suppose the lapse of an eternity, during which the divine mind existed without exerting an act of creation, and without any existence extrinsic to himself, and it is inconceivable, that during any assigned point in that period, he would have had any motive to creation, rather than in any other point of that duration. Either, then, he must have existed from the eternity *a parte ante*, without exerting a creative act, and when he did commence creation, must have done it without an assignable motive to select that period rather than any other in the whole precedent eternity, or creation flowed from his nature, as an effect from a cause, as an eternal theatre for the communication of life and happiness, and consequent display of wisdom, power and goodness.

This view precludes the notion of a successive creation of intelligences and worlds at different epochs in eternity. Its advocates contend, that a belief in such a creation could only have arisen from the narrowness of human views, which contemplate events only in succession; that they derived their origin from the succession of our ideas; and that it would follow from them, that new volitions can arise in the divine mind; that it can be instructed by experience, and from one creation be led to infer the necessity of another.

This theory supposes, that there must have been the same single and complete plan before the divine mind from eternity, without succession, addition, improvement or change; and that the whole universe, perfect and entire, co-existed with the divinity, as a necessary result of his nature, furnishing a theatre for the display and scope of his attributes. The perfect pattern flowed from the divine archetype as streams from a fountain, or effects from a cause.

Such seems to have been the sentiment of many of the ancient philosophers, who believed, that the physical universe was without beginning, and would be without end. In the sixth Æneid, Virgil beautifully expresses what was probably the prevalent philosophy of his time; that an infinite mind, diffused through the elemental mass of visible nature, gave it form, and imposed laws upon it. Pope expresses the same sentiment:

> 'All are but parts of one stupendous whole,
> Whose body nature is, and God the soul.'

This dogma, with some modifications, formed the creed of the Manicheans. The eternal existence of two elemental principles, matter and mind, probably furnished them with their conception of a good and an evil principle. From mind, simple, indissoluble, incorruptible, flowed reason, right thoughts and all goodness; and from corruptible and changeable matter, appetites, passions, and whatever in our nature is terrene and unworthy. Hence all in our nature that is good flowed from mind, the good principle; and all that is evil from the evil principle, matter.

The opponents of the eternity of matter, among other arguments against it, consider the doctrine at war with the Mosaic account of creation, and by consequence with divine revelation. That being simple truth, it must, of course, be equally contrary to fact. It is certain, beyond question, that the human race would be poorly compensated for the abandonment of the guidance and immortal hopes of the Scriptures, by the adoption of any theory, however plausible and splendid.

But the sober and religious advocates of this theory, (and it has such,) contend, that the one view is no more incompatible with the history of creation in Genesis, than the other. They affirm, that Moses had no purpose, in his record, to inculcate systems of physics or astronomy, but simply to advance such great moral and religious truths as were equally important to human well being, or any theory of creation; and that, had he undertaken to propound to the Jews a system of cosmogony, physics and chronology, in exact accordance with abstract truth, beside that it would have had no tendency to enlighten and guide men to moral truth and duty, it would have been so directly at war with the received hypotheses of the times, as would have required another revelation, and another series of miracles to sustain it. They insist, moreover, that the term in Genesis, which is rendered 'created,' would be more properly translated '*arranged*,' or '*disposed*,' and that the passage should read, in the beginning God arranged or harmonized the heavens and the earth, which before were chaotic and without form.

That illustrious and pious oriental scholar, Sir William

Jones, informs us, that the Hindoo Institutes of Menu are supposed to be as ancient as the writings of Moses. A definition is given in that book of the word 'day' as applied to creation. It states, that, when used to express this idea, it imports a period of several thousand years. The theorists in question apply this solution to the term 'days' in the first chapter of Genesis. The six days, in which the Creator arranged the chaotic elements, and reduced them to order, in their view, indicate the successive epochs of creation, or the different changes, which our world has undergone in acquiring its present arrangement and form.

To investigate these high questions is a natural, and it seems to me, an innocent impulse of the human mind. Every one, in the present order of things, has greater or less facilities for making them. Different and conflicting views of these grounds of opinion cannot but meet the inquiring eye. There can be no harm in the love and the stern investigation of truth, lead where it may. The inquirer should bear in mind, that nothing should be conceded to the love of system, or the pride of opinion. The best and most vigorous minds will always be most docile, and most ready to see, that the faith of the scriptures and the motives and hopes of immortality are interests not to be suspended, or put at hazard, by reasonings predicated upon the probabilities of a theory of creation. It seems to me, that the truth and importance of 'the sure word of prophecy' are in no wise connected with the reception or rejection of the one system or the other.

LECTURE XLIII.

THE DELUGE.

No one, among the readers of our country, is ignorant that we lately possessed an accomplished scholar, and a most amiable man, who maintained, with all the devoted and absorbing zeal of a Columbus, seeking the means of exploring a new world, that the earth is a hollow sphere, concave instead of convex at the poles, and that our globe possesses an interior as well as an external world; that the interior world is habitable, and may be entered at the poles. What a treatise of geology he would have been able to give us, had he discovered and entered his interior world!

As it is, our knowledge of the interior of the earth is very limited. The lowest depths, to which human research has penetrated, in mines, caverns, the beds of rivers and ravines, bear no more proportion to the central point of the earth's semi-diameter, than the thickness of the coat of varnish on an artificial globe, to the distance between its circumference and centre. The earthy matters thrown out by the explosion of volcanoes, though in most instances evidently ejected from depths below any point reached by human exertion, are found to be so nearly similar in all eruptions, as to furnish very little evidence, in regard to the interior structure of the earth.

As far as we are acquainted with its internal constituents, it is an accumulation of earths, oxydes, metals, salts and gases, so arranged in juxta-position, as that the heterogeneous elements sustain a perpetual and mutual action and reaction. It consequently carries, in its own bosom, the cause of a ceaseless series of changes, which, to vague and indifferent observation, might seem an evidence of imperfection; but which are, probably, tending towards a result of beneficent design. Geological investigation teaches us beyond the possibility of doubt, that the earth has undergone various successive changes, of a power adequate to the obliterating of all other records of their action, except those traced in its own enduring bosom. Whether, with Hutton, we are to attribute the chief change to fire, as the innumerable crystallizations over the whole earth, and its substratum of granite, a species of half crystallized rock, would seem to indicate; or to water, as the marine exuviæ imbedded in the strata of limestone and secondary formation, and the traces of diluvial action manifest, wherever the earth has been penetrated, are supposed to show, is not capable of discussion in the narrow limits prescribed to us.

Geological science seems at present divided between the two rival schools, one of which contends, that investigation shows no changes in the earth, for which causes now in action, such as rivers, ocean-currents and changes, volcanoes, chemical action, and the insect formation of coral reefs are not abundantly adequate to account. Theirs is called the fluviatile system, which is supposed at present to be the ascendant theory.

The disciples of the diluvial school contend, that the earth bears manifest traces, that it has been submerged beneath the waters, in such a way as to have acquired stratified deposits of sand, marine exuviæ, and organic remains in the dry and interior parts of all the continents. Not only are traces of a catastrophe, which cannot be assigned to any other known cause, every where visible, but mythic tradition, and the wonderful coincidence of the testimony of the ancient poets, concur in striking congruity with the recorded narrative of the deluge in the Scriptures.

The Chaldeans have their history of Xisustrus preserved, which is only that of Noah with some slight variations. The Egyptians left it on record, in their sacred books, that Mercury engraved the rudiments of science for them on columns, which resisted the deluge. The Chinese have their *Peyron*, a mortal beloved of the gods, who saved himself in a boat from the general deluge. There are many traits of resemblance between their history of Fohi and the scripture account of Noah. The East Indians, in their sacred books, give still more detailed traditions of a deluge which happened, according to them, more than twenty thousand years since. A single woman, and seven men, were all that were saved on a remote mountain of the north. They add, that two animals of each species, and two individuals of every plant, were preserved with them; and that the god, Vistchnou, transformed into a fish, brought a boat to the mountain to their relief. The same tradition is preserved in the Edda. The killing of the giant, Ymus, produced such a flow of blood as submerged the world, with the single exception of Belgemer, who was saved in a boat with his wife.

We may consider the beautiful lines of Ovid on the deluge, and the fable of Deucalion and Pyrrha, as a general summary of the traditions of all the ancient poets respecting it. They present a most impressive picture, which, in its general features, seems almost a transcript of the narrative recorded in Genesis. The recess of the flood, and the emersion of the earth from the waters, are thus presented in the last five lines of the picture of Ovid:—'The sea again has a shore, and it absorbs the swollen rivers. The streams subside. The hills are seen to emerge. Dry places are multiplied from the decreasing waves. After a long day, the groves display their bare trunks, and retain the slime upon their branches.'

The sum of the narrative of the Scriptures, is in the following terms:—'The fountains of the great deep were broken up, and the windows of heaven opened; and the rain was upon the earth forty days and forty nights; and the flood was forty days upon the earth; and the waters increased, and bare up the ark, and the waters prevailed exceedingly upon the earth; and all the high hills that were under the whole heaven were covered. Fifteen cubits upwards did the waters prevail, and all the high hills that were under the whole heaven were covered.'

'For my own part,' says the eloquent St Pierre, 'if I may venture to declare my opinion, I ascribe the general deluge to a total effusion of the polar ices. * * * My supposition is, that at this tremendous epoch, the sun, deviating from the ecliptic, advanced from south to north, and pursued the direction of one of the meridians, which passed through the middle of the Atlantic ocean and the South Sea. In this course, he heated only a zone of water, frozen as well as fluid, which, through the greatest part of the circumference, has a breadth of four thousand five hundred leagues. He extracted long belts of sea-fogs, which accompany the melting of the ices of all the chains of the Cordilleras, of the different branches of the icy mountains of Mexico, and of Imaus, which, like them, run north and south of the sides of Atlas, of the summits of Teneriffe, of Mount Jura, of Ida, of Lebanon, and of all the snow-covered mountains which lay exposed to his direct influence.

'With his vertical flames, he quickly set on fire the constellation of the Bear, and that of the Southern Cross; and presently the vast cupolas of ice, on both poles, began to smoke on every side. All these vapors, united to those which arose from the ocean, covered the earth with an universal rain. The action of the sun's rays was further augmented by that of the burning winds of the sandy zones of Africa and Asia, which blowing, as all winds do, towards the parts of the earth where the air is most rarefied, precipitated themselves, like battering-rams of fire, towards the poles of the world, where the sun was then acting with the greatest energy.

'Innumerable torrents burst from the north pole, which was then the most loaded with ice, as the deluge commenced on the seventeenth of February, that season of the year when winter has exerted its full power over our hemisphere. These torrents issued at once from every floodgate of the north; from the straits of the sea of Anadia, from the deep gulf of the sea of Kamtschatka, from the Baltic Sea, from the straight of Waigat, from the unknown shores of Spitzbergen, from Hudson's and Baffin's Bay, which is still more remote. Their roaring currents rushed furiously down, partly through the channel of the Atlantic ocean, tore it up from the abysses of its profound bed, drove impetuously beyond the line; and their collateral counter-tides, forced back upon them, and increased by the current from the south pole which had been set flowing at the same time, poured upon the French coast the most formidable of tides. They rolled along, in their surges, a part of the spoils of the ocean situated between the ancient and the new continent. They spread the vast beds of shells which pave the bottom of the seas of the Antilles, and the Cape de Verd islands, over the plains of Normandy, and carried even those which adhere to the rocks of Magdalen's strait as far as the plains which are watered by the Saone. Encountered by the general current of the pole, they formed at their confluences horrible counter-tides which conglomerated in their vast funnels, sand, flints, and marine bodies into masses of indigested granite, into irregular hills, into pyramidical rocks, whose protuberances variegate the soil in many places of France and Germany. These two general currents of the poles, happening to meet between the tropics, tore up from the bed of the seas huge banks of madrepores, and tossed them unseparated on the shores of the adjacent islands, where they subsist to this day. In other places, their waters slackened at the extremity of their course, spread over the surface of the ground in large sheets, and deposited by repeated undulations in horizontal layers, the wreck and the viscidities of an infinite number of fishes, sea-urchins, sea-weeds, shells and corals, and formed them into strata of gravel, pastes of marble, plaster, and calcareous stones, which constitute to this day the soil of a considerable part of Europe. Every layer of our fossils was the effect of a universal tide. While the effusions of the polar ices were covering the westerly extremities of our continent with the spoils of the ocean, they were spreading over its easterly extremities those of the land, and deposited on the soil of China strata of vegetable earth from three to four hundred feet deep.

'Then it was that all the plans of nature were reversed.

Complete islands of floating ice, loaded with white bears, ran aground upon the palm trees of the torrid zone, and the elephants of Africa were tossed amidst the fir groves of Siberia, where their large bones are found to this day.

'The vast plains of land, inundated by water, no longer presented a career to the nimble courser, and those of the sea, roused into fury, ceased to be navigable. In vain did man think of flying for safety to lofty mountains. Thousands of torrents rushed down their sides, and mingled the confused noise of their waters with the howling of winds and the roaring of thunder. Black tempests gathered round their summits, and diffused a night of horror in the midst of day. In vain did man turn an eager eye to that quarter of the heavens, where the dawn was to have appeared. He perceives nothing in the whole circuit of the heavens but piles of dark clouds heaped upon each other. A pale glare, here and there, furrows their gloomy and endless battalions; and the orb of day, veiled by their lurid coruscations, emits scarcely light enough to afford a glimpse, in the firmament, of his bloody disk wading through new constellations.

'To the disorder reigning in the heavens, man in despair yields up the safety of the earth. Unable to find in himself the last consolation of virtue, that of perishing free from the remorse of a guilty conscience, he seeks at least to terminate his last moments in the bosom of love or of friendship. But in that age of criminality, when all the sentiments of nature were stifled, friend repelled friend, the mother her child, the husband the wife of his bosom. Every thing was swallowed up in the waters; cities, palaces, majestic pyramids, triumphal arches, embellished with the trophies of kings; and ye also, which ought to have survived the ruins even of a world, ye peaceful grottos, tranquil bowers, humble cottages, the retreats of innocence. There remained on the earth no trace of the glory and felicity of the human race in those of vengeance, when nature involved in ruin all the monuments of her greatness.'

Though few may share the conviction, that the deluge was caused by the sun deserting the ecliptic and traversing lines of latitude from the equator to the poles, and thus causing the melting of the polar ices, no reader can fail to be impressed with this eloquent and affecting picture; or fail to believe that such would have been the actual spectacles and results of the flood, be its causes what they might.

The characters of this catastrophe, the most terrific and sweeping in the recorded history of our planet, are traced by those who contend for the authenticity of the scripture account of the deluge, in the stratification of the belts of secondary formation, circumscribing the whole circumference of the earth, and in the utmost depths to which the interior of the earth has been penetrated. Every part of our continent abounds in these geological medals, attesting the epoch and results of the deluge. The vast valley of the Mississippi, as we shall hereafter see, is more freshly and entirely of secondary formation, and more abundant in organic remains, than any other known portion of the earth.

No event that has occurred since the commencement of time, seems to have fastened its remembrance so deeply and indelibly in the human mind. Poets have sung it. The pencil has found in its imagined incidents, the most touching pictures. The pulpit has made it the theme of the deepest and most thrilling representations of the consequences of general iniquity, visited by the Divine vengeance. Finding the basis of their views in the scriptures, they have represented the life of man, in the innocence of the primeval days before the flood, to have been prolonged to nearly a thousand years, a period longer than whole dynasties recorded in the subsequent history. A patriarchal family saw about them a realm of a million of descendants, all looking to their abode as the natal spot. The earth produced fruits and grains in spontaneous abundance. Man grew into life with fibres as of iron, and sinews as of brass, strong, hale, and free from disease. Unbridled and unhallowed passions outgrew even his strength. He forgot God, and trusted to no other divinity than his own power. He founded his sentiments of justice in his might. Earth sent up to heaven a general shout of revelry, and the cry of oppression and bloodshed. The world abounded in palaces and towers, the strong holds of ambition, luxury, and lust. The wailing of oppression, violence, misery, and blood-guiltiness, rose to the Divine ear. All the sons and daughters of men, were either of the oppressors or the oppressed. To the one class, the terrible lustration of the deluge was the washing away of crime. To the other, it was death bringing sure relief to misery. The guilty and the innocent were submerged together. The lofty palms, pinnacles, domes, and even mountains, were ascended in vain. The father, with his family clinging to him; the husband, with his wife hanging to his bosom; the fair maiden, clasped in the arms of her beloved, all perished together. Vast countries forever submerged, and now known only by the mariner's sounding-line, then raised their green surfaces, where now roll the barren waves of the ocean. Every sea was then sprinkled with isles of verdure at such short distances, that there was no sea which a frail skiff might not navigate. All was whelmed in the deluge, beneath a shoreless ocean.

LECTURE XLIV.

SKETCH OF DILUVIAL AND FLUVIATILE CHANGES.

We have neither space nor inclination to discuss the points of question, upon which the diluvians, and the anti-diluvians are at issue. The stratified layers of sand and vegetable earth, and the organic remains of aquatic animals, found at the greatest depth in the fertile valleys, may be plausibly referred to fluviatile action, and the bursting away of lakes and collections of water. The long continued wearing away of the soil at the sources of rivers, and the deposit of the earthy and vegetable matters, borne along by their turbid waters, and deposited along their alluvial valleys, in the lapse of ages, would form such masses of soil, as compose the more fertile plains of all countries.

The most superficial observer cannot fail to have remarked, that the alluvial valleys of the long rivers of our country are chiefly of this character. To recur to tracts, which I have personally explored, the American Bottom, forming the Western shore of Illinois along the Mississippi, in a word, the whole wide alluvial valley of the Mississippi exhibits a soil precisely of the same character with that, which is now borne along in the turbid waters of its spring inundations, and deposited in its annual overflow. Wherever it is perforated to the depth of fifty or sixty feet, the stratum of alluvial earth is dug through, and water-worn pebbles, leaves, logs and sand, similar to those every where seen in the present bed of the Mississippi, are reached. These irresistible evidences, that this vast superincumbent layer of earth was washed down from hills and mountains, perhaps, a thousand miles distant, and borne along, and deposited, where they now are, by the river, are presented to the husbandman many miles from the present bed of the river.

The traveller, who ascends the American Bottom from

Kaskaskia to the point opposite the mouth of the Missouri, fails not to discover, at every step for fifty or sixty miles, proofs of powerful fluviatile action of this kind. At the distance of four or five miles from the present channel of the Mississippi, are seen high and beautiful limestone bluffs, marking the outline of the valley-belt, like a prodigious wall. The almost perpendicular face of this high parapet is marked with colored water lines, groves, cornices, the parallel indentations of attrition, or projections of accretion, indicating the successive inundations, or subsidences of the river, as it swelled or sunk by the rise or fall of its different, large tributaries above. They precisely resemble the water-lines, that mark the same accidents in the bluffs, that bound the present channel of the river. Appearances of the same character, marking the former rise and subsidence of the Illinois, are seen in the high and striking bluffs of its long alluvial valley. As these lines are twenty or thirty feet above the highest present floods of these rivers, they seem to indicate, that these rivers once had a channel of four times their present width, that the bosom of the full river was then thirty feet higher than it now is, and that all the rich and friable soil of these wide valleys once floated in their rivers.

But will any conceivable fluviatile action account for similar stratification of table plains on the sides and even summits of the highest mountains? Will they furnish an adequate solution of the deposition of sea shells on the tops of the highest hills in the interior of continents, and for the organic remains of sea animals imbedded in the limestone cliffs of the Rocky Mountains? Will they account for the numberless salt springs, whose waters are more briny than those of the ocean, found at the greatest distances from the sea, facts not difficult to explain, admitting, that the continents were formerly submerged under the sea?

Dr Buckland, an English clergyman, celebrated for his geological attainments, at present professor of geology at Oxford University in England, has published a work on the organic remains found in various caves in England, Germany, France and Italy, of which he gives minute descriptions and drawings. He is the most particular in his description of his discoveries in a cave at Kirkdale in England. Of the veracity of this highly respectable author, and the authenticity of the facts, which he records, there can be no doubt, especially as concurrent testimonies to similar facts begin to be multiplied in all the continents.

He describes the remains of twenty-three species of animals found in these caves, noting the astonishing fact, that the bones of the hyæna, tiger, elephant, rhinoceros, and hippopotamus, well known to exist at present only in tropical climates, make the greater proportion. He thinks, that the number of hyænas, that left their bones in the Kirkdale cave, could not have been less than between two and three hundred. Beside these bones remain, yet undissolved, particles of the bones of the animals, that they had devoured.

The same kinds of remains, in similar proportions, were found in Franconia, Hartz Forest, Sandwich, Saxony, Wittemberg and Bavaria in Germany, at Fouvent in France, and the Val d'Arno in Italy. Remains of similar animals, now inhabitants of the hot regions of Africa and Asia, are found near the estuaries of the frozen streams of Siberia, and strange to relate, some of them even retaining the hair upon their bodies.

It is related, that a discovery, equally surprising, has been made of a meadow in England, in which, below the upper peat stratum, are found in great abundance the arborescent ferns, and other vegetable remains of tropical climates. Mr Atwater, a laborious geologist in our country had published, that he had found in the valley of the Ohio, impressions in fossil coal of the stems, leaves and flowers of the bread fruit tree, and other vegetables of tropical climates. His accounts were received with incredulity and ridicule, until, since these celebrated discoveries of Dr Buckland, sustained by so high a name, and until similar coincident discoveries, continually brought to light in all the temperate latitudes, have compelled a respectful comparison of his testimony with the constantly accumulating mass to the same general result.

'All the plants,' says Buffon, 'imbedded in the rocks of St Chaumont are of foreign species, such as are not found in the country about Lyons, or the rest of France; but such as flourish in the East Indies, and in the hot climates of America. They are, for the most part, capillary plants, and particularly ferns. Their hard and compressed tissue rendered them convenient for this sort of engraving, and to preserve them in moulds all the time necessary to impress them upon stone. Leaves of the plants of the Indies impressed upon the rocks of Germany struck Leibnitz with astonishment. This cause for wonder is found to be infinitely multiplied as accident and research extend the empire of geology. Nature seems to have a certain affectation in showing it. On all the rocks of St Chaumont, we do not find impressed a single plant of the country.'

To the same class of facts we may obviously refer the masses of bones and organic remains of the unknown animals, denominated mammoth and Megalonyx, found at different depths in all parts of the western country, and particularly at Bigbone Lick in Kentucky. Bones of animals of a still more enormous size have been dug from the soil at Plaquemine on the Lower Mississippi, and are shown in our museums. These remains have been found in vast quantities and in places too numerous to specify. Discoveries of similar remains are made in Russia and Tartary.

In excavating the earth of the Portland and Louisville canal on the Ohio, at a depth of between twenty and thirty feet below the surface, the laborers came upon what appears to have been an ancient cemetery. It contained the bones of great numbers of human skeletons of a color nearly black. The bones, horns and teeth of various animals were found among them. One of the human skeletons was found standing erect, holding in his hand a beautifully polished semiglobular stone of the size of half an orange. The color was striated with white and red. The hand, that held the stone, was raised at an angle of forty-five degrees with the shoulder. Near these skeletons, and at the same depths, were the remains of regular hearths of brick and limestone. The limestone was beautifully polished, and the bricks only so much unlike those in present use, as to show, that they were not made by the same people. The charcoal of the last fires, that blazed on the domestic hearths of this generation of a past world, was found unchanged.

What abundant materials for reflection in decyphering the mysterious inscriptions on these medals of epochs, and a world, that have passed away! We know not, but that the vegetable soil, which the emigrant turns up with his share, in the recently cleared wilderness, or the unpeopled prairie, was once, in the circle of earthly transmutations, the sentient flesh of a fellow being, and that the pearly dew-drop, which glistens in the bell of the wild forest-flower, once rolled, a tear drop, down the cheek of a bereaved mourner. Proofs thicken upon us, from the force of which we cannot escape, that the most solitary American wilderness has been peopled in the ages of the past by human beings.

Voltaire, in his Philosophical Dictionary, under the article 'Inundation,' expressly denies the physical possibility of the deluge, and asks, 'was there ever a time, when the earth was entirely submerged? It is physically impossible!' Such an assertion is in keeping with his naturally arrogant and superficial mind. We do not, it is true, observe any of the powers of nature in her present ordinary routine in sufficiently energetic operation, in opposition to the natural gravity and fluidity of water, to raise the waters of the oceans sufficiently to submerge Chimborazo and Himalaya. But we do know, as has been seen, that an aerial ocean, forty-five miles in depth, in the form of oxygen and hydrogen gas hangs suspended over our heads. Portions of this ocean are decomposed in every rain that falls. It only requires a more powerful and uniform concurrence of those atmospheric agents, that produce a partial rain, to decompose the whole atmosphere, and to submerge the world again. Were not the omnipotent hand, that rolls the spheres, constantly holding the elements in equilibrium, we might fear a deluge every time that thunder decomposes the air over our heads.

No geological phenomenon more strikingly evinces the wisdom of the arrangements of Providence, than the beds of rivers. The blood, propelled by the heart through the arteries to the extremities, and there taken up by the veins and carried back to the heart to circulate in the perpetual circle of life, shows no more striking manifestation of the wisdom of Providence, in the economy of the human body, than the configuration of countries, by which they are at once watered and drained, in the structure of the globe. The earth offers no more striking example of this configuration, than the valley of the Mississippi. Suppose at one time we contemplate this valley from the Alleghanies, and at another from the Rocky Mountains, at the remotest head-spring of the Missouri. Let us trace the thousand rivers that rise in these mountains and flow down their eastern slope; and, in the other position, attempt to number all the streams that flow to the same point from the west. What hand, we shall ask in astonishment, but one guided by infinite design, could have scooped out such an exact basin, with such a perfectly graduated inclination, that each spring has its valley, each stream its basin, every river its narrow dividing ridge, operating as an arranged inclined plane to drain every portion of its slope. This complicated tissue of arteries and veins circulates the indispensable irrigating fluid to the main channel of the trunk, which rolls its accumulating waters downward to the sea, to return, as we have seen, by the clouds, and circle through the same channels, producing the same beneficent results again. In the more elevated regions, you stand on the dividing ridge of the great rivers. Springs gush from under the cliffs, as you look towards the rising sun. They trickle along their appointed bed, tribute still added to tribute, until they form a river that rolls into the Atlantic. You turn your face towards the setting sun, descend the declivity a few steps, and drink from the fountain that flows in an opposite direction, and finds its way at the distance of eight hundred leagues from the estuary of its neighboring spring, into the gulf of Mexico.

Who established these accurate and narrow barriers, and graduated these vast extents with such an exact slope, that a gentle and equable declivity is furnished for the waters through all the long course of their passage? The slightest mistake in the inclination of the plane, would have turned all these streams back upon their source, and the vast extent of fertile valleys would have become the steaming and pestilential surfaces of lakes and uninhabited marshes.

Contemplate the same unerring wisdom of foresight in the continuous lines of high hills and cliffs, that form the everlasting bulwarks of all the great and sweeping rivers in their whole courses. This wonderful spectacle cannot fail to impress every observing traveller, as he is conveyed on these rivers. The battlements that are raised along the courses of North River, the Susquehannah, Potomac, and particularly the long channel of the Ohio, Tennessee, Cumberland, Mississippi, and Missouri, to confine them to their beds and prevent their inflicting desolating inundations, cannot but arrest the most careless attention. One cannot note these lines of bluffs, as long as the courses of their rivers, and extending in an uninterrupted line a thousand leagues, and opposing such ample and irresistible barriers to the waters, without looking through those second causes by which some geologists would account for them to the ultimate cause, the purpose of the Creator, the secure habitancy of these valleys by men; or fail to be convinced that the river-channels were formed for the draining and the irrigation of the country; and that the configuration of the surface, to convey all the waters requisite for irrigation through the country in channels, was alike arranged to subserve the purposes of beauty, safety, and utility. So far as second causes are concerned in this admirable configuration of the country, I see no solution more adequate to account for the digging these long channels, and arranging these admirable slopes, than the deluge. Whatever cause may have produced the emersion of the continents from the ocean, the waters flowing off towards their ocean-beds, would find by the action of their own laws precisely such places as are their present channels, and in the lapse of ages would cut them down and denude their bluffs, as we now see them.

It needs no elaborate reasonings, to prove that the Alleghanies, the Rocky Mountains, and the whole vast sweep of hills that mark the outer rim of the Mississippi Valley, are wearing away, and the *debris* constantly deposited in the valleys of the rivers, or borne down to the gulf of Mexico. The recession of the sea, the gradual encroachment of the Florida and Louisiana shore upon it; the waters of the Mississippi, turbid with as much earth as they can hold in suspension, distinguishable by their ashy color, for many leagues from its mouth; the increasing number of shoals and bars where these deposits are precipitated, are conclusive proofs that the earth is gaining fast upon the sea in that quarter. This gain must be an equal loss to the country, through which the rivers flow. The same may be predicated of the valleys of all the other rivers of the globe.

Whence happens it, that in the lapse of so many thousand years, every particle of earth has not been washed away from the mountain and hill sides; and that the mountains and hills have not, ages since, presented the spectacle of naked skeletons of everlasting rock? Such is not the fact. Many of the steepest hill and mountain-sides, washed by every rain, are still covered with thick layers of the richest and most friable vegetable mould. It seems to me, that nature has some arrangement of compensation not yet explained or understood, by which, in her own way, she repairs and renews this *detritus* of her slopes, borne away by the rivers. I neither adopt the rough-cast creed of the hunter, that the mountains and hills grow as fast as they are washed away; nor the transcendental theory, that they repair their losses by receiving supplies of consolidated sun-beams, radiated into their substance. I only see, that the hills and mountains load the rivers with *detritus*, without seeming to lose by the tribute borne from them from age to age.

La Place has demonstrated, that what had been formerly set down as an aberration of our planet, the apparent change of its orbit, as marked by the precession of the equinoxes, a change which some astronomers had predicted would eventually destroy our system, instead of being an evidence of a principle of destruction, is really a result of the settled order of the universe, and that, not to have been subjected to this law, would have been evidence of aberration and tendency to decay.

The views which I take of the phenomena of our world, convince me, if no other person, that by the operation of laws contained in itself, all the changes which the earth is undergoing are changes for the better, and harmonies instead of symptoms of decline; and that the ultimate tendency is, to cause it to become a more convenient and happy abode for its sentient inhabitants of every description.

Another deluge would change its surface. Volcanic eruption or earthquake, of a terrible energy to cause the centre to become the circumference, would annihilate no particle of its matter. Were it even heated by a comet to ignition and vitrification, the mass would change its form without annihilating it, or weakening its subservience to its physical laws in the slightest degree. The combustion of fuel, every one now knows, destroys nothing of the substances of which it was composed, but only separates it into its constituent elements, the amount of matter remaining precisely the same.

LECTURE XLV.

GEOLOGY.

In this lecture I shall present tabular views of some of the more prominent doctrines and terms of geology, chiefly compiled from Bakewell's introduction to the study. The elementary principles of geology were deduced from discovering, that wherever the earth was deeply perforated, it discovered surprisingly regular crusts, or integuments, which have been familiarly illustrated by comparing them to the different coats of an onion, or to the successive coats of paint laid upon an artificial globe. The deepest of these integuments is composed of rocks extremely hard and semi-crystalline, called granite. These rocks are called *primary*, because they contain neither the organic remains of animals, nor vegetables, nor intermixtures of other rocks. Their substance seems uniform, and not compounded with the rocks that lie above them. They are common on the highest summits of mountains.

On other summits, these rocks are covered with superincumbent strata of another character, and the granite belt shows itself only at the basis of the mountains. A belt of this kind of rocks, in the United States, generally skirts the northern sea-shore, the northern shores of the great lakes, and certain summits of the Rocky Mountains, where they are visible upon the surface. Boulders, or masses of this kind of rocks, are found detached from their natural position, apparently by some of the changes which the earth has evidently undergone, in the Mississippi Valley. These masses are scattered among limestone and other rocks of secondary formation, far from points where granite is found in its native position. A crust of this kind of rocks, at certain depths, probably encompasses the whole globe.

Between this crust, called primary formation, and the strata of secondary formation, is a coat of rocks of an intermediate character, between the primary and secondary, and apparently compounded of both; from this circumstance, called transition formation. This class contains only the remains of sea-animals, leaving the inference that they were formed under the sea. Most of the metallic ores are contained in these two classes.

Above the transition is the secondary formation, containing organic remains of the lowest classes of animals, constituting the first link in the chain of animated existence, and the equally humble vegetable remains of an aquatic growth appropriate to marshes and lakes. It consists, for the most part, of sandstone, argillaceous slate, called shale, and beds of fossil coal and limestone.

The upper series of secondary rocks are generally stratified limestone with beds of clay, shell and sandstone interposed. The organic remains in these strata are of marine formation, but of different genera and species from those in the lower rocks. They contain the remains of animals of higher orders, possessing a brain and spinal marrow. These are all oviparous, and of the fish, or lizzard tribe.

The tertiary strata consist chiefly of clay, limestone and friable sandstone. They also contain organic remains, and numerous bones of the class of quadrupeds denominated mammalia, which belong to genera and species that are no longer known. Volcanic and basaltic rocks are ejected from volcanoes, or have been otherwise formed in a state of fusion. In these are found a few human skeletons, though in such positions, as to render it probable that they were cases of accident. It is a singular fact, that the fossil remains of monkies are the only classes undiscovered in any of the formations. One of the indispensable prerequisites for reading books of geology to profit is, to understand the import of some of the geological terms of more frequent recurrence. The disciple of nature must be willing to bow himself to the dry and laborious effort of occasional studies, unrelieved by any associations of interest, except those connected with a view of the intrinsic importance of the subject.

Granite denotes a species of rock denominated *primitive*, extremely hard, white, or gray, and its fracture exhibiting the general aspect of crystallization. Next to it stands *quartz*, one of the hardest classes of stones, of which mountain masses are composed. It gives plentiful sparks, when struck with steel. In crystallized quartz, the fracture is conchoidal ; in the uncrystallized, splintery ; and in lustre vitreous. In all its forms it is generally translucent, and of vivid colors. It is the substance of some of the precious stones ; and it fuses with alkali, and forms glass. *Flint*, *chert*, *hornstone*, *opal*, *chalcedony* and *agate*, are a modification of this substance ; and the milk-white pebbles in gravel are composed of quartz.

Feldspar is next in hardness to quartz, and chiefly distinguished from it by being lamellar in its fracture, and its susceptibility of being divided into thin plates. Its crystals are prismatic and shining, and of a lustrous brilliancy. The colors are white, gray, yellowish and reddish white. It may be melted into a semi-transparent glass without the aid of alkali, having been found to possess a certain amount of potash in its composition. It is the chief material in many kinds of porcelain. *Mica*, or Muscovy glass, consists of very thin leaves or laminæ, which may be separated with a knife. Its plates are elastic, by which circumstance it may be distinguished from talc, which in other respects resembles it. The plates are flexible, but not elastic. *Chlorite* is a kind of green *talc*.

Hornblende is a stone of a black or dark green color, and is both heavier and softer than quartz or feldspar. It may be scratched with a knife, yields a bitter smell, when breathed upon, and melts easily into a black glass. It is the connecting link between primary rocks, and those of volcanic origin.

Limestone is a well known compound of lime and carbonic acid. *Gypsum* is a compound of the same base with sulphuric acid and water ; is less common than lime, does not effervesce, as that does, with acids, and is sometimes called selenite, and vulgarly plaster of Paris. Slate is green in its purest form in roofing slate, and is bluish or greenish gray, of a silky lustre, and easily divided into lamellar plates. Its composition is far from homogeneous, being generally of a complex combination, in which *silex*, or flint is the largest, and *alumine* or pure clay the next largest component. Porphyritic rock is compact and homogeneous with distinct crystals or grains imbedded in it. *Amygdaloidal* stone contains rounded cavities filled with mineral matters of a different kind. *Brescia* is composed of angular fragments of rocks cemented together. *Puddingstone* consists of rounded rocks imbedded in a kind of paste. *Gneiss* is slaty granite. *Graywacke* is a coarse slate, containing fragments of other rocks or minerals, varying in extent from two inches to the smallest fragment. When the particles are extremely minute, it becomes slate. When they are larger and angular, it is *brescia*, with a paste of slate. When the fragments are rounded, it is puddingstone. *Trap* rocks are such as are composed of feldspar and hornblende, and receive their name from the Swedish word *trappa*, a step or stair, because these rocks divide into regular forms, resembling the steps of stairs. *Basalt* is a rock of a greenish or brownish black color, possessing a considerable degree of hardness, which will yield, however, to a knife. Soft earthy basalt, mixed with green earth, forms the rock called *wacke*. The prodigious basaltic columns of Staffa, or the giant's causeway, and those of the Scuir of Egg in the Hebrides, have been the theme of innumerable descriptions. *Lias* is a kind of dark argillaceous limestone lying in strata, accompanied by a stratum of dark bluish clay. The name lias is probably a corruption of *layers*, as the lias limestone strata are generally regular and flat; and are raised from the quarry in thin slabs. The finer kinds of this stone receive a polish, and are used for lithographic drawings. *Oölite* is a kind of yellowish limestone, alternating with beds of clay, marle, sand and sandstone; and is called oölite, or roestone, from the small globules, like the roe of a fish, that are imbedded in many of the strata.

Such are a few of the geological terms of the most common occurrence, for want of understanding, which many a reader has turned away from books upon this science in disgust. These terms comprise scarcely a fiftieth part of the whole difficult nomenclature of geology. But the accurate understanding and remembrance of these, together with that copious portion of the terms, that the most superficial reader of geological books will not fail to understand, will enable the student to comprehend common treatises upon the subject.

Salt springs are most common in the vicinity of the coal strata, and are among the most unequivocal testimonies of the former submersion of our earth in the sea. They are, probably, the retained waters of the ancient submersion, that percolate through fissures in the close strata, which have prevented their having flown to the ocean with the original retiring brine. *Rock salt* is probably the remains of the evaporation of lakes and pools of salt water. The mineral, by slow evaporation, would be separated from the impure salts that exist in sea water. The impurities, being more deliquescent, than the muriate of soda, were washed away, leaving the salt in its comparative purity. The most numerous and extensive repositories of rock salt are in Hungary and Poland. It is a most striking demonstration of the benevolent forecast of providence, and a conclusive proof, that every thing has been arranged to prepare the world for habitancy by man, that this most indispensable substance has been thus abundantly supplied in this form, and in the form of salt springs, in the interior of the continents, and at such great distances from the sea, that it could not have been procured from that quarter, except at an expense, which the poor could not afford to pay. So numerous and abundant are salt springs in the central parts of the Mississippi valley, that there are few places, however remote from the sea, where it cannot be procured at a reasonable rate.

When the vast and then unexplored country of Louisiana was ceded to the United States, in the body of documents, which Jefferson presented to Congress upon the subject, he adverted to a statement by some travellers, that far up the Missouri, there existed a mountain of rock salt. The statement was received with unsparing ridicule. Why had it not melted, and been washed away ? was the question. It might have been asked, with still more force, why the friable vegetable soil of the hill sides, and the mountain declivities have not long ago been all washed from the bare rocks ? Nature has her own undiscovered compensations, her own methods of arriving at results, that baffle human solution. Rock salt in elevated positions is shielded by superincumbent strata, and by being combined with earthy and mineral matters, by which it is prevented from ready deliquescence. Under these circumstances, a salt mountain would dissolve less rapidly, than a hill side of tender soil would wash away. Perhaps nature has some mode of repairing and renewing the waste of so precious and indispensable a substance, with which we are altogether unacquainted.

Jefferson, however, was not alone in crediting the existence of salt mountains. We have a splendid description by count Alexander Laborde, of the salt mountains at Cardona in Catalonia, a province of Spain. One of these salt rocks, he affirms, is six hundred and thirty-three feet high, and twelve hundred and twenty wide at its base. 'Nothing,' he continues, 'can compare with the magnificence of the spectacle of the salt mountain of Cardona at sunrise. It towers into the air, like a mountain of precious gems, displaying the various colors produced by the refraction of the solar rays through a prism.

The reason, why the purest water is obtained from the greatest depths is, that in digging into the earth, we are constantly approaching primitive formation, and passing through the strata of fermenting vegetable earth, deliquescent matters, and soluble impurities. In boring four or five hundred feet, pure water is generally obtained even under the most extensive salt marshes. But the pipes must be secured from admitting the waters of the intermediate strata.

The kinds of coal best known among us, are *bituminous coal* and *anthracite*. The coal between the bases of the Alleghany mountains and the sea, is generally of the latter character, while that of the vast beds of the western country is of the former class; and is readily distinguished by its bright and pitchy flame, and its yielding out a great quantity of pitchy and unctuous matter resembling tar, and applicable to the same purposes.

In primitive and transition formations, generally in hills and mountains, and abundantly in Pennsylvania and other portions of our country, occurs a coal which is extremely hard and splendent, burning without smoke or flame, and in appearance resembling plumbago, or black lead. This is called *anthracite*. How was coal formed? Much of our bituminous coal contains the distinct granular texture of wood; the striated radii about the knots, and even the appearance of the bark. These are appearances too common and obvious to remain matters of common curiosity. Coal, it appears sufficiently probable, may have been formed by the accumulation of various vegetable matters, intermixed with metallic oxydes and salts, bitumen, and sulphur. Pressure, moisture, fermentation, chemical action and time, have partially decomposed these matters, and recomposed them into coal. But the extent and thickness of the coal-strata, in various places, seem to preclude the reasonable supposition that such amounts of vegetable matter should have been accumulated at one epoch. Is it not more natural to suppose that carbon is an original, elementary constituent of the globe? Let us consider the fact, that limestone is one of the most abundantly distributed of all the classes of rocks. Every one knows that carbonic acid constitutes a large proportion of the composition of this rock. The quantity of pure carbon in limestone, amounts to nearly one-eighth of its whole mass. Were the carbon disengaged from the limestone in calcareous ranges, it would form an immense bed of carbon proportionate to the thickness of the limestone stratum; but out of proportion thicker than any coal-stratum known to exist. Is it not, therefore, as natural to suppose that some great and simultaneous chemical action disengaged the carbon from the lime, and left it in such strata as we see actually accompanying coal, as that nature was compelled to resort to the circuitous operation of accumulating vegetable matter, and then by another process to convert it into coal? In a word, why is it not as probable that carbon was the original formation, as limestone?

The thickness of coal-strata in coal-fields, varies from a few inches to several yards. The beds are generally separated from each other by thin laminæ of earthy or mineral matter. In South Wales, a coal-field has been discovered in which the different strata are together, ninety feet thick. The best veins in the United States, are from ten to forty feet in thickness. Few are wrought any where to profit, which are less than two feet thick. The value of a coal-field depends on the quality of the coal, the thickness of the vein, and its depth beneath the surface.

The bounty of Providence again opens to view, in the wide diffusion of this fossil, the poor man's fuel, and in its abundant provision in the cold countries, many of which, without it, would be uninhabitable. It is common in Great Britain, France, Saxony, Silesia, and Thuringia, in Germany; in various parts of Asia, in New Holland, and in no part of the globe in greater abundance, or of better quality, than in the eastern parts of the Mississippi Valley.

The annual consumption of coal, in England, is rated at the enormous amount of seven millions of tons. But for the vast supply of this fossil recently discovered in South Wales, it has been calculated that the coal of England could not have lasted more than six or seven hundred years. I am glad to believe that there is no basis for any reasonable calculation, that the coal of the United States can ever be exhausted.

Peat, or *turf*, is a singular, bituminous, earthy matter, full of small fibrous roots, found in wet and marshy meadows, in strata from four to ten feet in thickness. It is cut and dried in oblong masses, resembling bricks, and burns with a mouldering flame, which however yields a great degree of heat. This fuel is found in great abundance in heathy and cold countries; and furnishes, in many places, cheap and inexhaustible supplies of fuel for the poor. It is generally believed, that it is renewed by a process not unlike the growth of vegetation, and that, in a series of years, where the strata have been exhausted, they will be found replenished with the same material.

LECTURE XLVI.

GEOLOGY. LIMESTONE. CORAL. METALS.

Limestone, of such immense importance in building, and one of the most interesting of the geological formations, is still more widely diffused than coal. Its most common forms are crystalline, or primary limestone, magnesian limestone, marble, and chalk. White, or statuary marble, has been generally procured from Italy, Switzerland, and the Grecian Archipelago, though white marble is common in the United States.

In the primary limestone, no traces of organized remains are found; but in secondary limestone, they are innumerable. It has been supposed that in the primary, the traces of animal organization have been destroyed by the process of crystallization; but that all limestone, from the circumstance of the innumerable organic remains in it, was originally composed of the shells and exuviæ of marine animals. But there are many reasons for supposing that lime exists, as an original principle of elementary combination, independent of requiring supplies of animal matter for its formation. Is it not generally unphilosophical to limit nature to circuitous processes to produce her results, when she seems to have delighted in primary and original forms? They, however, who contend that lime is entirely a formation connected with marine animalized-matter, find a stupendous analogy in the immense work that is going on in various parts of the seas, more particularly in the great Southern Ocean. Voyagers and naturalists have placed the fact beyond all question, that coral reefs are raised in a few years from fathomless depths in the ocean. Innumerable marine polypi, following their own mysterious instincts, commence their united labors, and attach their mighty work to the bottom of the sea. They build on, rearing scaffold above scaffold, till an island raises its surface from the waters, and, by processes all arranged by Providence, becomes covered with soil, plants, and trees in succession. What a prodigious work to be achieved by these little beings, but a grade above brute matter! How infinitely beyond the proudest dreams of human projection! May not these seemingly contemptible insects, in process of time, bridge the ocean, or dot it every where with islands, visible from each other? With what feeble instruments Omnipotence can produce results that defy all human imitation, and mock the efforts of all human power! Whence do these zoöphytes and moluscous animals procure the lime, which, mixed with a small portion of animal matter, makes the base of these mighty erections? No doubt it results from a power of vitality and assimilation within themselves; for the sea-water, in which they exist, contains but a very minute portion of lime. In proof that it may be so, we find an animal that feeds upon marble, and yet its body yields no lime to analysis.

It is hard to discriminate which are the most striking features of nature, her mystery, sublimity, power, or simplicity. Who can contemplate, without profound astonishment, countless millions of little architects, almost motionless and lifeless, which yet feel that they have a mighty ministry to accomplish, and operate with a wisdom and unanimity which leave all human imitation behind, in rearing innumerable coral columns, thousands of fathoms high in the dark and ever-heaving abyss of the seas, which support islands that become covered with verdure, men, temples, and harvests? Such are the works of the Omnipotent; and such instruments, in his hand, are adequate to forming islands in the seas!

The ores of metals are generally found in the matrices of rocks of a peculiar character, in continuous lines, called *veins*. To enter into any details of the vocabulary of metallic veins, would lead me beyond my purpose. The metallic ores generally occur in primary, transition, and secondary rock. The technical terms are *rake veins*, *flat veins*, *accumulated veins*, and *cross-courses*, according to their dip, length, richness, and form. All the phenomena of mines, indicate that the minerals were imbedded in the rocks subsequently to the formation of the rocks themselves.

Whenever we examine the interior of the earth with a right spirit, we shall be struck with manifold proofs of the same benevolent forecast for the well-being of man, as on the surface. Iron, infinitely the most valuable and indispensable of all metals, is diffused in every country almost like air and water. I am convinced that the abundance of all minerals and fossils, is very nearly adjusted to their utility to man. Gold and silver, to which an artificial state of society has affixed an estimated value far beyond their real utility, are every where scarce, and obtained with difficulty. To the countries, where nature has provided them in the greatest abundance, Mexico and Peru, they have proved a scourge, a curse, and a source of luxury, idleness, effeminacy, and poverty.

It is much to be questioned, if mines of gold and silver are of real utility to any country, or whether it will be an advantage to ours, that a wide and extensive region on the eastern declivity of the Alleghanies, from the centre of Virginia through the whole width of North Carolina, across the highlands of Alabama, and extending into the countries occupied by the Cherokees and Creeks in that state and Georgia, has been discovered to abound in gold. Larger masses of pure gold have been found in this district than in any other country. Frequent discoveries of mines have been made, by which the owners of the lands have been suddenly enriched. Many thousands of mining adventurers have flocked to this quarter from all countries, and it has become the theatre of gambling, unprincipled speculation, and demoralizing influences of every sort. These results seem naturally to attach, in every country, and under all circumstances, to this mode of gaining wealth. It is said, that the tin mines of England have enriched that country, while the gold mines of Peru have impoverished Spain.

Our great and happy country has mines of iron, copper, and particularly lead in the greatest abundance. Nowhere in the world are mines of this mineral wrought with so much ease, and yield such ample amounts of this metal, as in Missouri and Illinois.

LECTURE XLVII.

GEOLOGY. AGRICULTURE.

PRETERMITTING the utility of the study of geology to mineralogy, building, canalling, forming rail roads and other similar national works, the materials and the proper construction of which must materially depend upon the knowledge of facts, which an enlarged acquaintance with geology only can furnish; the improvement of agriculture is essentially connected with the study of this science.

Let us never lose sight of the great pursuit that is the common mother of the human race. The real benefactors of mankind are those, as Swift beautifully said, who teach, how to raise two blades of wheat, where only one grew before. A patient, laborious husbandman, who tills his fields in peace and privacy, is a much more useful and respectable person, than a successful demagogue, or a visionary theorist, who imagines himself an orator, a scholar, and a writer. The fields ought to be the morning and evening theme of Americans, that love their country. To fertilize and beautify his fields ought to be the prime temporal object of every owner of the substantial soil. In this primeval and satisfying pursuit, for which man seems to have been formed by his maker, are peace and health and contentment; and the study of nature, in the ever open and unpolluted page, fresh from the impress of its great author, is always ready to inculcate its still lesson upon the reaper's and the ploughman's heart. I consider agriculture as every way subsidiary not only to abundance, industry, comfort and health, but to good morals, and ultimately to religion; and that every one, who promotes agriculture, collaterally aids these high ends. Let us always regard the American farmer, stripped to his employment, and tilling his grounds, as belonging to our best class of citizens. Let our motto be 'speed the plough.' May the choicest of heaven's blessings descend upon the contented and unambitious inmates of our farmhouses and cabins. Let us supplicate the blessings of God upon their peaceful labors.

England is the garden of Europe, because almost every acre of ground is scientifically cultivated, and on principles, which have been brought to the test of the most rigid and exact experiment. New England, of whose soil and climate the inhabitants of the more favored and fertile divisions of the country speak, as if it were abandoned to sterility and inclemency, is really the most productive portion of the land; because the industrious and calculating people do not throw away their efforts in mere brute strength, but bring mind, plan, system and experience to bear upon their naturally hard and thankless soil. On every side, the passing traveller sees verdure, grass and orchards in the small and frequent enclosures of imperishable rock, and is delighted to witness a fertility won from the opposition of the elements and nature.

In the following observations I chiefly quote Bakewell. Paley observes, that in the peculiar conformation of teeth in graminivorous animals, and in the production ofgrasses, which serve them for food, we may trace marks of relation, and of a designing and intelligent cause. It is as reasonable to infer, that the wearing away of mountains, and the forming of soils for the sustenance of the vegetable tribes are a part of the severe plan of a regular series of operations in the economy of nature. Hence, also, we may infer, that those grand revolutions of the globe, by which new islands or continents are elevated from the deep, are part of the same series of plans extending through ages of indefinite duration, and connecting in one chain all the successive phenomena of the material universe.

By a wise provision of the author of nature, it is ordained, that those rocks, which decompose rapidly, form the most fertile soils. The quality of soils depends on the rocks, from which they were formed. Granitic and siliceous rocks form a barren and hard soil; argillaceous rocks a stiff clay; and calcareous rocks, when mixed with clay, form marle. When not supported by other strata, they rear a short but nutritious vegetation. For the formation of productive soils, an intermixture of three earths, clay, sand and lime, is absolutely necessary. The proportion requisite for the formation of a good soil depends much on the climate, but more on the quality of its sub-soil, and its power of retaining and absorbing moisture. This alone may create a barren soil, which upon a different sub-soil would be extremely productive. Where this is the case, drainage, or irrigation, offers the only means of permanent improvement.

Different vegetables, also, require different admixtures of earth, because it is necessary to their growth, that the soil should be sufficiently deep and firm to keep them in their place; that it should not be too stiff to prevent the expansion and growth of their roots; and lastly, that it should supply them with a constant quantity of water, neither too abundant nor deficient.

Hence we may learn, why different degrees of tenacity, depth, and power of retaining or absorbing moisture are required in soils for different kinds of plants. Thus, in uncultivated countries we find, that certain vegetables attach themselves to peculiar situations, in which they flourish spontaneously and exclusively; and it is only by imitating nature and profiting by the instruction she affords, that we can hope to obtain advantageous results, or acquire certain fixed principles, to guide us in our attempts to bring barren lands into a state of profitable cultivation. When rocks contain in their composition a due proportion of silex, clay and lime, they furnish soils whose fertility may be said to be permanent. The most fertile districts in England were not made so by nature, and their original fertility was independent of human operation. Some small portion of the earths and alkalies is found by chemical analysis in plants. But it would be contrary to fact and analogy to suppose, that the earths in a concrete state form any part of the food of plants ; for it is now ascertained, that the earths and alkalies themselves are compound substances.

The principal elements found in plants are hydrogen, carbon and oxygen ; and by the experiments of Gay Lussac, and Thenard, it appears, that the hydrogen and oxygen in starch, gums, vegetable oils and sugar exist in precisely the same proportions, that form water. Carbon, the other principal elementary substance found in plants, exists both in water and the atmosphere. These contain in themselves or in solution all the elements necessary for the support and growth of vegetables. But most soils are either too wet, or too adhesive to admit plants to extract these elements in the proportions necessary for their growth. Manures supply this deficiency, by furnishing, in greater abundance, the hydrogen, carbon or azote, which they may require. In proportion as soils possess a due degree of tenacity, and power of retaining and absorbing heat and moisture, the necessity for a supply of manure is diminished ; and, in some instances, the earths are so fortunately combined, as to render all supply of artificial manure unnecessary. He, who possesses on his estate the three earths, clay, sand and lime of a good quality, with facilities for drainage or irrigation, has all the materials for permanent improvement ; the grand desiderata in agriculture being to render wet lands dry, and to supply dry lands with sufficient moisture ; to make adhesive soils loose, and loose soils sufficiently adhesive. The intermixture of soils, where one kind of earth is either redundant or deficient, is practised in some countries with great advantage. By an intermixture of marle, the most unproductive soil is rendered fertile, and the necessity for manure superseded. In some lands, a mixture of light marle, which contains scarcely a trace of calcareous earth, is of great service. Sterile and gravelly soils have recently been rendered productive, by mixing them with chalk ; the most liberal application of manure having been found ineffectual or injurious. In stiff clay soils, where lime is at a great distance, the land might frequently be improved by an intermixture of siliceous sand. A proper knowledge of the quality of the sub-soil, and the position of the substrata is necessary, to ascertain the capability of improvement, which land may possess. It may frequently happen, that a stratum of marle or stone, which lies at a great depth in one situation, may rise near the surface in an adjoining part of the estate, and might be procured with little expense.

Lime is the only earth which has generally been used to intermix with soils, and has been considered as a manure. But its operation, as such, is very imperfectly understood. Burnt lime, when caustic, destroys undecomposed vegetable matter, and reduces it to mould. So far its use is intelligible. It combines also with vegetable or mineral acids in the soil, which might be injurious to vegetation. Here its operation is likewise intelligible. But if we assert, when burnt lime has absorbed carbonic acid, and become mild, that it gives out its carbon again to the roots of the plants, we assume a fact, which we have neither experiments nor analogies to support. The utility of lime in decomposing vegetable matter, and neutralizing acids is obvious. But its other uses are not so evident, except we admit, that it acts mechanically on the soil, and renders the clay or sand, with which it is intermixed, better suited to the proper expansion of the roots, and more disposed to modify the power of retaining or absorbing the requisite degree of heat or moisture, which particular vegetables may demand.

Where soils are properly intermixed, instances are known of lands producing a succession of good crops for many years without fallowing or manure. I have seen a luxuriant crop of barley growing on land, that had borne a succession of twenty preceding crops, without manuring. This was in an exposed and elevated situation, and upon a hill of magnesian limestone, which has been frequently referred to by chemical writers as peculiarly unfavorable to vegetation. The limestone of this hill contained twenty per cent of magnesia.

The temperature requisite for the growth of plants is influenced by the power of different soils to absorb and retain heat from the solar rays, which depends much on their moisture and tenacity. It is a well known fact that the vegetation of perennial grasses, in the spring, is at least a fortnight sooner on limestone and sandy soils, if not extremely barren, than on clayey, or even deep, rich soils. It is equally true, but not perhaps so well known, that the difference is more than reversed in the autumn. This effect is ascribed by Egremont, with much probability, to the rich or clayey soils absorbing heat slowly, and parting with it again more reluctantly than the calcareous soils, owing to the greater quantity of moisture in the clay, which is an imperfect conductor of heat. Calcareous soils might be frequently much improved by a mixture of clay, sand, or gravel, which in many situations is practicable with little expense, and would well reward the labor of the experimental agriculturist. Thus far Bakewell's Introduction, which should be attentively read, as containing a condensed view of the essentia principles of agriculture.

Many of the American soils possess, from the bounty of nature, an inexhaustible fertility. Such are belts along most of our larger water-courses, as the Hudson, Mohawk, Susquehannah, Delaware, Ohio, Mississippi, Missouri, and Illinois. We may add to these, the broad alluvial belts of the rivers of the Lower Mississippi. These soils are black, dark-brown, gray, or red, and, in many instances, the vegetable stratum is fifty feet in thickness.

That our soils are yet too fresh and fertile to require these laborious processes of manuring, intermixing, irrigating, or draining, deduced from a scientific application of geological knowledge, is no reason why this most useful and delightful of all studies should not be philosophically pursued. Who can be so dead to all noble and useful curiosity, as not to be stimulated to inquire into the secrets of Nature's store-house, in virtue of which researches, he may be enabled to teach her how to fill her horn of plenty, and put forth her grand variety of vegetation? Who will fail to recollect, that there is in our language a word of such terrible import as famine? Who can forget that this most excruciating of all earthly tortures is an infliction upon beings with the same sensibilities, organs, and dimensions with ourselves; that millions have suffered this living death, and that gray-headed parents have thus perished within hearing of the cries of their famished children? Who would not wish to learn how to draw the nutritive sustenance of life more abundantly from the bosom of our common mother?

I would not deem so poorly, even of the gayest and most fashionable among our young readers, as not to suppose that they will be interested in that science, which teaches to clothe the fields and gardens with beauty and abundance, to rear and feed the nations of bees in their fragrant realms, to make the lambs bound upon the hills, and the valleys to stand thick with corn. It is the most cheering, uncloying, healthful, and satisfactory of all human pursuits, rendering the husbandman nobly independent of all but God; the pursuit, in which the ambitious, the worshippers of the world, fortune, and pleasure, after being worn with their inanity and disappointments, generally choose to end their days under the rustling of their own shades, and listening to the hum of their own bees, and the cheerful sounds of their own domestic animals.

In no country is it so easy to become an independent and happy husbandman, as in ours. Uncounted millions of acres of exuberant fertility invite him to select his farm, and rear his cabin in the shade of his own trees. There let him find his *dulce domum*, the spot endeared to him by the associations of beauty and abundance won by the labor of his youth from the barren luxuriance of nature, by the smiles of his spouse and the gambols of his children under his own free bowers, where none can molest nor make him afraid. There let his days flow in useful labor, and the perpetual festival of rendering the family that binds up the bundle of his chief charities, satisfied and happy; in communion with nature and nature's God, ripening to be transplanted from the paradise formed by the industry of his own hands, into the Paradise of God.

After every thing else has been tried to satiety, and has been found labelled 'vanity and vexation of spirit,' this pursuit soothes, satisfies, keeps back premature wrinkles, dyspepsia, and organic affections of the heart.

LECTURE XLVIII.

GEOLOGY.—WRITERS UPON THE SUBJECT. ORGANIC REMAINS.

I CANNOT but suppose that you will be sufficiently interested in this subject, upon which I have but touched, to wish to know where you may prosecute your researches, in a more ample and thorough investigation. I know of no book, which I think a person, commencing the study of geology, will read with so much pleasure and profit, as Bakewell's Introduction to it. He is plain, practical, sensible, and full of instruction. Among the earliest systematic writers upon geology, were Burnet and Lister. Hutton and Werner were the heads of the old school of geology, as Lyell, Fitton, and Sedgwick, are of the new. The works of De La Beche, Brande, Conybeare, and Ure, are mentioned with praise, and are worthy of an attentive perusal. Dr Buckland's work upon the organic remains of the English caves, is an eloquent and instructive book. Buffon, Cuvier, Blainville, Jeffroy, and Desmarest, are celebrated French writers upon this subject.

In America, this noble science has but recently begun to excite attention, though no country offers a more interesting field, or a more ample harvest. Yet we have already had our Maclure, Silliman, Troost, James, Schoolcraft, Featherstonehaugh, and many other respectable names of geological writers. We have the most ample promise, with such precursors as guides, that this elder and enduring scripture, the bosom of the earth, that feeds and clothes us while we live, and piously shelters our remains when we die, will find faithful and successful interpreters, who will discover in this record of God's past dealings with the world, new grounds of confidence, and new reasons to love and trust him for all the periods to come. I return to a few brief details of the history of organic remains, with which I propose to close an article, which I have been fearful I should have rendered tedious had I gone extensively into its details, or dealt much in its copious and difficult nomenclature.

I have already remarked, that human skeletons and bones have been very rarely found imbedded in secondary rock formations, and even those of coal and peat. It is a strange fact, that the remains of monkies of any class are still more rare. But the quantities of other organic remains of all the animals at present known, and of many that do not now exist, are prodigious. If every portion of our earth that has once been life, were to burst in one re-animated resurrection from the soil, what a spectacle would the face of our earth exhibit!

It is a common error in the Mississippi Valley, to suppose that the bones of the largest and most remarkable of ancient herbivorous quadrupeds, the mammoth, have been found only in this region. Professor Pallas affirms, that from the Don and Tanais, in Russia, to the remotest shores of Siberia, there is scarcely a river in the banks of which the bones of this animal are not abundant. Two large islands near the mouth of the river Indigerska, are said to be composed of the bones of the mammoth, intermixed with ice and sand.

Mixed with them are the bones of the rhinoceros, and of various other huge animals.

The body of a fossil elephant has there been found entire, with the flesh preserved by being buried in ice. It had a mane along its back, and was covered with coarse, red wool, protected by a kind of hair, indicating that it was an inhabitant of cool climates. This animal was from fifteen to eighteen feet high. Bones and teeth of the mammoth are not unfrequently found in England in beds of diluvial gravel and clay, and in caverns. The bones of the rhinoceros are found, with those of the fossil elephant, in Siberia. In the year 1771, the entire body of one of these animals was found in the frozen sands of that country. Bones and teeth of the hippopotamus are discovered in England, France, and Germany. Bones and teeth of a large animal, called the mastodon, are dug up both in Europe and America. The great mastodon had pointed grinders, was a native of North America, and equalled the elephant in size, and resembled that animal in many particulars. Its bones, and even entire skeletons, have been abundantly met with in those salt marshes, known in the western country by the name of *licks*. Parts of the flesh and stomach have been discovered with them, and in their stomachs certain plants, the names of which are known in Virginia.

No place has yielded such ample supplies of these bones, as Big-bone Lick, in Kentucky. It is a marsh of muddy and alluvial soil. Salt water oozes up from this soil, diffusing a briny sapidity through the clay that attracted immense numbers of the former animals of the country to it, which, by their licking the earth for salt, gave its name to the place. A thousand beaten paths, like those about barn-yards, led to it in every direction. Here are the deposits of the bones of whole generations of these animals. They lie imbedded in the alluvial soil, from four to ten feet in depth. Immense quantities have been dug up, of which part have been carried to Europe, and the remainder appear in greater or smaller quantities, in almost every museum in the United States.

The bones of two other animals of extraordinary form have been found in this region. The one has been called megatherium; the other megalonyx. In many respects they were similar, and differed chiefly in size. The former was of the size of the rhinoceros, uniting the structure of the armadillo with that of the sloth, with claws of vast length and size. The remains of carnivorous and ruminant animals are very abundant in Europe, while those of the camel and other large mammiferous animals are rare. Skeletons of the Irish elk, and the American mastodon have been found erect in bogs and marshes, which proves, that the surface of the ground had there undergone little change, since they perished. That the flesh and stomach of the mastodon has been found not protected by ice like those referred to as having been discovered in Siberia, proves at least, that these remains are not of any great antiquity. It seems certain, that they must have lived in a condition of our planet very different from its present one. The northern parts of Europe are wholly incapable of supporting the immense numbers of elephants, which must have spread over all the valleys of what is now the frozen ocean. Nor would it remove the difficulty to suppose, that the temperature of those climates was then higher, and that it was, as the vegetable remains render probable, the country of palms. It has been seen, that these animals have been found preserved with a thick coat of hair and wool, clear indications of their being adapted to live in cold climates.

As might be expected, these organic remains are in different degrees of preservation. In the icy regions, the enamel of the tusks is perfect. In other places they crumble on exposure to the air. Bones of the rhinoceros, mastodon, and other animals were recently found on the surface near Irrawaddy in Ava, of extreme hardness, and impregnated with iron. Caverns contain the bones of carnivorous animals in the greatest proportion. Immense quantities are found, as we have seen, in those of Germany and Hungary. Three fourths of them belong to species of bears that are now extinct. In some, the animal earth, intermingled with bones, is found more than ten feet deep ; and, according to M. Esper, in one cave there were found quantities sufficient to fill many hundred wagons.

Of the animal remains of the Saurian class, the fossil ichthyosaurus has been met with of immense size in lias. In many respects it resembles the crocodile. Great numbers of skeletons of four species have been discovered in England, some of them twenty feet in length. Bones of the megalosaurus have been dug up at Tilgate in England. It is supposed, the animal must have exceeded seventy feet in length !

But the most extraordinary of all these animals must have been that denominated iguanodon. The remains of this astonishing lizard are found in the county of Sussex in England ; and what is equally surprising, vegetable remains of lofty arborescent ferns, like those of tropical climates, in which races of animals, similar to the iguanodon are now found. 'Imagine,' says Mr Mantell, 'an animal of the lizard tribe, three or four times as large as the largest crocodile, having jaws with teeth equal in size to the incisors of the rhinoceros, and crested with horns ! Such a creature must have been the iguanodon. Nor were the inhabitants of the water much less wonderful. Witness the plesiosaurus, which only required wings to be a flying dragon.'

Scarcely a month elapses, in which, in some perforation of the earth in the valley of the Mississippi, new proofs are not disclosed of the former habitancy of this valley by a people at least sufficiently civilized to be acquainted with the use of metals. At first the facts were considered as wanting confirmation and credibility. They were ridiculed by some superficial and pretended naturalists, who had not studied the history of organic remains in all parts of the world. After many isolated discoveries were united, and bore a concurrent and irresistible testimony, it became the prevalent fashion to refer them to the Spaniards, and to the first adventurers travelling up and down the western rivers. To render this violent supposition plausible, they were obliged to imagine, that some great alluvial change had buried these historical monuments, which could not be more than a hundred years old, twenty feet beneath a soil, which has been apparently undisturbed a thousand years. It is utterly incredible, that such causes should have operated in places so numerous and wide from each other. The iron weapons, the coins, the regular walls of masonry, the brick and limestone hearths in the bed of the Louisville canal, concur, with the recent unquestionable discoveries in the same place, to which I have already referred, to convince me not only that this country was formerly inhabited by a comparatively civilized race of men, but that this epoch of habitancy preceded that of the races, who erected the western mounds, and left them filled with their pottery, with here and there trinkets of copper and silver, and with their bones. Why is it either more strange or incredible, that America should have been inhabited by civilized races of men, now no more, than that England should have had in some unknown period of the past, forests of palms and arborescent ferns, inhabited by the elephant, rhinoceros and hyena?

Where are the millions, whose mounds rise in the solitary places of the desert, and testify, that men, with all their keen and burning passions once dwelt there? Notwithstanding some flippant writers have recently affirmed, that there is nothing in these mounds, which may not have been the work of the present Indians, and, more absurd still, even of nature, I am clear, that no person could see the mounds of Grave Creek, on the Ohio, Circleville, on the Scioto, and Cahokia, near the Mississippi in Illinois, without being satisfied, that these immense, though rude erections, were reared by a more laborious and municipal race than the present Indians. Nothing in the present race bears any relation to the skill and art necessary for moulding the ancient pottery found in these mounds. Part of them are cone-shaped, and appear to have been cemeteries, being full of human skeletons. Others are of immense size, as those at Circleville; and seventy feet high, as that at Grave Creek, and in regular mathematical figures, as are most of those of the largest size. Imagination is confounded, and the mind is pained with the intenseness of its own thoughts, as it contemplates these abiding memorials in the earth of a perished generation, and inquires when they lived, who they were, and why they are all gone ?

It may not be easy to trace the relations of these entire ruins of a living world, that has passed away, with the other harmonies of nature, with the other benevolent results of the purposes of providence. It would be easy to prove, that death was one of these benevolent purposes. If it were benevolent, that such a series of living beings, as now exist on the earth, should be created, it must be part of that benevolence, that they should grow old, and die, and give place to others. Not only would immortal men and animals on the earth have been inexpressibly wretched, from the necessity of their condition, but the earth itself would long since have been covered with them without ability to feed them, or even to give them a place for their feet to rest upon. Life and death succeed each other, and must of neecssity, in the works of God. Every thing changes, but nothing is lost. A new harmony of the universe stands forth in the study ot geology, if it teach, that all the changes, which the earth is undergoing, continually tend to render it a better and happier habitation for man.

What a mystery is this physical universe, on which the rational being, who inhabits it, casts a few searching glances, before he takes shelter beneath its bosom ! At the first survey, every thing seems blended in inextricable confusion. Another survey enables him to class species ; and subsequent inspections and comparisons qualify him to form genera. He finds himself in command of the immense resource of classification. He has the power of assigning to their own rank and family even the earths, rocks, minerals and fossils, that seemed in a confusion that defied arrangement, and utterly incapable of subjection to any system of order. This faculty of classification gives him powers over nature, that most clearly show the supremacy of the reasoning animal over all other beings here below.

A single idea in the mind of Newton was the germ of that analysis, which unfolded the laws of the physical universe. A mere circumstance led La Place to a still severer analysis of these laws, which completed the system of his great predecessor. A single idea led Cuvier to those astonishing investigations, by which he was enabled to write the natural history, and detect, if I may so say, the living habits and modes of life of a world of animals, of which no living resemblances now remain. From seeing their grinders, vertebræ and bones, he followed them to their ancient pastures, and divined the history of their life.

To the vague common gaze, what could seem more confused and incapable of classification, than the stars in the fields of ether? The astronomer finds system upon system, in the most perfect arrangement, the most beautiful order.

Alas! that life, which might be improved for thousands of years in these high and ennobling pursuits, is so short! We see and feel, that the very soil itself on which we tread, has been sentient flesh; that strange and unseen forms of life in innumerable varieties have had their day and are now no more. We become persuaded, that continents have been submerged, where oceans now roll, and that Chimborazo and Himalaya were once beneath the abyss.

It is a natural reflection, from what we have discovered of the past, and yet little calculated to soothe human pride, that the studious and musing geologist may come, a hundred generations hence, to some perforation of a valley or mountain-side, and find imbedded in the strata of stone, the bodies of the beautiful and the gay; some with their arms extended in marble, others in crystallized limestone, the fair in veins of porphyry, all fixed in their everlasting niches, affording only a geological study, and the theme of an idle theory or a vague conjecture.

LECTURE XLIX.

STEAM.

The invention that will give character to the discoveries of this age, and one that has had, and will have more influence upon the physical advancement of society than any other, is the application of steam as a power to drive machinery, propel vessels upon the water, and vehicles of conveyance upon roads. It has enabled the inhabitants of countries, where coal and wood abound, and which want quick streams, to create a power more certain, and at the same time more manageable than running water. The convenience of having manufactories just where they are wanted, and of placing them in the towns and cities, is not one to be overlooked. In a word, steam-power has so many advantages over that of water, that it is superseding it on all sides. A very few peculiarly favourable sites for water-power excepted, it is a question, if it be not in the end the most economical; as it is certainly the most disposable power, even where the ordinary advantages of water-power are at hand. It follows that the first result of this discovery has been the increase of the power of machinery of the labor-saving class, to a degree unprecedented in any former age of the world. In whatever direction you travel, wherever you find civilized men dwelling in towns and villages, you see the smoke of steam-engines streaming aloft from their manufactories, and hear the heavy rumbling of labor-saving machinery.

As an associated result, inventions in the making and improvement of labor-saving machinery have proceeded in an equal ratio, and in a proportion corresponding to the increased demand for the article. Enter a large cotton-manufactory, where all the processes from carding to sending forth the beautiful bleached muslins are in operation, see the thousands of wheels in rapid and everlasting whirl, mark this wonderful and complicated machinery performing the nicest and most delicate operations with more than human dexterity and precision, consider that all this whirl, all these seemingly innumerable complications of wheels, all this wonderful concurrence to one of the highest results of art and skill have existed in some human head as the archetype of these patterns, and we then begin to comprehend to what extent modern improvements have been carried. Operations which would formerly have been hopeless to the invention of the human head and the dexterity of human hands, are now performed with the unerring, untiring, and inexhaustible power of steam. The most ingenious and amusing parodies of the present day, are such as have been predicated on the supposition of performing all the domestic operations, all legislative and ecclesiastical functions, and even love and marriage by steam.

But even these results of the application of steam, incalculable as they are, dwindle in comparison with its utility in propelling vessels upon rivers, waters, and roads. Affording inconceivable facilities of transport and travelling in every country where it is applied to propelling steam-vessels and carriages, it seems more directly adapted to benefit the United States than any other civilized community. We have a vast surface of country, over which the greater part of the unwrought roads are heavy and inconvenient. The people are more active, more strongly impelled by the appetite of wealth, and furnish more agricultural avails, in proportion to the cultivators, than any other country. Nature has given us a surface in its bays, rivers, and lakes, more adapted to water-communication. The Mississippi Valley constitutes the far greater portion of our extent. This valley is watered by the longest river in the world, with almost innumerable rivers flowing into it from all points of the compass. These rivers generally have long courses and deep channels, and are capable, for the most part, of steam-navigation. If the inhabitants could have received from nature a consent to the request to furnish them with the easiest, cheapest, and pleasantest mode of transport and travel, it would have been in the form of granting them steam-navigation. Without this invention, a century would have been requisite to bring the advancement of the West to the same point, as the last ten years of steam-navigation have effected. Without this, it would have been a country of shepherds and unimproved husbandmen for a century to come. It has united the most distant points in easy and rapid intercourse, and brought towns, five hundred leagues apart, into a kind of juxta-position.

It is but very recently that this power has received a new application, and one of a character almost to warrant the vaporing predictions of declaimers upon the perfectibility of human resources and inventions, who have prophesied that ploughing would shortly be done by machinery. Steam-coaches have been put in motion on the rail-roads in England, and the example has already been followed on the rail-roads in the United States. These carriages are propelled along rail-ways with a power and rapidity that distance all competition from those drawn by horses, as much as steam-boats leave behind vessels propelled by oars. Some of them have been driven with the fearful rapidity of nearly a mile in a minute, falling little short of the swiftness of the flight of birds. It is thought they may be easily and safely propelled with a velocity of twenty miles an hour. On the roads where these carriages have been put in operation, thousands of stage-horses have already been dismissed from their hard bondage to the quiet pastures. The competition of these powerful, cheap, and expeditious conveyances, has so reduced stage-fare on the rail-road routes, as to warrant the expectation that horses will be driven from the roads, and steam-coaches generally substituted. We may calculate the gain to humanity, which will result from harnessing this untiring and inexhaustible power in place of the generous steed urged onward by the lash, and consider that every four horses required a space of ground sufficient to support a man; and that, in the same proportion as we can dispense with animal power, we can afford space and subsistence to more men. In the increased cheapness and facility of travelling, and the frequency of intercommunication between distant points of the country, in the more general interchange of visits and opinions, an impulse has already been communicated to society, which has wrought a greater and more visible change in its aspect, than any which history has recorded.

I do not affirm that all these results have been propitious or desirable. The power of society has been impelled by the influence of this new order of things to operate more in massive and combined action. These engines, originating in the power of concentrated intellect, are in action inexorable and unsentient abstract entities. They have neither hearts, compassions, nor sympathies. Man, losing in them his individuality and his impulsive nature, becomes a fraction of a vast consolidated creature, all selfish, and a machine of calculation, as much increased in power as diminished in sensibility. Wealth arrays more charms in the same proportion as it procures new consideration, and purchases new pleasures. Avarice, always a predominant instinct of human nature, becomes a more simple and absorbing motive to action. Men feel less, as they calculate more; and the whole order of society seems to approximate towards the sure and unsentient movement of machinery.

But as a compensation in the opposite balance, invention has received a new impulse, ambition new incentives, industry a new motive, fashion new models, varying still oftener than those which used to be adjusted to the phases of the moon, political economy new elements on which to base new calculations, and all classes of physical improvements an accelerated march. As one epoch has been denominated the age of the reformation, another that of the discovery of printing, and a third that of the discovery of America, the present may be denominated the age of associations, revolutions, and steam.

I will attempt to present a brief view of the nature of the power, and the mode of raising and applying it. We have seen that a constant evaporation takes place from the surface of all waters in a state of fluidity, which evaporation is greater or less, according to the increased or diminished pressure of the atmosphere, and the greater or less intensity of the solar action. This kind of evaporation, which is the origin of dews and rains, I have already considered.

In order to create the mechanical power of steam, an artificial process is necessary. Water is confined in a close vessel, called a boiler, to which heat is applied. The first effect of increasing the temperature of the confined water is by a property common to all bodies to expand its molecules and enlarge its bulk. But the accession of caloric, by its own elasticity and the expansion of the molecules of the water rapidly escapes, carrying off a portion of the water in a visible form, and possessing great elasticity. This is called steam. The more rapidly and powerfully heat is applied to the water, the larger is the volume of escaping steam, and the more elastic its power. Such is the balance of this action and reaction, that no increase of heat will cause the thermometer to indicate more than 212 degrees, so long as the water is allowed free evaporation. It hence appears that the natural form of water, of a temperature higher than this, is vapor. For, sustained at this degree of heat, any quantity of water will gradually evaporate, and in the form of a visible elastic fluid will unite with the atmosphere.

If this steam be enclosed in any vessel, its expansive elasticity will tend to burst the enclosure. This expansibility not only increases with the increase of the heat applied to the closed vessel, but in a geometrical ratio, while the temperature advances only in an arithmetical ratio. Thus if steam, in a close vessel of water, heated to 251 degrees, exert an elastic force equal to two atmospheres, that is, 30 pounds on a square inch of the vessel's interior surface, raising the temperature to 292 degrees, will create a pressure equal to four atmospheres, or 60 pounds. Under the ordinary pressure of the atmosphere, which is about 15 pounds on a square inch, and at the temperature of 212 degrees of Fahrenheit, a cubic inch of water is converted into a cubic foot of steam. A cubic foot contains 1728 cubic inches; consequently water at this temperature, passing into steam, is converted into 1728 times its former bulk. The freezing point of water is 32 degrees of Fahrenheit. But it is a singular property of water, that it requires six times as much heat to raise it from 212 degrees to steam, as it does from 32 degrees, the freezing point, to 212 degrees. It follows that all the excess of heat necessary to convert it from 212 degrees to steam, is required to give the water this elastic form, which, from its not being indicated by the thermometer, is called latent heat.

The only limit to the degree of heat, and consequent expansibility of confined water, is the strength of the vessel, or, in other words, the mechanical pressure, to which it may be submitted. It is capable of being raised to 800 degrees of heat, and in fact of being made red hot.

As water is converted into steam by imparting caloric to it, or increasing its temperature, abstracting the caloric from the vapor reconverts it into water again. This reconversion of steam to water, by the abstraction of heat, is called condensation. Steam is employed to create a vacuum, that is, to expel the atmospheric air from a vessel by introducing steam, exerting an elastic force of expulsion, greater than the pressure of the atmosphere. Consequently, the air is expelled, and the steam enters, and takes its place. If the vessel be closed in this state by a stop-cock, or otherwise, and be allowed to cool, the steam within will condense to water in the vessel occupying but a 1728th part of its bulk in the form of steam, and consequently the external atmosphere will press upon the vessel, as upon a vacuum.

Such are the more prominent phenomena of evaporizing water, and such the mode of creating the immense power of steam, a power, known in the abstract to the ancients, but in its applications to drive vessels and machinery, of recent modern invention. That water was susceptible of yielding a power of this sort must have been known as early, as the fact, that water could be made to boil. It may well seem astonishing to us, that the phenomena connected with the vaporization of water should have been so long known, and that the almost equally obvious property of its elastic expansibility and consequent susceptibility of application, as a moving power, to machinery, should have been of such recent discovery. The idea of applying this power to drive machinery was first advanced by the marquis of Worcester, in his 'Century of Inventions,' published in 1683. As this has proved one of the most important inventions, that has ever been made, I deem it right to present his own account of it in his own quaint language.

'I have invented an admirable and forcible way to draw up water by fire; not by drawing or sucking it upwards, for that must be, as the philosopher terms it, *intra sphæram activitatis*, which is at but such a distance. But this way hath no bounder, if the power be strong enough. For I have taken a piece of whole cannon, whereof the end was burst, and filled it three quarters full of water, stopping and screwing up the end, as also the touchhole, making a constant fire under it. Within twenty-four hours it burst, and made a great crack. So that, having a way to make my vessels so, that they are strengthened with the force within them, and the one to fill after the other, I have seen the water run, like a constant stream, forty feet high. One vessel of water, rarefied by fire, driveth up forty of cold water, and a man, that tends the work, has but to tend two cocks, that one vessel of water being consumed, another begins to force, and refill with cold water, and so successively, the fire being tended, and kept constant, which the same person may likewise abundantly perform, in the interim between turning said cocks.'

It does not appear, whether the marquis of Worcester ever applied his acquaintance with the elastic power of steam to the construction of any sort of steam engine. In 1698, the method of producing a vacuum by the condensation of steam was invented by Captain Savary, who, combining this discovery with that just named, constructed an engine for raising water, for which he was granted letters patent.

Savary's engine, although it contained all the essential principles of the subsequent improvements, as an incipient and incomplete idea, might be expected to produce a rude and unwieldy application, and failed even in the single result contemplated by him, the drainage of the Cornwall mines in England. Successive improvements were introduced by Newcomen and Cawley. The improvement of the former consisted in a much more useful way of producing condensation, by throwing cold water into the cylinder, and effecting condensation by what is called the *jet*.

To these improvements, Humphrey Potter added that of making the machine work its own valves. Papin, a French professor of mathematics, made an improvement upon former engines in 1707, and, on the strength of this, though it was even subsequent to Newcomen's improvement, the French have claimed the invention of the steam engine. Smeaton followed Newcomen in improving the atmospheric engine invented by the latter, and carried it to that degree of perfection, that it still remains in use.

But the most illustrious name in the history of the inventions and improvements of the application of steam is that of James Watt, born at Greenock, 1763. Endowed with surprising talents, as an inventive machinist, he added to native powers great industry and patience. Of the celebrated chemist, Black, he learned the philosophical principle of latent heat, upon one of the facts of which, he says, he had previously stumbled by accident, without knowing the theory that explained it. Under circumstances of great difficulty, from limited means, Watt proceeded rapidly to develop with astonishing sagacity and precision, the principles of the present application of steam.

His first conception was the invention of a separate condenser, which immediately, and, as he states, in the course of a single day, led to the improvements of the engine now in common use. Henceforward, steam became a new mechanical power, destined to operate a greater change in the condition of human society, than, perhaps, any human invention that has yet been made. Manufactories on this principle began to arise, and the invention of projectors and machinists was stimulated to powerful action, by seeing the practical results of the discoveries of Watt. We can only give place to the names of some of the adventurers in this new walk of discovery. Edelcrantz, Brunton, Oldham, Hornblower, Woolf, Cartwright, Leupold and Trevithic each produced inventions purporting to be improvements in the steam engine. Trevithic and Vivian were among the first to produce high pressure engines, remarkable for elegance, ingenuity and power, applicable to what are called loco-motive carriages to travel on land. I have noted, to what a prodigious extent of improvement these loco-motive engines have been carried even in the infancy of their application.

Our ingenious countryman, Perkins, has invented a steam engine of much greater power, than any other in use. He affirms, that, at the same time, it is perfectly safe. The prodigious force of this engine may be judged, when it is stated, that the pressure, thus raised, is equal to 450 lbs on the square inch. But either from the complication, expense, or imagined danger of his engine, he has wholly failed in being able to bring it into any practical use. He has applied the power of his engine, as a propelling force, to throw balls from a cannon. The power has been found fully equal to that of gunpowder, with the added advantage, that balls can be discharged in uninterrupted succession, and for any length of time. But the practical difficulty was found to be, the maintaining the power, by keeping a sufficient quantity of water, at the unusually high temperature, requisite for his purpose. Mr Babcock, also our countryman, has invented a very safe and convenient boiler for a high pressure engine. It is said to require much less water and to expend far less fuel, than the engines in common use, and to possess the additional advantage of being almost entirely free from the danger of explosion.

Every one knows, that various claims have been preferred for the honor of the invention of the first application of steam to drive vessels upon the water. Both the English and French contest with the United States the renown of this immortal invention. Waving all discussion of the prior claims in regard to the theoretical application, it is generally admitted, that the honor of the first complete and successful practical application of steam power to this purpose is due to the United States.

Rumsey and Fitch conceived the idea of this application at the same time. Both exhibited models of steam boats in 1784. Fitch succeeded in propelling a boat upon the Delaware in 1785. Rumsey obtained the same result upon the Potomac in 1786. Fitch never found adequate patronage; while Rumsey succeeded in England, in procuring the construction of a steam boat, which, however, was not set in motion, until after his death, in 1793. Miller in Scotland, in 1787, made an abortive attempt to apply steam to navigation. Stevens of New York was more successful, perfecting his improvements in 1794, to the extent of being able to drive a boat by steam at the rate of six miles an hour.

Fulton seems clearly to have been the first, who conceived the idea of paddle-wheels; though there are not wanting those, who affirm, that he obtained a knowledge of all the improvements, which he added to steam vessels, from other inventors; and that he unworthily claimed the honor for himself. We have neither space, nor inclination to enter into the discussion of the conflicting claims, that sprung up at this time, each assuming precedence in regard to the successful application of this grand invention. In 1797, Chancellor Livingston of New York built a steam boat on Hudson river, and obtained from the legislature of the state an exclusive privilege, provided he should produce a boat, that could be impelled at the rate of three miles an hour. In this he failed. In 1801, Evans of Philadelphia made important experiments of the power of steam, which, however, were not followed by any important practical result. The first completely successful experiment of a steam vessel being propelled upon the water, with any considerable rapidity, was that of the model steam boat of Fulton, on the Seine at Paris, in 1803.

Fulton determined to renew his experiment, on a large scale, on the waters of the United States. But no adequate engines could be procured from any other quarter, than the establishment of Watt and Bolton. The vessel was not built, and the machinery in readiness, until the summer of 1807, when his steam boat commenced running on Hudson River, under Livingston's exclusive patent.

The Stevenses were but a few days later in moving a steam boat of their contrivance, with the requisite velocity. Being precluded from the waters of New York by the abovenamed patent, they conceived the bold idea of moving their boat round to the Delaware by sea. This was the first attempt to navigate the sea by steam power. The younger Stevens went on, steadily improving the models of his steam boats. The patent of Livingston and Fulton was set aside by an important legal decision, and Stevens put a boat in operation on the Hudson, which performed its trip with the astonishing velocity of thirteen and a half miles an hour! The three first boats, that ran on the Hudson, were called the Car of Neptune, Clermont, and Paragon.

It was five years afterwards, that steam boats began to be used on the waters of Great Britain. In 1816, the first steam boat crossed the British channel from Brighton to Havre. In 1815, a steam boat ran between New York and Providence; and in 1818, a steam ship plied between New York and New Orleans, touching on the way at Charleston, and Havana. In 1820, steam packets were established between Holyhead and Dublin. In 1825, the steam ship Enterprize made the immense passage between London and Calcutta! Steam boats were first introduced upon the waters of the Ohio and Mississippi in 1812. At present more than 200 run on these waters alone. The velocity, convenience and cheapness of this mode of conveyance by water have acquired an extent, which words are not needed to convey, as there are very few persons, who have not experienced them for themselves. As an instance of the degree of velocity, I cite the example of a steam boat, that has made the trip from New Orleans to Louisville, estimated at 1450 miles, against the mighty current of the Mississippi and Ohio, in eight days and a few hours! Unhappily, either avarice, or rashness, or intoxication, or puerile and reckless ambition to make a quick trip, or the use of imperfect or worn out boilers, or all in conjunction, have produced many fatal explosions, by which hundreds of lives have been lost; and associations of terror, connected with travelling by steam have tended to diminish the number of passengers, and the sense of security in those, who still continue to travel in this way.

The imagination is lost in contemplating the simplicity and immensity of this blind and untiring power, which has been brought to produce results beyond even human intelligence and delicacy of touch. In one place a single engine draws water from a mine, with the power of 600 horses. In another place, it extends its long arms over an immense manufactory, giving motion to thousands of wheels. The whirl of picking, carding, spinning, weaving, weighing, and stamping cotton, is produced by a single wheel driven by steam. In another place, the steam-engine is seen in a brewery, pulling up the barley from wagons and grinding it, pumping cold water into some of the boilers, and despatching the boiling liquid into cooling pans from others, and performing most of the anomalous and indescribable labors of the establishment. In another direction, it is driving hundreds of vessels against the currents of the mightiest rivers, from the Mississippi to the Ganges, and the rivers and seas of China. In another direction, it is seen unharnessing the generous and docile steed, and sending him back to his pastures, and whirling carriages with many tons weight attached to them, far beyond the speed of carriages drawn by horses.

Who could have imagined that a power, locking up within itself such results as dismissing millions of hands from severe and heart-wearing toil, and of changing, by its numberless associated results, the whole face of society, could be raised from that apparently simple and powerless element which flows from the hills, rolls in the streams, distils from the sky, and fills the ocean-bed; or that human invention would be able to evoke and direct this power from such an element?

LECTURE L.

POLITICAL ECONOMY.

The exact import of the much hackneyed modern term, *Political Economy*, may be best understood by tracing it to its primitive meaning. It is derived from Greek terms, which imply the domestic policy of communities. The latter part of the term signifies the law or regulation of the house. The same management which renders a household orderly, peaceable, thriving, and respectable, when enlarged and applied to the policy of a nation, causes it to become a respectable and flourishing nation.

Some families prosper and grow flourishing in their condition, apparently with as little management as the waters of a river require to move downwards. Others, wiser in their own estimation, labor and toil to no purpose. All their efforts seem to have no other result than misadventure, and a steady tendency towards decline. The most common mode of accounting for the difference, is to attribute it to the good or bad fortune of the two families. Destiny, or fortune, have in truth nothing to do with it. If the proper elements are rightly acted upon, the result of prosperity is sure. Bad fortune is generally bad management. The rules, of the right direction and fortunate issue of family management, are comprised in *domestic economy*. Political economy is no other than the same easy, quiet, simple prudence and knowledge of right management, applied to the more numerous and extended household of a nation. The wisdom, good temper and firmness that conduce to the right management of a family, generalized and applied to the more extended relations of a nation, constitute political economy.

It has been the misfortune in popular and free-governments, and it has been eminently so in ours, that the public voice, in selecting the prime managers of the commonwealth, on a principle diametrically the reverse of this, has generally chosen men, to govern the national family, who were full of words and confidence in themselves, and who have founded their claims to public confidence on having made wreck of their private resources. Deprived of comfort and of means, and having proved their incompetence to manage their domestic concerns, they become subject to the yearnings of affection for the management of the public weal. Their having rendered the function assigned to them by God and nature a sinecure, their having proved their inability to manage small things of their own, seems to furnish them with claims upon a function of infinitely greater difficulty and combination, of the same kind. According to our political arithmetic, a man who has proved himself incompetent to steer a skiff, has, *a fortiori*, still more strongly proved his inability to manage a ship of the line. A man who has run his own private affairs to bankruptcy, in our view cannot reasonably urge any new claims, from that circumstance, to be entrusted with the financial concerns of a nation.

The danger of being flattered and beguiled by demagogues, the influence of the cunning over the weak, the power of controlling the majority by combinations of the corrupt and intriguing, such are the peculiar exposures of a country like ours, vast in extent, the citizens independent and self-willed, and yet, in their pride of opinion and freedom, generally ruled by a few plausible men, whose chief art consists in ruling without permitting their power to appear. But our object is not to discuss abstract principles of government, or to lament the evils that spring from the excess of freedom, but to lay down some of the more important doctrines and maxims of political economy.

The external show of a country in splendid and populous cities, magnificent mansions, sumptuous theatrical exhibitions, great progress in the fine arts and general advancement in luxury, though commonly received as the imposing index of prosperity in a state, is a very deceptive criterion of it. Rome gave these evidences, beyond all countries that have figured in history, in the times of the monsters in the form of emperors, who were at once the cause and the effect of the approaching ruin of the empire. Greece gave them, as the last symptoms preceding her utter degradation. England and France exhibit them at the present day, and nothing but political regeneration can prevent the same results from following the same causes.

What then are the results of a wise political economy, and the evidences of a flourishing country? They are general competence, equality, comfortable subsistence, and contentment of the people. They are strong and well-formed men and women, with free and enlightened minds and vigorous wills. They are a flourishing agriculture, great numbers of good farm-houses, neat, not sumptuous edifices, excellent roads and canals, flourishing commerce and manufactures; the people simple-minded, strongly imbued with nationality, and, above all, frugal, industrious, and of good morals. Such was Rome, such were the Grecian States, such were the Swiss, in the healthful epochs of their national existence.

The political disadvantages of a savage condition are, that only a few men, spread over an immense surface, can find subsistence in it. It requires as much land to furnish game for one savage family, as would be adequate to support a thousand by tillage. In the savage condition, not only are advances in comfort and intelligence precluded, but the old, the feeble, and a great portion of the children, perish from exposure and hunger.

The next advance on the social scale, the pastoral condition, must have generated the necessity of property, and a body of municipal laws. The progress of civil society has been at once the cause and the effect of civilization.

The right application of political economy consists in legislating wisely, with a view to national wealth, comfort, and defence. The natural causes that tend to develop the wealth and prosperity of nations, are so strong that civil communities, even when mismanaged by ignorant and vicious rulers, generally present an advancement in wealth and comfort. Nations have grown rich and powerful, not only without the aid of legislation, but, in most cases, against it. Hence the peculiar enormity of the guilt of bad rulers.

A high standard of national morals is indispensable to a great and flourishing people. Industry, frugality, loyalty, benevolence, charity, and order, cannot otherwise exist as public virtues. All history teaches, that a poor and virtuous people are both more powerful and happy, than a rich, highly-refined, and depraved people. Moderation, forbearance, and general good-will, reign in the former; jealousy, envy, intrigue, ambition, war, degeneracy, and voluptuousness, in the latter. A truly enlightened people will never allow their rulers to plunge them into war, unless the cause is such as to make war just or inevitable.

The best motives to stimulate a community to the greatest amount of *production*, are security, rapid exchanges, tending to the constant increase of comfort, and placing the consumer in the easiest relations of transfer with the producer. That is to say, it is better to find the consumer in a neighbor, between whom and the producer there is mutual esteem, than in a stranger beyond the seas. Apart from the expense of long transports and triple duties, the neighbors, with common wants and a common language, will be most likely to establish an understanding of mutual advantage.

We shall see that the accurate and extended division of labor is one of the essential elements of free and rapid production. The next element is easy, unexpensive, and frequent exchanges. These exchanges belong to all the productions of labor, to every thing necessary to the subsistence, comfort, or luxury of the community; all the products of the fields, forests, waters, mines, and whatever can be fabricated from them. Industry and ingenuity, security and freedom, supply motives to mould from them innumerable articles of a value imposed either by want or fancy. The more frequently these products are exchanged, the more they multiply.

The productions of a country that can neither be consumed nor sold, have no intrinsic value. The innumerable cattle of the pampas of South America, and the wild horses of the prairies of Mexico add little to the national wealth, because the districts, where they most abound, are nearly uninhabited. The grass within ten miles of Boston, New York, and Philadelphia, is of more value than that of fifty millions of acres of the prairies of the western country. Napoleon's famous *continental system* caused such an accumulation of coffee, a luxury so universal as to have become co-extensive with civilization in England, as that great quantities were said to have been thrown into the sea, because it would not pay duties and charges on being landed.

The savage state has been preferred to the social on account of its supposed liberty, independence, and exemption from artificial wants. But if the absence of wants, wild freedom, and the reckless indolence of a savage, constitute a degree in the scale of happiness, perfect insensibility would constitute a still greater. The surest test of the happiness of a community is the rapid increase of its population. This scale is graduated by nature. Men will not multiply, except where subsistence is easy and existence a blessing.

The circumstances of the social compact render it necessary that when a man enters into it, he should resign a part of his natural liberty as the price of purchasing security for the rest. The compact of legislation should be, to leave the citizen entire master of his own conduct, limited only by his being interdicted any act, which will infringe the stipulated rights of all the other parties of the compact.

God could have given us food without labor. He has seen fit only to impart fertility to the earth, and faculties to man to create food. Such various and unremitting exertions are necessary to subsistence in civilized society, that the requisite cultivation will only be practised under the institution of laws which give security to property. Agriculture is the foster-child of freedom and security. Countries once blessed with the security of laws, became in consequence the gardens of the world; deprived of laws, they are now desolate and frightful deserts. Vast extents of Asia and Africa furnish examples.

Plato, Fenelon and Harrington have given us most delightful pictures of imaginary republics, predicated on the nature of man as he should be. Wise legislation should be based upon the nature of man, as he is. Owen's social system would be practicable, if men were angels. As it is, predicated upon abstract theories of human nature, if it were practicable, it would degrade men to brutes.

The republican Swiss carry baskets of earth up steep ascents, inaccessible to beasts of burden, to create a soil on a little nook of mountain rock. The women poise their burden of water or faggots on their head, and knit busily, as they walk on with it. A Chinese woman steers her boat with one hand, handles the sail with the other, rows with her feet, bears her child, slung over her back, and regales herself with her pipe. Where such an industry prevails, property must be secure, and must accumulate rapidly.

In society one man will have greater facility, endowment, inclination and opportunity for one sort of production, and another for another. Hence the origin of barter, or exchanges. One fabricates fire-arms; another hunts. One makes ploughs, and another tills the ground. The four produce much more of their respective products than they would, if each made fire-arms, killed game, wrought ploughs, and tilled the ground for himself. They exchange products for their mutual benefit. Hence the ultimate improvement of society, the division of labor. Imagine the number of operatives, and the variety of products necessary for the comfort of the humblest citizen. The labor requisite to all the articles of his establishment must have been divided between a thousand persons. The farmer of the remotest interior procures his tea from one extremity of the globe, and his coffee from the other. To understand the utility of the division of labor, take the following example. A new hand at a forge, can hardly make three hundred nails in a day. A trained blacksmith can forge a thousand. Boys, that are nailers by trade, have forged three thousand three hundred in a day. A nail machine, tended by one man, will produce ten thousand in an hour. A workman without machinery, and not acquainted with the trade, could scarcely make a pin in a day. In a pin factory, the smallest number to each person is about five thousand in the same length of time.

Agriculture, of all employments, tends most to health, good morals and contentment. The farmers constitute the stamina—the strength, subsistence and security of the community. Manufacturers in our country are more attractive in their appearance and manners, are better informed, and have more of the artificial air of society. In return, they have more wants, and suffer more discontent. The advocates of manufactures affirm, that the reason, that more immorality appears among manufacturers, than among farmers is, that in such establishments, offences necessarily become matters of general notoriety, which in the seclusion of the country pass unobserved. In all forms of society, some will be more industrious, and will make better calculations, than others ; thence some will be rich, and others poor. There is a natural and implied contract between them. The rich have supplies, which they do not want, and the poor have labor to offer in exchange, which they do want. Hence arises between them an exchange of the means of subsistence for labor. The value, produced by the operative, exceeds that, which he has consumed. The excess constitutes an income for the employer. This income can be obtained only through the medium of him who works. Hence the reciprocity of benefit between them, rendering them mutually dependent upon each other. Without the rich, the laborer might starve, or rob. Without the laborer, the rich man would have to work for himself.

The operatives consume, and reproduce. The wealth, thus destined for the reproduction of labor, is called capital.

The implied contract between the operative and the capitalist is, for the food and clothing you furnish me this year, I will create you something of greater value for the next.

Credit is the employment of the capital belonging to another. He, who has it, possesses the command of a capital, exactly corresponding to the amount of it; but with the appended disadvantage of the drawback of a premium, called interest, to him of whom the credit is obtained. A healthy, industrious and economical person, in almost any country or state of society may lay aside something from his expenditure, as the germ of a capital of his own, which, if properly managed, increases in a compound ratio. The second thousand dollars is often acquired with less difficulty than the first hundred.

The natural odium of the operatives towards the capitalists is an unjust one. He, who has honorably accumulated a fortune, can hardly avoid benefiting the community in various ways. His pleasure was more in the acquisition, than in the subsequent enjoyment; and, after all, he is quite as dependent upon the operative, as the operative upon him.

That capital, which is employed in the maintenance of productive laborers, is *circulating capital.* That, which is laid out in buildings, manufactories, rail roads, turnpikes, canals, improvement of lands, and generally, what is called real estate, is *fixed capital.* The greatest benefit, that can be conferred on the laboring classes, is to increase the consumable produce of a country. While this is abundant, it signifies little to whom it belongs. The rich can derive no benefit from it, except by employing it, that is by maintaining productive laborers. Whatever tends to abridge and facilitate labor, increases the productions, and is beneficial to the operative, as well as to the capitalist. Hence the public utility of machinery, rail roads, canals, and all great works of that class.

The invention of printing enabled one printer to publish as much as a hundred copyists; and at the same time publish it better. It was thought, that the result would be, to throw ninety-nine operatives of this class permanently out of employment. But books cost but a hundredth part as much. A hundred readers could afford to read a printed book, for one who could buy it in manuscript. The consequence was diametrically the reverse of the calculation. Authors and readers were infinitely multiplied, so that a hundred persons were employed in printing, and its subsidiary occupations, to one copyist before the invention. We conceive, that the same answer will apply to all objections against labor-saving machinery. Capital reaches the laborer in the form of wages, which must always allow the capitalist a profit on the labor, and afford the laborer the means of living. If wages are such that the laborer cannot maintain a family, the race of operatives would gradually diminish, and the scarcity of hands would raise wages. On the other hand, if wages are too high for the profit of the capitalist, his will and resources to employ operatives would be exhausted. These relations act, and re-act, to preserve the common level of fair wages, and to prevent extortion and injustice on either hand. It affords as striking a proof, as those we have been contemplating, that all the relations of the moral universe are settled in perfect wisdom and benevolence.

In times of scarcity and insufficient production, it is seldom wise for a legislature to interfere, and attempt to adjust and regulate the rate of wages to the price of provisions. The high price, consequent upon scarcity, will itself regulate the equitable proportion. The evils in this case are irremediable, or at least are oftener increased, than diminished by unwise attempts to legislate upon them. At a time, when England was afflicted with the severest famine ever known in the country, parliament, in compassion to the general distress, ordered, that articles of food should be sold at moderate prices, which it assumed to prescribe. The result was, that food became dearer than before, or was entirely withheld from the market.

The principle that operates upon wages would be thus mathematically expressed; the rate of wages varies directly, as the quantity of capital, and inversely, as the number of laborers.

The capital of a country is the aggregate of the capital of the individuals. It can employ as many people upon public works, as it has the means of maintaining. Suppose a country to undertake a public work of any conceivable magnitude. It can complete it, if it contain within itself a sufficient number of operatives, not indispensable to producing, and, if it can continue to produce wherewith to subsist, and clothe them. Under such circumstances, the execution of public works not only does not impoverish a country, but, by creating a new stimulus to production, tends directly to enrich it.

The price of labor may be low, without being cheap, as is the case in Ireland. Practical men easily understand this seeming paradox. A shilling a day in England is as high wages, as three shillings in the United States. Again, the population of a country may have reached such an excess, and national wealth such abundance, as that low and insufficient wages may result from great capital. Such is the case in China.

The chief elements of the prosperity of a country are cheap and rich lands, high wages, and rapidly increasing population. In such a concurrence, capital accumulates. Early marriages, and numerous families are the result. The population of the United States has more than quadrupled, within the last half century. But wages have not fallen in consequence of this wonderful development of our resources. These advantages we owe to our abundance of fresh, rich and cheap lands, and our free institutions.

A dense population is highly advantageous to a country, when the capital will afford wages to enable the operatives to rear a family. A country is weakened by a numerous population, where there are great numbers of helpless and infirm people ; and where great numbers are reared in indolence, and to know and practice no useful labor. Where-ever population exceeds subsistence, multitudes are born to languish in poverty, and to fall early victims to want, disease, and wretchedness. How much greater havoc all diseases make among the poorer classes ! Thousands, that might have been restored, perish from want of pure air, medical assistance, and proper diet. Population may accumulate, as in China, and in some parts of Europe, so as to become actually beyond the means of subsistence in the country; and this is one of the most formidable political evils. A country, all peopled as one continued village, would be unhappy in fact, and would furnish a most unpleasant spectacle. The Kentucky predilection for range, is one that belongs to human nature.

The most effectual remedy for this excess is emigration. Most European governments have enacted laws to restrict emigration. It has been said, with as much beauty as truth, that the only good law against emigration is that, which nature has engraven in our hearts. The disadvantages of emigration are the disruption of the natal associations, ties and charities, and that instinctive love of our native country, with which Providence has endowed all good hearts. The advantages are wider range, ampler means of subsistence, and the cheap acquisition of land, the most valuable and honorable of all species of property. When unwise legislation, or oppression, drives the industrious and laborious artisans into a foreign country, an irreparable injury is inflicted upon the country, that loses them. Such was the result of the revocation of the edict of Nantz, and the expulsion of the Moors and Jews from Spain.

A country can support a greater number of educated than uneducated people, provided the result of the education be not to inspire a contempt for labor. Education, by expanding the sphere of thought, inspires more prudence, forecast, and combination of plan, by furnishing higher and more enduring motive. The recent alarm, that has been attempted to be raised in Europe, and even in America, against what has been called over education, as tending to create idleness and artificial wants, is as false in principle, as injurious in application. True education enlightens judgment and strengthens good sense, and judgment and good sense can never be adverse to industry and frugality. It is injurious to a country to educate too great a number with professional views. Such is the case in the United States.

The disposition to be beneficent, from the impulse of love to God and his creatures, is a divine principle. A great number of charitable associations originate, and are carried on in the spirit of ostentation, and tend to freeze, rather than warm the heart. The poor laws of England, and of the northern part of the United States, seem rather, in most instances, to have encouraged idleness and mendicity, than to have furnished adequate relief to misery. A profligate man will spend his wages in drinking at the tavern, when he knows that the worst that can happen to him, his wife and children, is to be sent to the poor-house. In Spain and Italy, there are numerous and great establishments for the distribution of bread and soup to the poor, and in no country are the streets and public ways so full of shameless beggars. Industry, economy, order, self-respect, and an occasional taste of the evils of idleness and dependence, are the best securities against being over-run with paupers.

The question, which of the three great pursuits, agriculture, manufactures, or commerce, is the employment, in the view of political economy, most useful to the state, is one indefinite and impossible to be solved. These interests so run into each other, that it is impossible to specify where the one commences and the other terminates. In northern countries, it is as essential to comfort, and even existence, to be well-sheltered and clothed, as to be fed. All that appertains to building and clothing belongs to manufactures. The farmer cannot grind his grain without the miller, nor house it without the builder. All the implements of husbandry are from the manufacturer. When the relative importance of each of the branches is fairly investigated, agriculture does not seem to possess that immense superiority which has generally been assigned to it. The question of political economy is not, to which of the three the preference should be given, but what are the proportions they should bear to each other, in order best to advance the prosperity of the community. As a general maxim, it is unwise for a country to legislate upon this subject, the public good being most likely to be advanced by leaving all these differences of pursuit to be settled by the keen vision and unfailing regard of each individual to his own interest. If there be a deficiency of clothing, the labor of the cloth manufacturer becomes more productive. Part of the labor of agriculture will soon be drawn by this circumstance into that direction. The keenness of interest and competition will more than supply the deficiency, and agricultural labor will again find its level. In the multifarious concerns of society, no one fact is so prominent as the tendency of every interest to find its level.

In regard to the risks and misfortunes of the different pursuits, it is wonderful to see how admirably Providence has balanced and adjusted every thing. The caprices of climate, the uncertainty of seasons, the great physical accidents of nature to which agriculture is exposed, the fluctuations of political events, and the caprices of fashion that hang over manufactures, and the still greater risks that attend the still greater stakes of commerce, reduce the choice of a pursuit to a calculation, in which it is difficult to determine the preponderance of good or evil.

Very large or very small farms seem equally opposed to national prosperity. The confiscation of the national domain in France operated inconceivably to the prosperity of the country. The tenure, during the revolution, being deemed insecure, the lands were sold cheap. A great many moderate landholders were thus established. The necessity of accumulating capital for their establishments, impelled them to habits of order, industry, and economy. In Belgium, one of the best cultivated countries in Europe, the average of the farms is about forty acres. In Tuscany, a country remarkable for the excellence of its agriculture, the farms seldom exceed fifty acres.

No nation has been known to grow rich on mines of silver and gold. Of all the mines, those of coal are the richest and most valuable. Mines of iron, lead, and tin, have more tended to enrich England, than all the treasures of

Mexico and Peru have added to the resources of Spain while she owned them. The richest mines of a country are those which lie no deeper than the share of the plough runs.

Fisheries are a more lucrative national resource than mines. The fisheries of Newfoundland have been more valuable to England and the United States, than the richest mines of gold would have been. The English and Dutch domestic fisheries yield a great revenue. They are a vast source of wealth and revenue to China.

As the capital of a country becomes larger, the profits derived from it diminish. During the reign of the emperor Augustus, interest fell at Rome from ten to four per cent, owing to the great influx of wealth from the conquered provinces. In India, where the proportion of capital to the number of laborers is comparatively small, wages are extremely low, and interest uncommonly high. The common rate of interest is from twelve to twenty-five per cent. In China it is thirty-six per cent per annum.

LECTURE LI.

POLITICAL ECONOMY.

We have remarked, that in the United States laborers are scarce and wages high, and yet interest is not much reduced. The reason is, that land is abundant and productive; and the profits upon agricultural capital have increased more rapidly than in any other country. Yet, as profitable employment is found for every accession of capital by the cultivation of new lands, the interest of money does not fall. Except in a country so circumstanced, low interest of money is an indication of national prosperity, as marking low profit to employers, and high wages to laborers.

Most nations have regulated the rate of interest by law. But all such regulations are impolitic, immoral in tendency, and essentially unjust. Money, as much as any other vendible product, is an article of marketable value; and, like all other articles of sale, will find its level, and regulate its own value. When one holds unemployed money, and another wishes to borrow, they will find ways to evade the law in consulting their own real or imagined interests, and will come to an understanding to accomplish that illegally, which, without the law, they would have accomplished as any other exchange. The result of usury laws is to excite the lender to schemes of extortion, and the borrower to mental reservation, in order to evade the law.

The real capital of a country is not money, but lands, saleable productions, raw materials, and manufactured articles. Capital is only estimated in money, by its being viewed as a representative. Productive laborers are employed from capital, and unproductive labor from income.

The value of articles is that, of which they are susceptible *in* exchange. The intrinsic value is that of utility; the value in use is that of exchange. Gems, and all articles of ostentation and ornament, have no intrinsic value; but their value in use is, that they can be exchanged for articles of intrinsic utility. Generally speaking, it is the application of labor to articles that gives them exchangeable value. The price of a load of hay is the sum of three elements; the wages of the haymaker, the profits of the owner, and the rent of the field.

The exchangeable value of an article consists of its natural value, subject to augmentation or diminution, in proportion as the commodity is scarce or plentiful. When the *supply* equals the demand, the commodity sells for its natural value. When it exceeds demand, it falls below that value. When it falls short of the demand, it rises above its natural value, and dealers make extraordinary profits.

The invention of money was a natural result of any extension or combination of trade. Exchanges to any great extent could never have taken place, had there not been a common measure, like money, to adjust their value. Whatever is universally received, as the measure of these adjusted values, is money. In different ages and countries, salt, iron, copper, leather, tobacco, fruits, shells, and a variety of articles, have been used as a circulating medium. Silver shekels were in use among the Jews, as early as the time of Abraham. Gold coins were struck at Rome two hundred years before Christ. The two metals of gold and silver have constituted the circulating medium of all civilized countries for many centuries.

Money is not an accurate standard of the value of commodities; for when it is plenty, it renders them dearer; and when it is scarce, makes their exchangeable value, estimated in money, cheaper. Thus the price of a commodity may rise, while its value falls. A loaf of bread may rise to double its former value, as denoted by money. But the value of this money may be so depreciated by its excess, as that double the price may not purchase as much as half did before the rise. Hence, because neither nature nor art furnishes us with a commodity whose value is incapable of change, we can have no fixed standard-measure of values.

Though money be not the real capital of a country, sudden increase or diminution of it, has an unfavorable bearing on the prosperity of that country. It requires time before articles can settle back to their natural level; and previous to that time, the pressure falls unequally upon the different classes. Unproductive laborers, and those who depend upon salary, are particularly affected by it.

A community is commonly, though not necessarily, rich in proportion to the amount of money in it. Flourishing countries, while they require abundance of money, possess the means of obtaining it. But the abundance of money is the consequence, not the cause of wealth. If a country possess a dollar more than is necessary for circulation, the wealth which procured that dollar has been thrown away. We may observe, too, that the necessaries of life are more sure to procure money than money is to procure them, as the reality is always more valuable than the substitute.

The greatest part of the money circulated in the world, has been coined from the mines of America. But the real comforts and luxuries which America has imparted to the old world, are its sugar, coffee, tobacco, medicinal drugs, and maize. The world is no richer for all that the mines of Mexico and Peru have furnished. It is utterly impolitic in a country to make laws against the exportation of specie. For, without such laws, no sooner does money accumulate beyond the wants of a circulating medium, than the money is exported in purchase of something from abroad. In the same manner, when it is scarce, foreign merchants will immediately remit it in purchase of necessaries, which have become cheap in consequence of its scarcity. If Spain and Portugal, while in possession of South America, could have kept, by their impolitic and absurd laws against the exportation of specie and bullion, all these amounts in their own dominions, they would have been long ere this as valueless as lead or copper. It is thus that every thing equalizes itself, and finds its level in the civilized world. Like water, it flows to the point of deficiency, and ebbs from that of redundancy.

The greater amount of specie, since the discovery of the American mines, has very much reduced the exchangeable value of money. History declares, that Xerxes, who brought an army of millions against Greece, only possessed a revenue of three millions sterling. The sterling pound derived its name from its being originally a pound of silver. Subsequent coinages, alloys and enactments have reduced the amount of silver to its present scale, while the nominal value remains the same. Edward the Fourth of England ordered a pound of silver to be coined into 270 pennies, instead of 240, which it had been before. Great injustice, as well as inconvenience, was the result. A corresponding rise in the price of commodities ensued ; and the poor were greatly distressed by the enhanced price of necessaries. In whatever country this arbitrary expedient of tyranny has been adopted, the same consequences have ensued.

Substitutes for specie are of modern invention. The Carthaginians used stamped leather, as a currency. This was, probably, a representative of real value, like our bank notes. The first bank known in the annals of commerce, was that of Amsterdam, instituted 1609. It issued no notes, and only received coin in deposit, which was transferred from hand to hand on the books, as occasion required, without removing the coin from its deposit. It was a mere instrument of safe keeping, authentic record, and convenient transfer.

The profit of modern banking arises from the use of the capital created by the difference between the amount of the notes issued, and the specie reserved in the bank. Banks ascertain by experience, what proportion of specie is requisite to meet existing and average demands. They regulate the amount of notes issued by this knowledge. When banks do not pay specie on demand, they become bankrupt. The bank of England is shielded from this result by an act of parliament. The credit of this great engine of British commerce and power being good, and the holders of notes having a confidence, that it will one day redeem them in specie, the notes have not fallen in value.

It is not necessary, that the value of the currency of a country should be equal to the value of the commodities, to be circulated by it; for the same dollar, or bank note, by passing rapidly from hand to hand, may serve as the medium of transfer to hundreds of dollars worth in a day.

Traders act, as intermediates, between the producers and consumers. Those, who purchase by the quantity, and directly from the producers, are called wholesale dealers. Those, who purchase of them to distribute to individuals, according to the demand, are retail dealers. Trade increases the wealth of a nation, not by producing, like agriculture, or fabricating, like manufactures. But it enhances the value of commodities, by bringing them from places, where they are plenty, to those, where they are scarce. The different climates and countries have each their peculiar products. Commerce interchanges them. Some lands of the same country produce grain, and others pasture. Some places have facilities for one species of manufacture, and others for another. Trade equalizes them. The merchants and traders encourage farmers and manufacturers to increase their products, by finding purchasers for them. Manufactures give impulse and prosperity to agriculture, by bringing the producer and consumer together, or placing them so near as to facilitate exchanges.

Retail trade is one of the most important of the divisions of labor. The consumer is enabled, in certain places, to supply his wants, and in such small and daily purchased quantities, as his means and his convenience may require. Commerce is another of the economical and most useful divisions of labor. A certain number of merchants distribute from country to country, the products of nature and art; that they who are engaged in raising and fabricating them, may be able to devote their whole time, capital and talents to their respective pursuits.

History teaches, that agriculture has no where made great improvement, without producing a corresponding prosperity of manufactures and commerce. The high cultivation of land in the vicinity of most cities has been the effect, rather than the cause, of the business of the cities. Good and numerous roads, and navigable canals are the grand facilities of agriculture. In Europe, towns were built, as fortresses and asylums from war and oppression. Consequently, towns preceded cultivation. In the United States, the natural order of things took place. Cultivation first spread farms over the country, and towns grew up, to supply the necessities of trade and exchange. The utility of canals is proved by the fact, that transport on them is scarcely a tenth part as expensive, as by teams over the generally heavy roads of the United States.

The home trade comprehends the internal and coasting trade of a country. It employs a greater amount of our own capital, than the foreign trade. If the Pittsburgh merchant sends down his manufactured articles for the sugar and cotton of New Orleans, the whole capital employed is our own. If the Philadelphia merchant sends his articles in exchange for the silks and brandies of France, only half the capital employed in the trade is ours. The other half goes to eurich France. The home trade has, moreover, the advantage of being more quick and sure in its returns. No two ports in the United States are so remote, as not to admit of returns in a few weeks. Trade between Boston and the East Indies requires at least a year to obtain a return of capital.

But though home trade has its advantages, foreign trade is also a great source of prosperity to a country. It is only after the home supply is furnished, that we send our surplus produce to foreign markets. It is only the excess of capital, that could not be employed at home, that we put into foreign commerce. An infinite number of new ideas is put in play, by carrying it on. More enlarged views, energy, combination of thought, and activity, are called into operation. The foreign commerce of Great Britain is the prime element of her power. History records the wonders achieved by the commerce of Tyre and Carthage. The very fact of carrying on a foreign commerce proves, that the country possesses a surplus quantity of products, either agricultural or manufactured, which cannot be disposed of in the home market; and which, if it could not be disposed of in a foreign country, would cease to be produced. The wines of Portugal could not be made in Great Britain. The British climate is more favorable for the growing of wool. Hence the British furnish the Portuguese with clothes, which they pay for in wines.

A bounty on the exportation of any article has the effect to tempt merchants to invest a capital in the trade, which would not yield a profit without it. A tariff on foreign products operates as an unnatural stimulant to excite to the production of it at home. Both are doubtful expedients, generally counteracted by the jealousy of the nation, on which the bounty, or tariff, is intended to act. The one nation imposes an additional tariff on the article, which the other fostered with a bounty. Between these stupid competitions, commerce finds its own level.

The general doctrine of all enlightened countries seems to be in favor of the perfect freedom of trade. It is predicated upon the idea, that trade is always more gainful, when left to the keen shrewdness of individual self-interest and calculation; in other words, that legislatures act most wisely, when they protect commerce, and otherwise leave it to take care of itself. For instance, if England could raise cotton and tobacco as cheaply as the southern states of our union, and those states could manufacture wool and iron, as cheaply as Great Britain, there would be no use in a foreign trade of exchange in these articles. But if twice as much value of cotton and tobacco can be raised in America as in England, and twice as much iron and cloth be manufactured there as with us, in a given time, a British tariff upon our cotton and tobacco, and an American tariff upon British cloths and iron would be a mutual injury, since the American could procure more iron and wool by a day's cultivation bestowed upon cotton and tobacco, to be shipped in exchange for those articles, and the Briton, in return, could obtain more cotton and tobacco, by manufacturing iron and wool, over and above the expenses of shipment for the exchange.

Such is the brief sum of the argument in favor of free and unrestricted trade, a doctrine, which all civilized nations now teach, and none fully practice. It is easy to see, that to settle the question of the policy of restrictions upon commerce, in the view of political economy, by such positive and mathematical calculations, does not take sufficient elements into the problem for a fair and satisfactory demonstration. Nations are guided, in settling such questions, rather by experience than theory. The most accomplished writers upon political economy have generally deemed all restrictions upon commerce unwise, and not only opposed to political experience, but founded upon ignorance of the nature of commerce, and the character of man. We are told, that the Turkish emperor can strike off the head of any subject unquestioned ; but that the attempt to regulate the price of the articles in the market of Constantinople is sure to raise a sedition. During the continental system of Napoleon, the French made bad sugar from beets, at double the cost of West India sugar. With this sugar they sweetened a substitute for coffee, made of bitter roasted endives. More labor was bestowed upon these miserable imitations, than would have been requisite to purchase the real articles. Such are the blessings, which nations have too often owed to their rulers, with the added circumstance, that they are generally accompanied by the horrors of war.

One climate produces, only with great labor and in small quantities, and of an inferior value, saccharine and coloring matters, which another yields with profusion. The former produces with ease and abundance, grains and fruits raised with difficulty in the latter. It is the interest of each party to supply itself by exchanges with the other. When we compel our lands to produce that, which they yield us at a disadvantage, at the expense of what they yield most readily, when we buy at a dear rate, that, which we might purchase cheaply, if we would draw it from points where it is produced to advantage, we become the victims of our own folly. The highest attainment of wisdom is, to draw to the greatest advantage from the forces of nature; and it is the last point of insanity to struggle against them.

Perhaps it would be better, in general, if government meddled no farther with trade, than to protect it, and let it take its course. Most of the legislation of princes and states, for regulating and restraining trade, has either been political blunders, or enactments obtained by artful men for private advantage, under the pretence of public good. When Colbert assembled the chief merchants of France, and desired their opinion and advice, how he could best subserve the commerce of France, their answer was in three words, 'let us alone.' One of the most solid maxims of government is not to regulate and govern too much. It would be wise and mutually advantageous to all nations, if they would permit commerce to be as perfectly free and unshackled between each other, as it is between the different parts of the same country. But it is not so; and perhaps never will be so. For one nation to adopt this principle in its fullest extent, in opposition to the practice of all others, subjects it to the common inconveniences of free and restricted trade at the same time. The question of encouraging domestic products, by a tariff upon foreign ones, is one too complicated, and compounded of too many elements to be settled by any sweeping abstract maxim of trade.

Bills of exchange are extremely convenient modes of adjusting balances of debt and credit between the merchants of two countries. The nature of such a bill may appear, from the following illustration. A woollen merchant in London sends broadcloths to the order of a merchant in Lisbon. He draws a bill on him to that effect. He finds a person in London, who is indebted to the merchant, to whom he has shipped his cloths. This third person finds it more convenient and safe to discharge his debt in Lisbon, by purchasing a bill of exchange from the woollen merchant in London. Consequently, he causes his name to be inserted in the bill of exchange upon the Lisbon merchant, as the person to whom that merchant is to pay the debt contracted by him, in consequence of the shipment of the cloths to his order.

If the value of our imports from England exceed our exports, there will be a greater amount of bills drawn by English merchants on us than we shall draw on them. After our debts and credits are balanced, as far as our bills will enable us, there will remain a surplus of bills drawn on us, which will require to be paid in money. Until recently, the most erroneous opinions prevailed in regard to the subject of the balance of trade. Many other elements beside the apparently favorable or unfavorable balance of trade affect the result. The most flourishing commerce may show a balance of imports over exports, and a ruinous commerce the reverse. A circuitous voyage may enable a merchant to triple the value of his exports in his imports, and yet show a balance of trade against the country.

The capital of a country consists of the capital of the inhabitants collectively. But the revenue cannot be thus estimated. A house, for example, can be transferred to different people in the same year, and may successively constitute a part of their several incomes. Hence the revenue of a country cannot be estimated by the aggregate income of the people.

Of two prodigals, the one spends his estate in building, furniture, equipage, and books. The other squanders his in theatrical entertainments, fire-works, and music. Both are ruined. But the one has spent his money among industrious tradesmen, and the products for which he spent his money remain. The other has in no way benefited the community, and no fruit of his ruin remains.

Capital cannot produce revenue, unless it is consumed. If consumed by industrious operatives, while they are consuming it something of superior value will be produced, and that product will be exchanged for other productions. It will be distributed among another order of tradesmen, and will afford precisely the same amount of encouragement, though of another kind. Whatever is saved from the extravagance of the dissipated, is a stock to contribute to the comfort of the industrious orders of society. During the feudal age, the English nobility had no other way of spending their wealth, than by maintaining in their houses a train of dependants, either in a state of absolute idleness, or with no better employment than to indulge the folly or flatter the vanity of their patron. Such is the case in Russia, and some other countries of Europe at the present day. The consumption of provisions in the house of an English nobleman in the feudal days was a hundred times greater than at present. We may not thence infer, that the estate which maintained such numerous retainers, produces less now than then. On the contrary, it is perhaps as much increased as the consumption is diminished. The difference is, that the produce, instead of supporting a train of lazy dependants, maintains perhaps a hundred times the number of industrious, independent workmen, part of whom are employing the produce of the estate, and part in supplying the owner with his luxuries. It was to obtain these more refined luxuries that he dismissed his train of dependants, improved the culture of his land, and, while consulting only the selfish gratification of his wishes, contributed essentially to the welfare of his country.

It is the business of one part of mankind to furnish work for the other. It imports little to the prosperity of trade, whether the wants be real or imaginary; whether founded in nature, opinion, fashion, habit, or emulation. Flourishing cities are supported by the tobacco-trade. Populous towns subsist by the manufacture of lace and ribbons. The watchmaker, while he polishes the case and files the wheels of his machine, is contributing as effectually to the production of corn, as though he handled the hoe and the plough. While the fisherman plies his nets and lines, and the seaman brings rice from abroad to exchange for tobacco, the market is supplied with two important articles of provision, by the instrumentality of a production which has no other apparent use than the gratification of a vitiated appetite.

Dr Franklin says, that a new cap was worn at church by one of the young girls of Cape May. This article of finery was bought at Philadelphia. To obtain similar ornaments, the young girls all fell to knitting worsted mittens, an article in request at Philadelphia, the sale of which enabled them to gratify their wishes. The origin of the braiding of straw in Massachusetts, furnishes a similar example on a broader scale ; that species of industry having become of national importance.

It is best that riches should be acquired gradually. When ignorant men obtain great wealth suddenly, purse-pride, the vilest of all pride, is the first result. They generally remit labor, without finding any substitute to divert their minds or occupy their time. They naturally fall into sensual indulgence. Idleness and extravagance lead them back to a far more dreadful poverty, than that from which they emerged. There are instances enough on record, of persons who have been ruined by drawing the highest prize in a lottery. The lower the ignorance of the drawer, the more certain his ruin. Give a guinea to a Scotch peasant, and you put him upon a study how to employ it to the most advantage. Give it to an English peasant, and he will employ it to repair his cottage, or buy new clothes. Give it to an Irish peasant, and he will experience more joy at receiving it than either. He will invite all his friends, treat them to whiskey, lose one day in social drinking, and the next day in sleeping off the effects of it.

The inequality of conditions is rendered, on the whole, beneficial to society by the great reactions of Providence. However opulent a man may be, it is beneficial to the community that he should endeavor to augment his wealth. Instead of his gains being subtracted from the pittance of the poor, the increase of his wealth is an addition to the general stock of the wealth of the community, by which the poor are benefited equally with the rich.

Such are some, of what we conceive the most prominent and important maxims of national thrift in detail ; which we have given in all possible brevity and simplicity, hoping, that their intrinsic truth and importance will redeem them from the estimation of being trite truisms.

Nations, as well as individuals, are subject to the moral laws established by the Creator. The highest prosperity of a nation can only be attained by conformity to those laws. Unhappily, the general course of most nations has been in opposition to them. There is a seeming national prosperity, and a real one, as there is a seeming and real national wisdom. Ambition and the lust of wealth, conquest and power have been the medium through which most statesmen, princes and legislators have interpreted their ruling maxims of political economy. Rome conquered and plundered the world to concentrate wealth and power in Italy, which nourished pride, extravagance, injustice, and sensuality, which generated effeminacy, faction, civil war, and finally the ruin of the country ; a ruin resulting directly from the attainment of the highest point of aspiration.

In more modern times, Spain possessed herself of the immense treasures of Mexico by the most revolting and merciless slaughter and oppression. The genius of the Indians, so to speak, avenged their cause, by inspiring avarice, indolence, rapaciousness, and the seeds of decline and ruin in the nature and character of their conquerors. Their treasures went to enrich other countries. Pride and oppression on the one hand, and abject submission on the part of their victims, begat indolence, extravagance and debauchery ; and, from being the most powerful nation of Europe, Spain has become weak, impoverished, and degraded.

England has accumulated the wealth of the world in a small island. Her wealth has enabled her to wage wars in the east and in the west. A hundred millions of operatives, in the other extremity of the globe, contribute to swell her coffers, and to pamper the fancies of her luxury. Is not the eternal justice of the moral law of the universe preparing for that country a terrible re-action ? Napoleon conquered the continent of Europe, and played with kingdoms and crowns, as if they had been counters and baubles. Prosperity blinded him, impelled him to the insane presumption of imagining, that he could conquer nature, as well as man. Behold the terrible consequences of slavery, in the great balance of divine justice, returning to plague the oppressors of humanity!

Let the princes and rulers of the earth learn moderation, benevolence, and justice. There is no other true political economy. As the nations become enlightened, despots every where totter on their thrones. The grand array of freedom against slavery, of the producing million against the consuming few, who fancied themselves 'born to eat up the corn,' is constantly becoming a firmer phalanx, in every country.

Political truth and justice must ultimately prevail. The ten thousands of the nations will no longer be tamely led out to war, and be slaughtered, like animals in the shambles, to gratify the ambition, lust and revenge of a few bloated favorites of fortune, miscalled nobles and great men. It will be every where perceived, that moderation, industry and frugality are the true political economy of a country. It will be seen, that office is a trust for the benefit of the people, and not of the holder. The career of ambition, conquest, extent of empire, and what has been for so many ages miscalled greatness, will be arrested. Nations will become wise, and communities will seek prosperity by the same maxims, which lead to the prosperity and happiness of individual families.

As a closing reflection, let us imagine for a moment what would have been the present condition of the world, had there been no wars, no misapplication of the means and industry of communities — but had all the treasure, labor and ingenuity, which have been expended to shed blood, desolate the earth, and water it with tears, been applied to diffusing useful knowledge and physical improvement. There would be now neither desert nor wilderness. There would be neither ignorance nor oppression. Improvements, inconceivable in our present degree of light, would long since have been advancing in every country. Every land would have been a garden; and the earth would have contained a hundred happy inhabitants for one, that it now supports. All this deprivation of what might have been, we owe to the accursed ambition of princes and rulers, to their love of oppression, and lust of power, and to the blind stupidity, and passive acquiescence of their weak and unresisting victims.

Unhappily, the present onward progress of society is rather in physical, than moral improvement, and the application of the astonishing inventions and improvements of the day is rather to the accumulation of wealth, and the means of distinction, than to the diffusion of true wisdom and national and individual morality. These improvements have not been directed to lessen the hours of toil for the humbler classes of society, in every country constituting so great a proportion of the inhabitants; to give them opportunity and leisure for the cultivation of their moral and intellectual powers. 'Physical,' says Combe, 'has far outstripped moral science; and, unless the lights of true philosophy shall open the eyes of mankind to the real physical and moral constitution of the world, and at length induce them to modify their conduct in harmony with the laws of the Creator, their future physical discoveries will only tend to deepen their wretchedness. Intellect, acting as the ministering servant of the propensities, will only lead them farther astray. The science of man's whole nature, animal, moral and intellectual, was never more required to guide him, than at present, when he seems to wield a giant's power, but in the application of it to display the ignorant selfishness, wilfulness and absurdity of an overgrown child.'

LECTURE LII.

INVENTIONS AND DISCOVERIES.

I PROPOSE in this and the following lectures, to present a very abbreviated history of a few of the more important inventions and discoveries. By inventions, I mean mental creations, and by discoveries, things, which existed before the discovery, and were made known by it.

Among the most prominent and important of all human inventions, I place that of making books. When I consider all that is involved in making a book, all the wonderful and almost indefinite complication of the separate efforts of thought necessary to this astonishing creation, I cannot but look with respect upon a creature, born the most weak and defenceless of animals, who has yet a mind, in which such astonishing powers inhere, that their natural development originated, by separate efforts, each prodigious in itself, that mysterious mental production, a book.

Who would imagine, that any eye, but the all-seeing eye, could have apprehended the whole web of thought, the whole power of burning conceptions, the whole train of affections and passions, as they spring up in the invisible depths of the human mind? But, in the invention of articulate language, man is enabled to lay open all these mysteries of his own consciousness to the ear and mind of another. A book is as much higher, and more abstract a display of human powers than speech, as that is higher than the inarticulate cries of animals. It requires the utmost stretch of all those powers, that invented this wonderful creation, to conceive all, that is implied in that term. It is not to impart to the living tones of the human voice, modulated by intellect, affection, love, hope, joy, fear, pain, grief, resentment and wrath, a power aided by the interpretation of the eye, and the kindling emotions painted on the human face divine, to speak to the heart, but it is to give to the bark of a plant covered with a little coloring matter, a power to transfuse the soul and spirit of one person into the mind of another. It is to record 'thoughts that breathe and words that burn,' on the everlasting page, so that they will stir up, a hundred generations to come, exactly the same thoughts and affections as were impressed in this mysterious way upon the book, a hundred generations before. It speaks not to the physical ear, but to the spiritual eye, and with its invisible crayons, renders the soul of a sojourner in clay, who has been gathered ages past to his fathers, embodied to the student in his retreat. Before this wonderful invention, the nurse, the scribe, the recorder, and monumental preserver of all others, all our boasted physical inventions, all the other improvements in the arts and sciences fade into insignificance. I will not deem so humbly of the right direction of your curiosity, as not to take it for granted, that you will patiently follow me, in a brief sketch of this wonderful invention, in all its successive steps of progress, from the invention of alphabetic characters up to the present book, exhibiting, at a single glance, the ultimate attainment of intellect, embodied in the highest improvement of taste in the arts.

The invention of articulate language is one so complex, elevated, and beyond all the reach of mere animal conception, that many inquirers have attributed it to divine origin and direct inspiration. To me, it seems more honorable to God, and conformable to analogy and the reason of things, to suppose, that God formed man with the necessity of communicating his thoughts and affections, and imparted to him such powers, as in their right direction and natural progress would result in this wonderful invention. The animals even have tones of love and wrath and warning ; tones, which render them mutually understood. The march of the human mind has an onward impulse. The native language of interjections, with which the man of nature would be endowed, would naturally accumulate, and advance to abstraction and the copiousness of articulate language in the progress of society.

The era of the invention of letters is lost in the unrecorded ages of mythic tradition. Whether the Hebrew, Chaldaic, Sungskrit, or Arabic alphabet is the more ancient, does not appear. From the nature of the case, the invention must have preceded the record. History and tradition concur in assigning the first recorded knowledge of letters to Cadmus, a Phenician prince, who founded Thebes in Greece, and brought thither from Phenicia the invention of letters, 1519 years before Christ.

Such is the vast interval between the invention of articulate language, and written and arbitrary characters, that to a reflecting mind, it becomes matter of astonishment, how this immense waste was passed over. Indeed, to a great portion of the species, it has proved an impassable gulf. That portion has never advanced beyond oral language. They who possess only oral language, are not more raised above the brutes by their rational nature, than we are above them by the natural influence of this single invention.

How many ages must have elapsed, after the invention of written alphabetic characters, before the concurrence of all the arts could have given birth to such a product as a modern book! The most ancient form of books seems to have been thin boards, strung together, covered with wax, and written upon with an instrument called *stylus*, whence probably the derivation of the modern term style.

Ivory, sheet lead, the leaves and bark of trees, bleached and flat bones succeeded waxen tablets, the inconvenience of which consisted in the ease, with which the characters might be effaced. The disadvantage of these materials consisted in their incapacity to be rolled, or bound together, so as to form that collection of leaves, called, from their original form of being rolled together, a volume. To these, and an infinite improvement upon them, succeeded *papyrus*, whence our term paper. This was the pellicle, or bark of an aquatic Egyptian plant, growing most abundantly in the Nile from ten to fifteen feet in height, and eighteen or twenty inches in circumference. These pellicles, properly prepared, laid at right angles to each other, like the warp and woof of cloth, glued, and pressed together, and smoothed, and polished by rubbing the surface, became a beautiful, though a scarce and expensive paper.

This plant being unknown elsewhere, the supply became unequal to the demand, as writing became an art more generally diffused among the nations. Parchment, or the prepared skins of animals, a most beautiful and durable material, upon which to write, became in many countries a substitute for papyrus. For some kinds of writing it is still in use. Its original Greek name imports, that it was an invention of Pergamus, and it is commonly attributed to Eumenes, a king of that country. But from the testimony of the scriptures, and other ancient records, there can be no doubt, that parchment was an invention of a much more ancient date than the time of Eumenes.

Tables of stone, upon which the decalogue of Moses was written, the stone walls of buildings, temples and monuments, and monumental brass, have been the enduring tablets, upon which history, and the desire of remembrance have recorded, in hieroglyphics, emblems, paintings and inscriptions, events in themselves important, or important in the estimate of the vanity of those who ordered them to be engraved.

In the oriental countries, where the palm tree flourishes, its broad, smooth and firm leaves, of a yellowish white, offered cheap and natural tablets for writing. By many millions of the oriental people, they are used for that purpose to this day. The inner bark of trees, *biblos* in Greek, and *liber* in Latin, has very extensively subserved the same purpose. Hence these two words came afterwards to signify a book.

According to Varro, papyrus was an invention coëval with Alexander the Great, and the building of Alexandria in Egypt. It continued the most general material for writing, and an important article of commerce, until about the fifth century of the Christian era. From that time the paper of Europe was chiefly made from the inner bark of various trees, laboriously prepared. It was an art learned from Spain, into which country the knowledge of it was imported by the Arabs.

Paper of a beautiful, smooth and firm kind was known to the Chinese and Japanese from time immemorial. This is an article, with which commerce has made us all acquainted at the present day. The finest sort of paper of these countries is made of silk. The prodigious amounts of their common paper are made of bark, chiefly from that of a species of the paper mulberry. It is also out of question, that cotton was extensively used, and by various nations, for paper, fifteen hundred years ago.

The very important and essential improvement of making linen paper is claimed as the invention of the Germans, Italians, modern Greeks, and the Arabians. In regard to the era of the invention, Ray dates it no farther back than 1470. There are incontestible evidences, however, of its having been used at a much earlier date. It was, probably, imparted by the oriental nations to the Arabians, by them to the Spanish, and by them to the rest of Europe. In making faithful research, touching the origin of many of the most important inventions, commonly supposed to have belonged to modern times, the truth is brought to light, that these inventions may be traced back from one country to another, until their commencement is lost in the darkness of ages that are without authentic record. Such views, in regard not only to inventions, but to whatever is deemed most beautiful, and of the highest genius in fine writing, caused the famous Scaliger pleasantly to say, 'perish those ancients, who have said all our good things before us!'

Paper for three centuries was manufactured on the continent of Europe much better than in England. But since the English have become the greatest manufacturing people in the world, the case is reversed, and they now manufacture the most beautiful paper. The French paper mills and we may add those of New England maintain an honorable competition with the English, in regard to producing the most beautiful paper. That of New England is much improved by the large importations of linen rags from Germany, which is a country renowned for the abundance and beauty of its linen. Various improvements have been introduced into this manufacture, such as that of giving the sheets any requisite length, by the use of machines for extending the sheets, and particularly by the use of the chloride of lime in bleaching it.

Previous to the invention of printing, all books were written in manuscript.

The business of the scribes was one of immense extent; and readiness and exactness were only acquired by those, who were trained to it, as a profession. So far from its being the fact, as is commonly supposed, that the exactness of the arrangements of the chapters, paragraphs, and artificial divisions of books had its origin in the improvement of printing, that art affected to imitate, in the minutest particulars, the forms and appearance of books from the hands of the scribes. Printers long kept their art a secret, that the books might be sold at the price of manuscript books. To continue the deception, the books were for a long time composed of parchment, like that used for manuscript.

The ink of the ancient manuscripts, the palimpsests, seems to have been something of the nature of charcoal, or lampblack, possessing the property of much more durability, than ink of galls, and sulphate of iron; but with the appended disadvantage of being easily discharged. Many of the remains of the ancient Greek and Roman authors would have come down to us but for this circumstance. The manuscripts were used in the middle ages by monks and scribes, after having discharged the ancient writings, as manuscripts to be rewritten with monkish legends, and lives of saints. Some of the original writings have been restored by discharging the monkish writings, and retracing the original characters.

The scribe began by preparing his parchment with a wide and handsome margin, which, together with the spaces for pages, paragraphs, columns and lines, was marked off with a square with great exactness. Each page was written with two columns, marked off by drawing a line between them, and with wide spaces between the lines. Capitals and particular words were emblazoned, by being written in letters of gold, or inks of brilliant and beautiful colors, strongly contrasting with the deep black of the body of the writing. The character, for a great number of centuries, was the Gothic black letter. Nothing could exceed the beauty of the manuscript of some favorite books in the libraries of opulent men, who affected to be choice in their books. Those, who have not seen some of the more beautiful of these manuscripts can form no idea of the beauty, illumination, emblazoning and ornament of these laborious products. It may be doubted, if the most splendid efforts of the modern press could compete with some of them in point of beauty.

Under these circumstances, we may easily judge of the scarcity of books in the dark ages. Only a few princes, rich ecclesiastical establishments, or individuals of opulent fortunes could afford to possess them at all. A complete bible, fairly written and emblazoned, would then have cost what would now be a competent fortune. In the ninth century, Albert, abbot of Gemblours, who was supposed to possess one of the most splendid libraries of the age, numbered a hundred and fifty volumes. Before the year 1300, the library of Oxford consisted of a few tracts, which, on account of their value, were kept chained in chests. At the commencement of the fourteenth century, there were four classics, Cicero, Ovid, Lucan and Boethius, in the royal library of Paris, which, with books of devotion, constituted the whole establishment.

These facts are sufficient to establish the importance of the art of printing, which, finding books the expensive and almost unpurchaseable luxuries of the rich, rendered them at once accessible to men of common fortunes, broadening their diffusion, until they became the air and water — the common heritage — of the whole reading community. But for this invention, monkish legends might still have been the favorite and prevalent reading of the day. But for this invention, the greater wealth, learning and power of the Catholic Church would have enabled it, in human probability, forever to have stifled the reformation. But for this, the ancient Aristotelian philosophy would have been the system of the ascendant, and Newton would have had to recant his theory of the universe, as Galileo was compelled to do before him.

The art of printing brought in its train light, liberty, and free and full permission, and even encouragement to investigate and decide according to conviction. On its banner were mourning and lamentation, and wo to bigotry and tyranny, and every effort to intimidate and enslave the free born mind. In fact, we are compelled to place this grand invention at the head of all, that have ever been made in our world, as being not only of prodigious importance, as an unconnected discovery ; but as enveloping the germ and bud of all subsequent discoveries. Without it, even the grand invention of alphabetic letters would have been, so to speak, an esoteric secret, of little use to the million, and without essential bearing upon the general diffusion of science.

The origin of even this discovery can hardly be claimed by Europe. The Chinese contend, that the art of printing was known, and practised by them at a period antecedent to our era. We have sufficiently authentic records to prove, that printing was in use in China in the sixth century. Sir George Staunton, whose means of information were most ample, informs us, that it was probably practised at a very early period of the empire. The following is their mode of printing. They first write, or draw a fair copy of the work to be printed. It is then given to the engraver, or more properly the carver, who glues the leaves of the manuscript upon a hard board, on which he retraces with a suitable instrument, the strokes of the writing, carves the characters in relief, and cuts down the intermediate parts of the wood. The beauty of the work depends, of course, on the person, who writes the copy. The adroitness of the carver is such, that he copies every stroke exactly, and the work is so neatly executed, that it is difficult to distinguish a printed from a written book. The board, thus engraved, contains characters for two pages. The printer then fixes it in a level position. Being provided with a hard and soft brush, he dips the hard one into the ink, and lays on the carved board enough to answer for four or five impressions, not inking for every impression, as we do. He then lays on the paper, and with the softer brush, he presses the paper on the board, by gently drawing the brush over it, a little increasing the pressure of his brush, at each new impression, until all the ink is taken up by the different impressions. In this way, one man is able to throw off several thousand copies in a day. Their ink is prepared with great care, and every thing, that relates to the finishing and binding is completed with the singular ingenuity, strength and gaudiness, that belong to all their manual operations. The great impediment to the extensive utility of the art is found in the prodigious number of their characters, the whole number amounting to 120,000.

Admitting that printing was practised by other oriental nations, as the Japanese, and the Hindoos from time immemorial, the immovably stationary condition of science, and all intellectual improvement in those countries proves, that the art, to be followed by its full results, must be practised by a people in all respects fitted to give it scope, and derive from it its natural fruits. The invention of printing, therefore, in Europe, in the fifteenth century, as to all its practical results upon the improvement and happiness of mankind ought to be considered a simple, original and unborrowed invention, the rather, as there is no reason to believe, that it was copied from any other people, or derived from any knowledge, that it had been practised elsewhere.

Great disputes have arisen, touching the place where, and the person by whom, the discovery was made. As many cities have contested the honor of having given the invention birth, as claimed to have been the birth place of Homer. Didymus has compiled hundreds of volumes, to settle the question, and has left it almost in the same uncertainty in which he found it. The following facts seem as well established, as such points are capable of being settled; that Harlaem in Holland, and Mentz and Strasburg in Germany, each claim to have given birth to the art of printing; that Laurentius Koster, a respectable citizen of Harlaem, in the service of the Dutch government, invented and performed the first European printing, at a period somewhere between 1422 and 1436; that he used wooden blocks, on which the letters were carved; that he used vellum, printing it only on one side, doubling, and pasting the leaves together, that they might show a printed page on each side. After printing a number of small works in this way, he advanced to the invention of separate wooden types, but never attempted to cut or cast types in metal. He followed the business until his death; and it was afterwards continued in his family.

Among his workmen were two brothers of the name of Geinsfleiche, the younger of whom was distinguished by the name of Guttemburg. The elder Geinsfleiche, with a fellow workman, as accomplice, about the time of the death of his master, stole a quantity of his master's types an apparatus, and absconded to Mentz, where, about 1440, he commenced printing with his stolen types. Hence the claims of that city to be the birth place of printing.

Guttemburg, the younger, carried the same art to Strasburg, and made various fruitless efforts to improve it, by substituting metal for wooden types. Some time about 1444, he left Strasburg, and joined his brother at Mentz. After trials of several years, they succeeded in forming a fount of metal types with cut faces. In 1450, a part of the Bible appeared from the press, printed with these types; and this was the first European printing with metal types.

An ingenious workman of theirs, Schœffer, completed the invention of metallic types, by casting them with faces. John Faust, to whom the original invention of printing has been commonly attributed, had been a partner of the elder Geinsfleiche, and was a man of great wealth and importance, Schœffer showed him his invention of types completely cast. Delighted with it, and foreseeing the consequences, he gave Schœffer his only daughter in marriage. It was not until after repeated trials, that they brought their type metal to the right degree of consistency. The first book, printed with the improved types, was a work entitled *Durandi rationale*, in 1459. In 1462, the firm printed a complete edition of the Bible, a most expensive work ; and in 1465, Tully's Offices ; and, in a short time, various works issued from their press.

Their edition of the Bible was a beautiful one, and cost them 4,000 florins, before they had printed the twelfth sheet. It was five years in the press. Faust took a number of copies to Paris, selling them at first for 600 crowns a copy, the price commonly given to scribes for very elegant copies of the scriptures, when transcribed. He gradually reduced the price to 30 crowns. They were exact imitations of the best manuscripts, and the purchasers were ignorant, that they were printed, it being the interest of Faust to keep up this deception as long as possible.

As he lowered his prices, his sales increased ; and copies seemed to remain with him in exhaustless numbers. Paris was at first astonished, and then alarmed at the mysterious number, cheapness and uniformity of his Bibles. It was soon rumored, that he was a magician, in league with the devil, though it might have seemed incredible, that the evil spirit would have given his aid in the circulation of the Bible. This consideration did not screen him. He was accused of magic, and his lodgings searched by the officers of the police. Several Bibles were found, and the red ink, used to illuminate the capitals at the beginning of each chapter, was pronounced to be his blood. He fled for his life, avoiding the inevitable fate, which, in those superstitious days, was reserved for those, who were reputed to be necromancers.

Credulity caught the dark rumor ; and the story of the Devil and Dr Faust, translated into all the European languages, and circulated by the harmless necromancy of his invention, in various versions, bristled the hair of the populace over all Europe. The substance of the most commonly received version seems to have been this; that Faust entered into a contract with the devil, that the latter should aid the former to produce books as many and as rapidly, as the former could sell; in consideration, after a specified time, that the spirit of darkness should possess Faust, body and soul; that the contract on either part being faithfully performed, at the expiration of the stipulated period, Faust paid the consideration of his immense gains by resigning himself to the devil, who flew away with him into the air, scattering his limbs in all directions as he flew, and carrying his disembodied soul to his own infernal home.

This man, whom perhaps a majority of the people of civilized Europe believed to have been carried off by the devil, was so celebrated for his beneficence and justice, as to have been called Gutman, or the good man. Though Koster must be admitted to have the fairest claims to be considered the inventor of a crude sort of printing on wooden blocks, Faust, from the patronage which his wealth and respectability enabled him to afford to Schœffer and others, by whom the casting of types was brought to perfection, may be considered the second parent of printing, with claims, perhaps, as well founded as the first to honors only a few years prior in time.

The kindred art of engraving had been known from time immemorial. The Jewish Scriptures speak of it as a well known art. From Homer's magnificent description of the shield of Achilles, it is sufficiently obvious, that the art of engraving had been carried, at that time, to a very high degree of perfection. It was known and practised to a certain extent by the Greeks and Romans. But the invention of printing afforded new incitements and facilities to improvement in this art, which continued to advance in a parallel march towards perfection with its sister art.

Stereotype printing has been generally attributed to the celebrated Didots of Paris, as the inventors. The British claim it as an invention of their artists. It is obvious, that it is no invention, but a mere return to the first principles of printing, only substituting solid blocks of metal for Koster's blocks of wood. Examples too numerous to cite can easily be produced of printers in various countries of Europe, who availed themselves of modes of printing, precisely like that of Stereotype, previous to the establishment of the Didots. But this grand establishment, by inventions of their own, carried this mode of printing to a perfection, which it had never before attained. So accurate and so beautiful were their editions of even English books, that they were enabled to undersell British works of the same class in London.

William Caxton is reverenced as the patriarch of printing in England, having introduced the art into that country, about 1473. Leland and Worde were his successors. Printing was first practised in Paris by Gering, Crantz, and Friburger, about 1466. For nearly a century, the most beautiful and accurate printing in Europe was performed at Venice. Aldus Manatias and Paulus, his son, greatly contributed to this preëminence of Venice in the art, by the number, splendor, accuracy and learning of their Greek and Latin editions of the classics. They stand at the head of the classical printers in the early periods of the art. They flourished between 1513, and 1574. The family of Etienne, or Stephens, transferred the preëminence of printing from Venice to France. Henry Stephens, the first of these distinguished men, was born in France, 1465; that is, not long after the invention of printing. Six or seven of the family succeeded each other, as printers of the highest order, rendering France in their time the grand mart of European books. Robert, the second son of Henry, had the high honor of collating from various manuscripts, and preparing the text of the Greek Testament now in use. The learned Richard Bentley thus speaks of this edition. 'The present text of the New Testament was first settled, (it is now more than 300 years since,) by Robert Stephens, a printer and bookseller at Paris, whose beautiful, and generally speaking accurate edition has since been counted the standard, and followed by all the rest.' Probably, no one family have had their names inscribed, as the publishers, in so many editions of valuable and classical books as this.

Printing was introduced into Moscow in Russia, by Peter Timofioffom, in 1560; and at Goa in the Portuguese colonies, and at Manilla in the Spanish possessions in the East Indies in 1580. Printing was introduced into Lima in South America, by the Spanish, in the year 1590; and in Mexico in 1600. The first printing in our country was in Cambridge, Massachusetts, by Stephen Daye in 1639; in Boston by John Foster in 1674; and in Philadelphia, in 1689. The commencement of printing west of the Alleghany mountains was at Lexington, in Kentucky, by John Bradford, in 1786. The first printing press in Cincinnati was established by S. Freeman and Son in 1795.

Our plan prohibits farther details touching the improvement and progress of this art of arts. To say nothing of the immense extent of printing in Europe, we have from 1600 to 1800 periodicals in the United States alone. Book publishing is extensively carried on in a great number of towns. The press groans under the burden, with which it is continually teeming; and if ages of darkness and decline are reserved for the future, as they have been for the past, it will be because literature will perish under an inundation of its own productions.

The press now exerts by far the most efficacious moral power that exists on our earth. Through it a thousand eternal heralds are proclaiming day and night, with untiring and unabating perseverance, truth and falsehood, and the dogmas of religion and atheism; inculcating free investigation, and submission to the spirit of bigotry; advocating freedom and slavery; singing, in the lofty phrase of rhythm and poetry, the praises of God and good men, and aspersing, on the other hand, every thing that bears the impress of greatness and virtue; and lauding, in strains of fulsome adulation, the worthless and the vile. But the efforts of the human mind are free and unfettered. The truly useful discoveries of the most obscure votary of truth and investigation, in the darkest nook of the world, are soon rendered, by the almost omnipotent ministry of the press, the common property of the human race. All the high and original thoughts of one mind, more inventive than the rest, soon become the common possession of all other minds. If truth be in its own nature stronger than error, there can be no danger, from this grand conflict between them, so long as the one is left perfectly free to combat the other. Truth is of the nature of God; and not only like him eternal, but omnipotent. It is mighty, and will prevail. The press is its powerful and universal herald. Let no one lay an unhallowed hand upon it, and degrade and weaken its energy, under the specious name of moderating and restraining its abuse.

If we take into view the epoch of this discovery, the condition of mankind at that time, the progress of the human intellect, and the state of general opinion upon all subjects, we cannot but be impressed with the benevolent foresight of Providence, in regard to the utility of this invention at that particular age, and under the existing circumstances. Man was intended by his Maker to advance towards the dignity and perfection of his rational nature. At one stage of his progress it would have been arrested but for the aid of written language. Another grand era had come, when a wider and more efficient diffusion of discovery, investigation and free thought were essential to the energetic advance of truth. The art of printing was discovered.

Thought is thus diffused as wide as the empire of mind, and receives from this invention the impress of the immortality of the mind in which it originated. Can we believe, that a thought committed to writing, stamped with the perpetuity derived from the press, and revived in a 'new and fairer edition' from age to age, shall remain forever, and the spirit, from which it emanated, be quenched in annihilation?

LECTURE LIII.

GLASS. PRUSSIAN BLUE.

In the preceding lecture, I have given brief sketches of the ultimate reach of human invention, in its influences upon the advance of intellect. I am led, in the following, by way of contrast, to present a summary view of an invention more directly connected with the physical comfort of man, than any other. I refer to the invention of glass. I may add, that by its utility in optics, it has contributed prodigiously to the advancement of science.

Dr Arbuthnot, contrasting the condition of the ancients with that of the moderns, humorously said, 'that Augustus Cæsar had not a shirt to his back, nor a pane of glass in his house,' and it is true, that the use of linen and glass is of very modern date. Nevertheless, we may not infer from the destitute condition of Augustus, as measured by our scale of comforts, that the Romans of his time were really so comfortless as such a remark might induce us to imagine. The finer and more beautiful fabrics of cotton might render the emperor comfortable as regarded his inner garment. But how could the inhabitants of a climate, which had a considerable winter, with snows and frosts, manage, during the severe weather, without glass? The very thought of wanting this most essential article is enough to make the inhabitant of a northern climate shiver. Ask such a one for the article most indispensable to physical comfort, and for which it would be most difficult to find any thing like a substitute, and he would answer glass.

Yet the Romans of the time of Augustus were comfortable. Apart from what we are taught by cotemporary history, the present view of Herculaneum and Pompeii, as denuded by the expensive curiosity of modern times abundantly proves, by occular demonstration, that they were studious not of comfort only, but of luxury and sensuality. Their bagnios, domestic contrivances, furniture and general arrangements show a people effeminately solicitous to pamper the senses, and to procure ease and indulgence. Though glass was known to these people, it is astonishing, that the use of it for windows, to admit light, and exclude air, were not in use. Oiled paper, and plates of talc were the miserable substitutes. Beside, from what we know of the habits of the Romans, from their numerous and most frequented apartments, from which the external air was not excluded, we conclude, that they were accustomed to pass much of their time in the open air. Their regimen and modes of life all tended to form a people, to whom the closeness of our apartments was unnecessary.

Why this most useful and ornamental substance, which the arts have derived from the ingenuity of man, was so little used by the ancients in their houses, if, as is affirmed, the art of making it was generally understood, we can now only vaguely conjecture. It is generally supposed, that it was made by the Tyrians, Phenicians and Egyptians. Parr, and other antiquarians maintain, that the first glass house was constructed at Diospolis, the ancient capital of Thebais. It appears from the writing of the ancients, that the Phenicians had made considerable progress in the manufacture of glass. Pliny informs us, that the Phenician colony of Sidon obtained, for some hundred years, the chief ingredients of their glass from the Phenician town Acco, now St John D'Acre, near the place where the small river Belus throws itself into the Mediterranean.

The account of the origin of glass, which Pliny has handed down to us is extremely plausible. A merchant vessel, laden with mineral alkali, having been driven ashore on the coast of Palestine near the river Belus, the crew went in search of provisions, and accidentally supported the kettles, upon which they dressed them, upon pieces of the mineral alkali. The river sand, on which this operation was performed, was vitrified by its union with the alkali, and thus produced glass. The important hint, thus accidentally obtained, was soon adopted, and the art of making glass gradually improved.

In the time of Pliny, glass was manufactured of the fine sand, collected at the mouth of the river Vulturnus. It was mixed with three parts of soda. It was fused a second time in a second furnace, and converted into a pure glass. Similar methods of making glass were used in Spain and Gaul.

Pliny informs us, that in the reign of Tiberius, an artist had his house demolished for making glass *malleable ;* while Petronius Arbiter asserts, that he was beheaded by the emperor. At the commencement of the Christian era, drinking vessels were commonly made of glass ; and glass bottles for holding wine and flowers were in common use ; though the word, commonly translated *bottles*, from the ancient languages, generally implies skins.

A passage from Lactantius informs us, that glass was used for windows in the third century. Various circumstances concur to strengthen historical testimony, that it was known for this use much earlier. The mystery is to conceive, why the ancients, so ready in general to adopt physical improvements, did not bring glass into general use for windows.

Italy was the first modern nation, that employed glass in windows ; though we have reason to believe, that the use, even in that country, was far from being common. Glass was introduced into England by foreign artists in 674 ; and was first used in glazing a church and monastery. But private houses were not lighted with glass windows, till the end of the tenth century. The application of painted glass to the decoration of church windows, a fashion so common in Europe, was practised at the close of the eighth century. It made rapid advances towards perfection, and all the ingenuity of art was exhausted in the production of those splendid windows, that at present adorn the Gothic cathedrals of Europe.

Glass is a composition of siliceous earth, fused with alkali either mineral or vegetable. Silex is in fact soluble in small quantities in a strong ley of potash. The chemical affinity of these substances fits them with a moderate heat to fuse into that perfectly homogeneous, beautiful and yet fragile article glass.

The proportions of some of the kinds most used in commerce follow. The best window glass is made by the fusion of sand with a kind of impure soda, called barilla, made by the burning of sea weed. Flint glass, so called, because pulverized flints were formerly used in the composition, is now made of purified sand 100 parts, red lead 60 parts, and purified pearl ash 30 parts.

The elasticity, firmness or brittleness of this remarkable substance appear to be very much affected by the rapidity with which it passes from a state of fusion into a solid form. When a drop of glass in fusion is suffered to fall into water, it is found to possess the property of flying into minute pieces, the instant a small part of the tail of the drop is broken off. As a general fact, the more suddenly glass is cooled, the more fragile and brittle is its texture.

To remedy this primary inconvenience of glass, the glass maker avails himself of a process, called annealing, which is done by placing the articles in a furnace near that of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this process, the glass cools very slowly and uniformly ; and is in a great measure freed from the defects of glass too hastily cooled. The admixture of lead has also a tendency to render the glass less fragile.

Under the head of optics, we have already seen the importance of this article in optical instruments. No point in the most delicate manufactures has been sought with more assiduity and research, in long and expensive experiments, than the making of clear, uniform glass, of the right degree of transparency, refrangibility, and general optical properties necessary to answer all the requisitions of telescopes and microscopes. Excellence in this species of manufacture has even been the object of national emulation between England and France. Dolland, a British artist, has reached great perfection in this manufacture.

Réaumur was the first, who made any direct experiments upon the conversion of glass into Porcelain. To produce this conversion, the following is the process. A vessel of green glass is to be filled up to the top, with a mixture of white sand and gypsum ; and then set in a large crucible upon a quantity of the same mixture, with which the glass vessel must also be surrounded, and covered over, and the whole pressed down rather hardly. The crucible is then to be covered with a lid, the punctures well luted, and put into a potter's kiln, where it must remain, during the whole time that the pottery is baking, after which the glass vessel will be found transformed into a milk white porcelain. Glass is used in the arts, as the basis of artificial gems. To such perfection has this art attained, and the imitations are so exact, that it is believed but very few, in countries where precious stones are much in use, can distinguish between the counterfeit and the real. Arschall succeeded in producing very exact imitations of the natural ruby. Fontanieu has explained an improved method of making pastes for every species of precious stone. Tassie, a Scotch artist, imitated most of the gems so admirably, that none, but the nicest judges, could detect the counterfeit. Catharine of Russia ordered a complete set of his imitations.

These gems are prepared, by fusing the ordinary materials of glass for topaz with oxyde of antimony ; the amethyst with what is called the Mayence base and manganese ; for beryl, antimony and cobalt, and so of the rest. All these preparations require great art, care, experience and skill in practice. The shops of jewellers abound in these glittering productions ; and there is no doubt, that innumerable of the vain votaries of fashion have glittered their hour in these artificial trinkets, not only producing the whisper of envious admiration of the supposed wealth, which could enable them to wear such costly ornaments, but have deceived themselves, in supposing them the workmanship of nature, instead of art.

Who, that has his lot cast in the temperate climates, where the apple and pear, the grape and wheat are indigenous; the regions, where winter and frost and snow concentrate families around the domestic hearth, can fail, as the wintry storm pours, to be thankful to the Creator, that he has furnished his feeble creatures with so many means of obviating the inclemencies of nature, or changing them to blessings? Remove from the inhabitants of any portion of our country the use of the single invention *glass*, and what substitute can we imagine to admit light, and at the same time dispel storm and cold? This wonderful creation of human ingenuity seems to me, more than any other physical invention, to separate the man of civilization from the savage.

I add to this lecture, a brief sketch of the discovery of Prussian Blue, not so much on account of its importance, as a solitary and detached discovery, as to show, that we owe many discoveries, and this among them, to accident; and that every discovery of this sort is found to bear so close an affinity to others, as to lead to various associated results. The original discoverer, probably, saw nothing in it, but the accidental knowledge of a method, by which to form a blue oxyde of iron, of a color almost to surpass the brilliant native blues, which nature herself produces in flowers. He clearly deemed the coloring matter a purely animal substance to be obtained only in the method, which he adopted by accident.

It has since been discovered to be a distinct acid, having very peculiar properties, uniting with all the metals to form the compounds, called Prussiates. This acid, in some sense intermediate between the animal and vegetable acids, is found to make a part of the circulations of many vegetables. In medicine, it has such an energetic efficacy, as to render its administration dangerous in any, but the most cautious and experienced hands. It furnishes the most concentrated and terrible poison known in nature. In certain forms it produces a fulminating powder of prodigious explosive force and noise. It offers a striking example of the power of chemical combinations, to modify the molecules of the compound in such a way as to cause it to produce a new affinity for the coloring matter of light. A train of chemical deductions of details too extensive to belong to my plan, and tending to throw new light upon the whole science, grew out of this discovery, which was at first viewed of as no more consequence, than merely the making known of a new and beautiful color.

The discovery is said to have been made in the following manner. A certain manufacturer of colors at Berlin, named Diesbach was preparing lake from cochineal. It was a part of the process to mix a decoction of this article with a solution of alum, and a little copperas or sulphate of iron, and afterwards to precipitate the coloring matter with a fixed alkali. As his decoction was prepared for precipitation, he discovered, that he wanted the requisite alkali. He borrowed the necessary alkali of Dippel, in whose laboratory he prepared his colors. That chemist lent him alkali, upon which he had distilled, a great number of times, a certain animal oil. Diesbach applied the alkali to his decoction, and instead of the cochineal lake, which he expected of a bright red, the precipitate was a most beautiful blue. As soon as Dippel witnessed this phenomenon, he was at once aware, that the peculiar and beautiful color was owing to the peculiar properties of his alkali. He immediately commenced a course of experiments to try if he could not impart the same property to another portion of alkali, by a process more simple. His experiments were successful, and the discovery of Prussian Blue was complete. The discovery was published for the first time, but without containing a description of the process in the Memoirs of the Academy of Berlin, in 1710.

In order to produce this brilliant color, it is customary to mix caustic potash with animal matters, as shavings of horn, or dried blood ; and calcine the compound with a moderate heat, until the charred matter yields no smoke. Then increase the temperature until the whole material, by insensible degrees, acquires a red heat. The matter is then thrown, red hot, into a considerable quantity of water, and the water is made to boil half an hour. Decant this water, and pour more upon the charred matter that remains, until the water poured on this matter becomes insipid. Mix these waters, and reduce them by boiling to the first quantity poured on the charred matter. Dissolve copperas and alum, in the proportion of two of the former to eight of the latter in hot water. Mix this solution, at boiling heat, with the ley also at boiling heat. A great effervescence will ensue. The water will become turbid, and of a greenish color inclining to blue. A precipitate will be formed, depositing the same color. Separate this precipitate, and pour upon it muriatic acid. Mix the precipitate thoroughly with the acid. The fecula will immediately assume a most beautiful blue. Pour on acid, until the blue is heightened to its utmost intensity. Allow it to settle for some time. Then wash it until the water comes insipid from the blue fecula. Let it dry moderately. The product is Prussian blue.

If any pure acid be poured upon an alkali perfectly saturated with the coloring matter of Prussian Blue, the acid forms no union with the alkali, is not neutralized in the slightest degree, and possesses no power to separate any portion of the coloring matter from the alkali. This separation is not procured, except when the acid is united with iron, the affinity of which with the coloring matter, united with that of the acid for the alkali, forms a sum of affinity, capable of producing the separation in question.

In this operation we have a strongly marked example of double affinities. It is one of the most complete and general examples that chemistry can furnish. Experiments prove, that iron is not the only metallic substance, the affinity of which, united with that of an acid, produces the separation of the coloring matter of Prussian Blue from an alkali. Any metallic substance, dissolved in any acid, has this effect in regard to any alkali. From this circumstance, the Prussic acid is an admirable test of the presence of mineral impregnations of any sort, in medicinal waters. Its utility in medicine is chiefly to be attributed to its character as a powerful sedative. The concentrated Prussic acid is believed to be the most sudden and terrible poison known in nature, operating almost instantaneously upon all animal life, when administered in very small quantities.

LECTURE LIV.

VACCINATION.

No one need be told, that natural small pox is one of the most dangerous, loathsome, contagious and mortal diseases, to which human nature is subject. It has afflicted all countries from time immemorial. Though the first authentic records of its ravages are cotemporary with the era of Mahomet, yet there are sufficient historical intimations, that instead of originating, as many have supposed, with the period of Mahomet, it had been transmitted from generation to generation.

There was no civilized country, that had not trembled under the prevalent infliction of this terrible scourge of the species. No inhabitant of any land, for many centuries, could expect to pass through life without receiving natural small pox. From one fifth to one tenth of all that were afflicted with it, fell victims to it. The pain, in violent cases, was excruciating, and the eruption loathsome beyond any other disease. The beautiful, under its infliction, became revoltingly deformed. The whole cuticle came off the face, like a mask; and they, who escaped malignant cases with life, had their visages so scarred, as to be no longer recognized by their friends. It was one of the pitfalls of life, through which, perhaps, as great a number as by any other single disease made their exit into eternity. It was, beside, one of the most violently and specifically contagious diseases known among men. Scarcely one in a hundred, brought within the sphere of its contagion, escaped it. Among the single words, that for ages inspired terror in the waking thoughts and in dreams, no one except death was enveloped with more associations of horror, than the name of this disease. Whole nations of people peculiarly exposed to its more malignant ravages, have been swept from the face of the earth by it.

In the natural onward progress of the human mind about two centuries since, inoculation was introduced, by which this malignant disease was divested of its chief terrors. The inoculated disease was comparatively mild, under the control of medicine ; and seldom carried off more than one in a hundred of its subjects. But even in this form, it sometimes assumed its native formidable character, inflicting death in its customary, loathsome and horrible progress. Beside, in obtaining the ascendency, to be substituted for natural small pox, it had to encounter the most fierce and sustained opposition from ignorance, prejudice and bigotry, in the form of objections to it on religious grounds. It was denominated defying God, taking his own work out of his hand, and presumptuously forestalling his providence, by inflicting a disease not dispensed from his hand.

The practice, recommending itself, like truth, by its own intrinsic value, gradually struggled through the war of blindness and prejudice, and was generally introduced in all civilized countries where small pox prevailed. Men had become satisfied with this comparatively easy tithe to mortality ; and expected no lighter tribute of this kind. The beautiful still trembled, lest theirs might be the face destined to be scathed with its impress of deformity ; but still voluntarily held up their arm to receive the infecting puncture, willing to compound, by this exposure, for the more formidable danger of the natural disease. In the year 1798, a still farther mitigation of this disease was made known to the world by Dr Edward Jenner, a name, which should be dear to humanity.

The following is a brief sketch of the Jennerian discovery. It had been observed, long before the promulgation of this discovery, that certain persons in the dairy counties in England were not susceptible of small pox, either in the natural way, or by inoculation.

In those districts it was also known, that these persons had previously been afflicted with a disorder caught from milking cows, when their udders were affected with a peculiar kind of pustular soreness. These facts had been compared as coincidences ; but no general system of inference had been drawn from them, until Dr Jenner, investigating this disease of the kine on the spot, came to the general conclusion, that this disease of the kine might be communicated, and would secure the person, who had received it, from the action of small pox. He published various works, in which this belief was fortified by the fact, that he had communicated this disease to his own child, upon whom inoculation with small pox was afterwards tried without effect. The experiment was tried upon hundreds and thousands with the same result. The government of Great Britain considered the fact, that receiving the vaccine disease secured the subject from small pox, so well established, that they awarded Jenner ten thousand pounds sterling for the discovery. To have believed himself the instrument of saving thousands of lives, and relieving mankind from the terror of one of their most formidable scourges, must have been a reward of inconceivably higher value to his humane and generous spirit.

Dr Jenner's narrative of his discovery brought to light the following facts. In the parts of Great Britain, where extensive dairies are kept, an eruptive disease had been known to exist among the cows, of a peculiar character, commonly called the cow pox. The seat of the disorder was in the udder of the animal. It communicated to the milker by contact, especially if the skin of the hand were broken or peculiarly tender. The person thus affected, milking other cows, often communicated the disease to a numerous herd. In the person thus affected, it was not a local disease, as in the cows, but a general indisposition, accompanied with considerable fever, running a regular course, but never terminating fatally. The person suffering this disease is ever after secure against the infection of small pox by contagion or inoculation.

These circumstances appear to have been known, time out of mind, to the inhabitants of the particular districts, where the disease has, from time to time appeared, and to them only. Innumerable instances of the long concealment of the most important information, in particular and remote districts, might be adduced. An example in point was brought to light by the investigation in question. It was, that inoculation for the small pox, so long considered a foreign invention, was discovered to have existed from time immemorial, in a corner of South Wales.

The kine pox, as it appears in kine, generally makes its appearance in the spring, in irregular pustules on the teats or udder of the animal. They are at first of a palish blue, or rather a livid color, and contain a watery, acrid fluid. The surrounding parts are swelled, and inflamed. The pustules, unless timely remedies are applied, are apt to degenerate into deep ulcers, which constantly discharge matter which grows thicker, and finally hardens into a cicatrix. The disorder never proves fatal to the animals, and can only be communicated to them, and to men, by actual contact with the specific matter from the sores. Both cows and men may suffer under this disorder repeatedly ; but after the first time of infection, the succeeding attacks are less severe, and much easier of cure.

A conjecture of Dr Jenner's, in regard to the origin of the disease in cows, ought not to be omitted. The horse is well known to be subject to a swelling and inflammation in the heel, called the grease, from which issues a very acrid matter, capable of exciting irritation and ulceration in any other body, to the surface of which it may be applied. Dr Jenner supposed, that the farmer, who had applied remedies to this disease in the horse, conveyed on his hands some particles of the infecting matter to the cows, which he afterwards milked ; and that thus the disease was originally communicated from the horse. He failed himself in his attempts to communicate the kine pox from this disorder in horses. But similar experiments, afterwards repeated, proved successful. From the grease of the horse's heel, the genuine vaccine pustule was produced in the cow, which was transferred to the human subject, and proved to be the genuine disease.

The casual disease, when thus accidentally communicated from the cow, is a comparatively severe disease, and is almost as much mitigated by inoculation, as the small pox, the comparative malignity of the two original disorders being considered. The small pox prevents its own recurrence, except in cases of the varioloid ; but only partially renders the constitution unsusceptible of kine pox. The latter disorder in the same degree insures against the former, and renders it only less susceptible of a repetition of the same disease. But the next grand advantage to the perfect safety of kine pox is, that it bears not a particle of that formidable contagion, belonging to the other disease, and that it can neither be communicated in the air, by the breath, or effluvia of the person affected with it.

The three chief points of caution, in the inoculation of this disease, are first the very considerable difficulty of distinguishing genuine from spurious matter. Acrid matter, from any sort of pustule, applied by inoculation, will excite inflammation, which will give birth to a pustule very difficult to distinguish from the genuine disease.

Second ; when the matter is genuine, but kept in a careless manner, and subject to spontaneous alteration, it is very apt to lose its power of communicating the disease. The virus of this disorder is more easy to part with this power, than the variolous matter ; and even when kept carefully, is likely to fail in communicating the disease, if it has been preserved for a long time.

Third ; when the matter has been taken from a genuine pustule, but has been furnished not by the clear limpid fluid, which forms the contents of the pustule in its earlier stages ; but by the purulent matter, which is found under the cicatrix, at that advanced stage of the disorder, when all the first fluid is dried up, and the pustule has lost its infecting properties. Neglect of right attention to either of these three points will be likely to produce a spurious disease, so much the more to be deprecated, as it will inspire the false security, which should arise only from the genuine disease.

Inoculation is performed by dipping the edge of the lancet in the limpid matter of the pustule of an arm, infected with the genuine disease, as soon as the pustule contains matter secreted by the disease, as a general rule, two days before, and two days after the eighth day from the inoculation, when the system is ordinarily most seriously affected with the disease. The cuticle of the inoculated arm is to be scarified with this lancet, until the true skin is reached, and becomes tinged with blood. If dry matter is used, it is rubbed on to the edge of the lancet, which is then held over the steam of boiling water, until the matter is softened and liquefied. When an infected piece of thread is used, the same measures are required, as when inoculating with variolous matter; that is to make a longitudinal incision in the arm, to apply the infected thread in the incision, and detain it there by an adhesive plaster.

The first indication of the success of the operation is a small inflamed spot, at the part, where the puncture has been made, which is very distinguishable about the third day. This continues to increase in size, becomes hard, and a small circular tumor is formed, rising a little above the level of the skin. About the sixth day, the centre of the tumor shows a discolored speck, owing to the formation of a small quantity of fluid; and this continues to increase, and the pustule to fill, and become distended, until about the tenth day. At this time, it shows in perfection the characteristic features, which distinguish it from the variolous pustule. Its shape is circular, sometimes a little oval, but the margin is always well defined, and never rough and jagged. The edges rise above the level of the skin, but the centre is depressed, and has not that plumpness, which marks the small pox pustule. As soon as the pustule contains any fluid, it may be opened for future inoculation; and about two days before and two days after the eighth day, when the matter is found to be in its greatest activity.

After the eighth day, when the pustule is fully formed, the effects on the constitution begin to be seen; and the general indisposition is commonly preceded by pain at the pustule, and in the armpit, followed by head ache, shivering, loss of appetite, pain in the limbs, and a feverish increase of the pulse. These continue with more or less violence for one or two days; and always subside spontaneously, without leaving any unpleasant consequences. During the general indisposition, the pustule in the arm, which had been advancing to maturation in a uniform manner, becomes surrounded with a circular, inflamed margin, about an inch, or an inch and a half broad; and this redness is an indication, that the whole system is affected; for the general indisposition, if it occur at all, always appears at, or before the time, when the efflorescence becomes visible.

I have been somewhat particular, in giving the history of the invention, and circumstances of the vaccine disease, as the necessity of practising the inoculation in every family is one, that comes home to us all. A parent, who should lose a child by small pox at the present time, one would think, would furnish himself with a source of heart-rending self-condemnation, which would last him to the grave; for the event could be charged only to the account of the most reckless and culpable neglect. But such is the slow and difficult progress of truth, and such it has been in every age, so many impediments has it to encounter from ignorance, prejudice, and wanton indifference and carelessness, that thousands still continue to die of the most loathsome and horrible disease, small pox, who, when asked, if they have been vaccinated, answer, no. Where this is written, in a population of 28,000, more than twenty deaths have occurred in a year from natural small pox; not one of which, it is believed, would have happened, had the persons been rightly vaccinated. At least, a thousand deaths have occurred the past year in our country from this wanton and heedless neglect. Alas! what a world is this in which we live ! How slow and difficult is the progress of information ! How many there are, who will resist all evidence, even at the risk of life ! How many would remain unconvinced, even though one came from the dead to teach them ! What need of patience and forbearance in those, who inculcate truth !

It cannot be disguised, that this most important discovery, forming an era in the history of human inventions, has been assailed within the few past years with more specious objections, than it has ever encountered before. A disease, as some contend, new in the annals of human suffering, but which I believe to have been coeval with small pox, called *varioloid*, or modified small pox, has extended itself over the civilized countries of Europe and America. It assails a small proportion of those persons, who have had small pox, either natural or inoculated, or the vaccine disease. It is believed, that the two disorders are about alike in their conservative effects against this disease. In many cases, it is a severe disease, and in some mortal. Its results have been by no means noted, classed, and reasoned upon, with that solicitude of investigation, which the importance of the subject demanded. But the general impression seems clearly to have been, that the vaccine disease is more certain to mitigate the virulence of varioloid, than the small pox ; and that there are fewer mortal cases of varioloid from the number of those, who have had the vaccine disease, than those who have had the small pox.

Be this as it may, there are so few instances of mortality from modified small pox, among persons, who have clearly had the genuine vaccine disease, that they may be classed among those anomalies and exceptions, that attend all general rules. In attacks of varioloid upon such subjects, the primary symptoms are often severe and alarming, threatening the most violent form of small pox. But the mitigating and restraining power of the vaccine disease shows itself at the moment, when its aid is most invaluable. The secondary fever, which destroys nine in ten of those who die by small pox, in those, who have had the vaccine disease, is either wholly arrested, or so mild, as to bring no alarm. Besides, numbers of those who die of small pox, it is believed, are falsely put down as persons who have been vaccinated, to shield survivors from the charge of heedless neglect, in not having procured the vaccination of their friends.

In fact, we have all of us seen small pox and varioloid prevailing for years in various towns of our country, where not one person in a hundred has been secured against infection in any other way, than by having had the vaccine disease. Can we doubt, that, but for the conservative effects of the vaccine disease, the desolating pestilence, small pox, would have swept these towns with the besom of mortality? Why should not desolation and death have scourged these towns, as small pox used to scourge them in places, where it prevailed, before the discovery of the vaccine disease? We perceive, in fact, that here and there a victim falls, generally among the ignorant, reckless and improvident. But the sick are not removed as formerly. No efforts are made to arrest the infection. The people, in the security of the vaccine disease, traverse the infected streets with confidence. We have thus under our eyes, even during the general prevalence of small pox and varioloid, a standing and universal proof of the general conservative effects of the vaccine disease. Scarcely any of the younger physicians, who attend these sporadic cases of small pox and varioloid, have had any other security against infection, than the vaccine disease. When we add to this, that varioloid is scarcely ever fatal to those, who have been genuinely vaccinated, it seems to me, that the vaccine discovery, instead of losing any of its importance, since the prevalence of varioloid, has in reality enhanced its claims, and proved itself of more value, than before the extensive diffusion of modified small pox; for we cannot for a moment believe, that varioloid is a new disorder, originating in the influence of vaccination.

LECTURE LV.

CHOICE OF PURSUIT.

My original purpose was to occupy myself entirely with views of physical nature, and the reflections which such views obviously suggested. The history of canals and rail roads, and various other improvements, which may well be claimed as exclusively modern, lay before me. But besides, that these subjects are worn to triteness in innumerable ephemeral publications, I could not answer it to my conscience, to close these lectures, without evincing my sense of the relative importance of moral, compared with physical truth; an estimate, which, in my mind, it is the great misfortune of the present day to have left almost out of sight. I deem one moral truth worth a thousand facts in the exact sciences. I deem the settling of the young, who are to constitute the next generation, in wise and right courses, of more intrinsic utility, than all the physical discoveries, and all the lore of the exact sciences, that have been accumulated, since the commencement of time. The only clue of order in my series of subjects, which must have seemed to the reader entirely desultory, has been to unite, as much as possible, interest with utility. The moral views, which follow, flow from the same purpose. I shall barely touch, as I pass, upon some of the leading ideas suggested by my subject, solicitous rather to excite attention to my theme, than to discuss it at length and in detail.

The first and most obvious truth, in reference to the choice of a pursuit, is that, in the constitution of things, it is so arranged, that every choice must necessarily present a balance of gain and loss, advantage and disadvantage, good and evil. The author of our being has seen fit in this way to adjust the scales of human condition, with an impartial reference to all that live, as wise and benevolent, as it is just; so that the chances of happiness are nearly equal to all the different races and conditions of men.

I view it as a truth beyond question, that Providence has designed man for the civilized state; and, as a subordinate part of that plan, has furnished every individual of the species with that kind and degree of endowment, which, rightly consulted, and directed, will fit him for precisely that part and place in the social edifice, which he is best qualified to fill. In this way every variety of aptitude, talent and capability, of which nature has furnished such beautiful gradations, such infinite shades and diversities, is labelled by the sign manual of the author of our being for the part which it is intended to perform. The highest responsibility of the parent and instructer is to ascertain, as far as may be, the pursuit or calling, for which his child or pupil is indicated. The embryo germs of temperament, endowment and character, even in minds of the most ordinary cast, are much more prominent, and strongly marked, than is generally supposed.

The young, then, who have arrived at that period of life, when the momentous duty devolves upon them, of choosing a pursuit, have first to enquire, for what pursuit or calling their temperament, faculties and powers best fit them. As their estimation, usefulness, and enjoyment in life will much depend upon right views on this point, they ought, of course, by patient and close observation, pursued with a fidelity proportioned to its importance, by intent study of themselves, as the changes of their health, propensities and prospects, the fluctuations of their spirits, their tempers in their collisions with their kind, in all the contingencies which befall them, furnish them with the means of forming just conceptions of the peculiar cast of their powers, and the walk in life for which their capabilities are best adapted.

It is of infinite consequence, that this scrutiny should be conducted by the severest reason, undazzled by any of those prismatic illusions, which imagination is so apt to present in the case, and which sober experience will be sure to disappoint. There are the immense promises of the law, alluring a crowd of aspirants and competitors, the greater portion of whom must fail to realize their expectations. There are the honors of the physician binding him, by the strongest of all ties, to the affection and confidence of the families that employ him. There is the ministry with its time honored claim, its peculiar title to be admitted to the privacy of affection, sickness and death ; and its paramount capability of the highest forms of that only eloquence, that swells, and softens the heart, by bringing its theme home to men's business and bosoms. There are the rapidly acquired fortunes and the various range of commerce and merchandize ; the growing importance of the avenue to a new order of nobility — manufactures on the great corporate scale. There is agriculture, constituted by providence intrinsically the most useful and important, and I may add, healthful and satisfactory of all pursuits ; and one which is now rapidly coming to be viewed in the light of scientific investigation and of a liberal calling. To adjust and settle the respective views, which the judgment and imagination will take of the chances of the various pursuits, presented to both sexes in the great scramble of life, and their contiguity and relation to love, marriage, wealth, distinction and happiness, will be found to be no easy task. Sometimes, in the soberest minds, one view will predominate ; sometimes another ; and the mind, like a pendulum, will vibrate between them.

Reason presents one decisive view of the subject. All these chances — all these balances of advantage and disadvantage — have long since settled to their actual and natural level. If the law present more tempting baits, and more rich and glittering prizes, over-crowded competition, heart-wearing scramble, difficulty of rising above the common level into the sun and air of distinction are thrown, as inevitable weights, into the opposing scale. The advantages and disadvantages of all the pursuits are adjusted by the levelling tendency of society in the same way. He, who is guided in this inquiry by common sense, will comprehend at a glance that it is impossible, in the nature of things, to combine all the advantages, and evade all the disadvantages, of any one pursuit. No expectation more irrational and disappointing can be indulged, than to unite incompatible circumstances of happiness. The enquirer must reflect, that every imaginable condition has its enjoyments, and in the opposite scale, its counterbalancing evils. It is folly to expect to form an amalgam of these immiscible elements. Reason can expect no more, than that we unite in the calling finally selected as many fortunate circumstances as possible, and avoid, as far as may be, its inconveniences and evils.*

Another view of the subject seems to me equally unquestionable. There is more honor, utility and happiness in filling a forward place, in what have been hitherto viewed by the prejudices of society as subordinate pursuits, than in being lost in the undistinguished crowd of those, who press into what are deemed the superior vocations. A parent ought to choose, for example, to see his son a thriving trader, an industrious and rising mechanic, or a respectable farmer, rather than an undistinguished lawyer, a dull preacher, or an envious and unemployed physician. No one can help remarking, that a mischievous and misguided pride to push their children in the direction of what are called the learned professions, is one of the growing and enormous follies of the parents of our country. They seem to imagine, that they have conferred on their children a kind of patent nobility, when they have thus introduced them into society. The consequence is, that each one of these professions is already crowded with supernumeraries, who have but slender chances to be useful or respectable, and who from want of employment, disappointment, and the unworthy arts and habits of competition, can hardly fail to become annoyances and nuisances to society.

This fond ambition of parents becomes more reprehensible, when we remark, that public opinion in our country professes to have associated no ideas of meanness and humiliation and dishonor, as it has in most countries, with the

* Vide 'Art of being Happy,' pp. 188, 189.

pursuit of agriculture, merchandize, and the mechanic arts, callings which there is little danger of over crowding. The universal feeling assumes to be that

> 'Honor and shame from no condition rise ;
> Act well your part ; there all the honor lies.'

No where, perhaps, on earth, does the employment receive its estimation from the man, and not the man from his employment, in the same degree as with us. We all feel, that no place dignifies a worthless man ; and that a respectable one gives consideration to his pursuit, be it what it may.

But having selected a pursuit, nothing can be imagined more effectual to paralize courage and energy, and dry up the very sources of happiness, than, after the choice is made, instead of pursuing the chances of happiness and success, which it offers, with unfaltering perseverance, to turn an envious and repining eye upon the honors and advantages of another. The settled purpose of perseverance and industry will find success and respectability in any calling, and will offer all the chances of good fortune, which the mutability of human things allows.

It is an unfortunate circumstance, in the present order of society, that these counsels have so little application to the other sex. Women, were they rightly trained, would be as generally capable of a pursuit as men. Where circumstances compel them to assume one, they more generally succeed, than men. Their passive courage is well known to be greater. Though interdicted in our country by opinion from every other pursuit, many are called to fill the office of primary instruction, an office well known to require an inexhaustible fund of patience, discretion and industry. A few gain employment, as writers ; though an absurd prejudice, in the estimation of the many, still renders this vocation so questionable, that no claim, but that of the most unequivocal success, gives the female author undoubted standing. There is, however, a prevalent mode of education, in which vast numbers of our females in the upper and middle walks of society are trained, which rears them in the unlimited desire of display, and the unquenchable emulation of dress and fashionable accomplishments. Too many of them have not drunk into the calm, contented and useful knowledge, which fits for the practice of the stern maternal duties, and the sacred and happy privacy of the parlor; and who, in the ordinary course of things, will be left dependent, alike unfitted by pride and ignorance for any pursuit. Indeed, it is a consideration calculated to excite the deepest regret in the mind of every philanthropist, that there is no profession for which unmarried ladies are trained; though nothing could ever be imagined more trying to the spirit of high minded woman, past her bloom, than that of managing a boarding house, or that, which surrounds a fair young girl with the noisy and refractory subjects of a village school. Deep must she drink of the bitter cup of probation, rightly and blamelessly to discharge her thankless duties.

The parent, who has trained his child to no pursuit, no mode of usefully and pleasantly occupying his time, has but poorly discharged the duties of a parent, let him have imparted ever so many superficial accomplishments, and what amount of money he may. In a republic, like ours, every one, male or female, ought to have a pursuit, an employment. One of the highest traits of character in a lady is a virtuous spirit of independence and sufficiency to herself. But the want of an adequate employment for females is an evil, the discussion of which belongs not, in its details, to this subject. I shall have fulfilled my purpose in hinting at this wide spread source of misery.

LECTURE LVI.

DECISION OF CHARACTER.

I KNOW of no one trait of character, that I deem so essential to every sort of success, as mental firmness and decision of purpose.

To the few, who possess it by endowment, and who enlighten, and guide it by sense and discrimination, it is their good star. It was the destiny and the long sword of Napoleon; the key, by which most of those men, whom history has denominated great, opened the temple of fame. In almost every case, where success may not be traced to accident, it has been the grand secret, by which the possessor has commanded fortune.

The far greater number of our species vibrate in a state of vacillation, are slow to combine the elements, upon which mental decision may fix, and are delivered from their suspense, only by circumstances beyond their foresight, or control. They want sufficient self reliance, vigor of mind, promptitude and concentration, to bring their thoughts to bear upon an alternative in such a way, as to decide with the full conviction of the mind. In view of a complicated subject of various aspects and choices, few are capable of separating, classing, arranging and combining, so as to be able to form a clear general judgment in regard to the whole, by having passed upon the divisions in detail, thence they are borne onward to their fortunes by the current of circumstances. But for this grand umpire of common destiny, vast numbers would live in a continual state of supine indecision, incapable, like the schoolmen's ass between the two bundles of hay, of fixing upon any alternative.

It happens of course, that they who can command vigor of purpose, and possess minds capable of a prompt decision, have a natural superiority over those around them, and a proportionate facility for controlling events to their advantage. 'But these rash and plunging men make mistakes,' say the cautious, 'and often involve themselves in painful dilemmas.' This may be; but I have seen so many failures, and so much misery result from indecision, that, I confidently believe, we encounter ten difficulties from this cause, to one produced by promptness and firmness of purpose. I have noted persons of decided character, reckless of the rules of prudence and judgment, but bold, persevering and unchangeable in their purpose. I hardly remember one of these rash characters, who did not prosper. Theirs is the trait, that commands fortune; and awes, and brings within the spell of their superior influence, those that surround them. These are the men, that, by a native buoyancy, take the ascendant in society. These are the men, to whom the helm is naturally resigned in storms. These are the men, who without fortune feel the internal consciousness, that they can obtain it. While those of weak and infirm purpose are hesitating, wavering, and balancing chances, these are the men, who seize fortune at the flood, plunge into the offered speculation, and float on the full tide to the completion of their wishes. These are the men, born to lay the less vigorous minds and hands about them under contribution.

The most difficult duty, which a young person has to perform, is to deny with inexorable firmness requests which he ought not to grant. When urged to compliance by compliment, the desire of popularity, reluctance to give offence, and various nameless mixed motives, the little monosyllable *no* is a kind of Rubicon, or rather the bow of Achilles. Whoever knows how to utter it with mingled gentleness, and firmness, cannot be said to want the rudiments of a strong character.

In regard to the subordinate plans and prospects of life, no person of ordinary spirit and ambition, be his position in society what it may, fails to have schemes continually presented to his mind, some dictated by simple aspirations after distinction and reputation; others calculated to ameliorate his condition, and increase his fortune.

There are three general aspects, which these schemes are likely to assume; the first one the feasible, brilliant, unquestionable aspect, compounded of the brightness and renovation of a morning sun, the exhilaration of morning coffee, and the juvenile vigor and audacity of morning thoughts. Faith then overturns mountains, and brandishes the keys that unlock the gold of Ophir and the temple of fame, with confiding assurance. That is not the aspect, in which to fix upon the assumption of the project.

The next is the indifferent and doubting view, taken by the yawning and heavy spirit, perhaps oppressed with dyspepsia, after dinner. Instead of morning rain-bows, the sky is all cerulean. The gigantic morning vigor, that saw no obstacles, has changed to indolent timidity; and the projector wonders, where his recent sanguine convictions of the result have fled. This is the view of the mere unreflecting animal man, the counselling of the stomach, rather than the brain; and this is not the crisis in which to embrace or reject the project.

The third is that of evening twilight, timid, discouraged, and presenting only elements for rejection and abandonment. Under these general heads, we may arrange all the varied aspects, deriving their coloring from the state of our feelings, which our plans assume, according as health, spirits, misfortune, depression and sickness influence them. The final assumption, or rejection, of every project ought to be settled by a kind of medical adjustment, compounded of all these different degrees of confidence and doubt. A mind of ordinary clearness in discrimination can hardly fail, in this way, to arrive at something near a just estimate of the intrinsic chances and practicability of the plan in contemplation; as thus settled by the conviction and confidence imparted by its varied aspects. The views of imagination, animal indolence and debilitating fear being thus thrown out of the calculation, the elements that remain, should be those of pure and simple reason, to be acted upon with untiring perseverance, and unshrinking confidence.

For it is obvious to one, who observes life with any attention, that innumerable plans laid in the purest reason, and fixed upon by the most discriminating judgment, entirely fail from want of perseverance, vigor, energy, and an undeviating struggle towards the end. The vacillation, and occasional assumption and relinquishment of the commenced scheme, the absence of hearty purpose to the end, which are entirely the fault of the projector, are often charged to the want of a wise and well concerted plan.

Again — a plan badly devised, and having fundamental defects, when pushed with force, and pursued with undoubting confidence and enthusiasm, and with double vigor, as it advances along its weak points, is often seen to terminate in complete success. '*Fecit quisque sortem sua vi*,' said the wise ancients. I would not affirm that faith and perseverance are adequate remedies for every degree of error and rashness in the fundamental plan ; but that a rash plan, carried out with unshrinking perseverance, has better chances, than the best one pursued with infirm purpose, and often broken off, and renewed.

Society in its present form presents an immense field of hard competition—a fierce scramble—a ring of innumerable competitors. The whole struggle may be conducted under the covert of prescribed forms, smiles, courtesies, bows, verbal civility and polite correspondence. It is only the merest novice, who is deceived, as to the part, he has to perform, by this specious exterior. Every other person is wide awake to the fact, that all around him, however polite their exterior, are bound to their interest by an irresistible magnetic influence. He knows, that no show of courtesies induces them to remit a particle of exertion, to outstrip competitors, to procure as many vacancies as possible, and to press with all the power that can be put in requisition to fill some one of them. It is as true in a natural, as in a spiritual sense, that the kingdom is taken by violence, and that the violent force themselves into it.

I have learned nothing from experience, so contrary to my early impressions, as adequate views of what can be accomplished in the course of a life, by firm and unshaken purpose, carried into effect by untiring perseverance. It would seem extravagant to assert, that a man has only to will any thing, within the compass of possibility, to be able to realise it. Yet if energy of will, strong conviction, and unabating industry act upon the desired end, the aspirant seldom fails, soon or later, to obtain it. Young men have been heard to assert in their festal moments, I will accomplish a certain end. I will reach a certain eminence. It is received at the moment as the inspiration of self conceit and the wine-cup. When the parties meet again, on the down-hill of life, to discuss once more the incidents of their youth, these words, verified in the event, are recalled as the presentiments of prophecy. The boastful prediction, on the contrary, contained in itself the elements of its fulfilment.

We read with a kind of vague incredulity, that a Spanish divine composed, copied out, and corrected from the press a hundred huge folio volumes. Every scholar could compose as much ; and perhaps, in most instances, it would be as dull and useless. But, as it is believed to be no easier to write dull books against the current, than pleasant ones with it, this would make nothing against the proof, of what perseverance can accomplish. Literature records almost numberless examples of similar results of untiring industry. We are told of a monk, whose establishment was on a solitary mountain in Spain, and who hewed for himself, with his own hands, a parlor, bed-room, cemetery and chapel, from the solid granite of the mountain. A young mind entertains no just conception, of what may be achieved, in any walk, by the steady direction of the industry of a life towards an end, to which the course and powers are directed, as towards a pole star. It seems destined in the course of human things, that this grand and yet obvious secret should be learned too late in life to profit by it.

Omnis dies linea—'a line every day soon makes a book'—is the secret of authorship. Madame de Sevigné, who declared, that she deemed the labor of making a book utterly beyond the power of her industry, was convinced, by collecting, and publishing the letters she had written, as an amusement, that she had actually accomplished this Herculean labor without having been made aware of it. Many a lady, who from mental indolence would shrink from the idea of meeting the labor of making a book, could easily gather up, among her hundred sentimental friends, volumes to prove the same point. A young laborer of twenty-one, with a full conception of what the labor and perseverance of a life can accomplish, would scarcely be afraid to contract to dig out a canal with his own hands.

Decision of character, concentration of mind, promptitude in coming to a determination, perseverance, and the industry, which is derived from the conviction, that labor can accomplish every thing, are, in my mind, essential to the attainment of great success in life. Contrary to the prevalent opinion, that these traits, which united, constitute strength of character, are almost simply constitutional, I know of no other, which may be so successfully cultivated in cases, where nature has denied the sanguine temperament, from which naturally flows mental decision, and the elasticity of thought and continuity of purpose, necessary to persevering labor. Thousands, who have labored under the infelicity to be constitutionally indisposed to these strong points of character, have been so deeply impressed with their indispensable necessity, as to have attained a good degree of the moral part of these important attributes.

Although I have indulged in what some, no doubt, will consider extravagant and unwarranted eulogy of decision and perseverance, but which has not expressed, by any means, the full extent of my admiration of these attributes, no one will so far misunderstand me, as to suppose, that I am not equally aware, that prudence and caution and the severest scrutiny of judgment ought to sit in counsel upon projects, before they are carried into execution. It is of little moment, whether those persons, who are incurably deficient in good sense and strength of mind, evidence their folly, in balancing with feeble and timid indecision between the simplest alternatives, or display it in rash schemes, the feeble progeny of lunacy and extravagance. The opposite extremes of their folly meet in the same ruin. I desire earnestly to inculcate on those, whom I might persuade, to pause, ponder, and sift, to turn every side and angle of the project to the day—to anticipate all probable results that may be calculated, to leave no place for unexpected surprise, that might have been foreseen, and nothing unprovided for, that human foresight or study could have divined; but when the decision is once made, to think as little of looking back, or relaxing the mind by the misgiving, or faltering of a moment, as though the iron bolt of fate, and walls of adamant precluded return. We may add, that, happily, keen discrimination, long reach of foresight, accurate powers of analysis, and cautious and prudent management are, for the most part, conjoined with firmness of purpose and vigor of decision.

The ancient adage 'medio tutissimus ibis'—*the middle course is safest*, has been transmitted, as the wisest general estimate of the course to be chosen, in regard to alternatives, the choice of parties and projects. The spirit of the maxim inculcates neutrality, wherever human interests and passions are concerned, and a medial course between the extremes of proposed projects.

It may have the seeming of arrogance to question the wisdom of a saying, so long deemed oracular. My business is to announce, what strikes me as important truth, not holding myself answerable for the constructions of any one. Instead of viewing this maxim a wise one, I deem it to be fit, as a general principle of action, only for a heartless fool, or an unprincipled knave; and beside, in ordinary cases, the most unwise and unsafe course, that can be chosen. What would be thought of the judge, who should invariably adopt it, as a ground of award between litigants? I admit, that to be a fierce partizan is always to want good sense. But to vacillate, in indifferent neutrality, between all parties, is to incur the distrust and contempt of all, and moreover, strongly to manifest the want of principle; as a well principled man can hardly fail to have opinions and principles, in regard to questions of agitating concernment. Wholly to suppress the expression of them, is to want the frank and manly independence of freedom, or to act under the restraint of servile and mercenary calculation. To choose the medium between proposed alternatives, is generally to incur the difficulties and disadvantages of both, and secure the advantages of neither.

I forget not the high praise, which has been bestowed upon such characters, as Pomponius Atticus, the friend of Cicero, who have maintained a kind of equivocal standing and friendship with the fiercest and most opposite leaders of faction. This example is wide from the one, which I would propose, under similar circumstances, either for imitation, or respect. Moderation and calmness, I grant, are always indispensable. But there is no kind of resemblance between the composed and firm expression of our principles and preferences, and the time-serving baseness of him, who courts all, and adheres to none. I bestow my highest commendation upon invariable self-possession, and unconquerable moderation. They are not only compatible with the most inflexible principle, but are generally indicative of it; but I never commend universal neutrality; nor always the midway between extremes. I would neither advise the mean nor the extremes; but either of the extremes, as an abstract principle, in preference to the mean. Let the choice be that of wisdom and discrimination — be it what course it may.

LECTURE LVII.

THE PROPER SELECTION OF BOOKS.

The literature of every great epoch in history has had a prevalent fashion, and been stamped in the mould of the age. That of the present day bears a peculiarly marked character. We have invented a new application of steam; and the power of machinery has been increased in a ten fold proportion. We have made canals and rail-ways, and discussed utility and political economy, until the manners of the age have been evidently affected. Swayed from infancy by the circumstances around them, a generation has grown up to understand the efficacy and value of little besides money; and to feel, that man, instead of allowing himself to become a creature of sympathies and affections, is bound to train himself to pure and simple calculation, undiverted from his arithmetic by the warm impulses of flesh and blood.

The literature of the time has received a corresponding impress and direction. Books, that had their origin in the moral sentiments, the thoughts of which sprung up from the strongly moved fountains of the heart, and which were so popular in the past age, are almost entirely gone by. Works on the duties, as connected with the affections, those of a cast corresponding with the philosophical writings of the ancients, such, for example, as Cicero's treatises "On Friendship" and "Old Age" and the like; and in modern time, the works of Fenelon, Marmontel, St Pierre, Chateaubriand, Madame de Staël, McKenzie, and writers of that school, are superseded by books on Political Economy, Chemistry and the Steam Engine. We have a few poets, who would have received that high appellation in any age or country; but the noblest of them is scarcely known by name among the people at large, while our innumerable rhymers imitate the measure at least of lord Byron, and pour their lullaby into a thousand periodicals. For the charming, inexhaustible, and unequalled paintings of nature and men of the Waverley school, we have the Bond street dialect and the dandy heroes of the Pelham and Bulwar school, in which men and women are viewed as compounds of fine clothes and sensuality. But above all, it is the fashion of the day with those, who assume to direct public opinion, to undervalue all knowledge and study, but that of physics, chemistry, mathematics, and what are called the exact sciences. Far be it from me to undervalue those important studies. But I do not often find these vehement partizans of the knowledge of facts and the exact sciences to be sensible and interesting companions. Persons may become talkers by being adepts in this sort of lore. But to me there is no learning more useless, than the mere accumulation of uncombined physical facts, without the capability of forming them into a system, and reasoning from them. The profound adepts in the exact sciences, the Newtons, Eulers, and La Places, were great to their age and the world, rather than interesting to their families and intimate associates. To converse well, to foster warmth and tenderness of heart, I would recommend the perusal of such books as the great work of Fontenelle, the Studies of Nature, Paley's Natural Theology, and books, in general, that exalt, and expand the conceptions, at the same time that they connect every fact in physics with moral ideas; and associate all with the wisdom, power and goodness of the Creator.

No one will go beyond me in admiration of the writings of Walter Scott, which have probably produced a greater effect upon the readers in our language than those of any other individual of the age. Who can help regretting, as he reads the works of this admirable master, that he should have limited his aim to the mere excitement of interest, without driving at a single mark in the sky, without having a visible moral for his scope, or giving a single definite attribute to his heroes, except that they are, invariably, unshrinking and unsparing duellists? Our regret is the deeper from being aware, that as he wove the warp and woof of all his narratives out of his own teeming brain, he could have pointed every one with a moral. The best of all his tales, 'The heart of Mid Lothian,' is a single solitary exception. The admirable moral it inculcates, takes nothing from its interest. What a halo would have invested the decline of this great and amiable man, had every one of his novels been charged with as rich and impressive a lesson! Compared with his writings, in this point of view, those of Miss Edgeworth take a high rank. I know of no book more calculated to be eminently useful to a young mind, or to impress it with a deep and permanent interest, than her Vivian, one of the best novels, as I think, of the age. For mere interest, 'the simple story' of Mrs Inchbald, a story, which scarcely one in a thousand of the present readers has seen, possesses to me a more harrowing excitement, than any one, which this age has produced; and I question, if any of the numberless novels of the writers in fashion have wrought, in the perusal, that irrepressible flow of virtuous tears, which every good heart paid to the novels of McKenzie in the past age. With all my partiality for Byron, with all my enthusiastic admiration of his genius, I cannot but admit my belief, that it would have been better for the age, that he had not lived. I cannot deny, that to me far more than half his verses are strained conceits, and harsh prose run mad in verse. As a man, who has seen more than fifty years, I recur with equal pride and pleasure to the calm and unstartling splendor, the celestial grandeur of the Paradise Lost, and the rich and harmonious amenity of Pope, and feel that great men have lived before those of the present day.

It is true, the present order of universal education is admirably calculated to bring forward the whole generation, upon which it operates, to an undistinguished equality and uniformity of acquirement. It presents us, as it were, a vast plain of pines of the same size and dimensions, height and verdure. Seen from above, the interlaced summits are as level as a scaffold. But the chances are unfavorable for the few majestic trees, that, under other circumstances, would have stretched into the sun and air of a higher region. The benevolent advocates of universal education have brought us to witness the intellectual experiment of the bed of Procrustes, in which long minds are amputated, and short ones stretched to the same length. The multitude have acquired the pride, confidence, and self will of supposed knowledge, we fear, without very ample capabilities of reasoning. Hence the present age is the empire of partizans, who lead the unreasoning million, that imagine they are leading their guides.

Still, notwithstanding, I think I can discern disadvantages to the present age from this order of things, I wish to add my earnest suffrage in favor of universal education. Its inconveniences are transient and temporary. Its blessings will be always in progress, and will last forever. Its self-will, pride and prejudices will pass away, and the intoxication be succeeded in another age by the sober self-government of reason.

I have no space for detail, in reference to the kind of reading, which I would recommend to the young. In one word, it would be writers of the old school, rather than the new, in the pursuit both of science and amusement. I much admire the writings of the serious French authors of the past age, as being deeply imbued with pathos and moral sentiment. Germany, too, has produced a rich harvest of literature, with which no modern scholar will allow himself to be unacquainted; and I know of no book more eloquent and instructive, and which will better repay frequent perusal, than Madame de Staël's Germany, in which that literature is charmingly reviewed.

Above all, let me press with most urgent and affectionate earnestness the love of books and study, as first, and last, and midst and without end, in furnishing the true and healthful enjoyment of rational beings. All, and infinitely more than all that Cicero has so eloquently said, in regard to books, as being our best and most constant friends in every place and vicissitude, is truth. Make sure and firm friends of books, of nature, and your own heart, and you may well sustain the inconstancy of all other friends, and the loss of all things else. Whoever has acquired a taste for reading, so fixed that it has settled into a habit, has become in the highest sense independent of all-other sources of amusement, and sufficient to himself. Fashion and society may set up their ephemeral idols, one day admitting, and another day excluding him according to its unsettled caprices. They may throw the sunshine of their favor alternately upon the rich, witty, learned, the young and fortunate and gay, and he may not be able to claim to be either. But if he have learned really to love study and books, and to hold converse with the mighty dead, he may set all their decisions at defiance. He can draw his supplies of interest and amusement, and those of the highest order, which life can furnish, from his own perennial and exhaustless fountains. Neither need he envy the possessor of the most magnificent apartments, in which to deposit his splendid copies, with their gaudy engravings, gildings and bindings To a real lover of books, a stall, so that it be amply furnished, is as good as the Vatican; and nature offers him her universal ticket of admission to the grand apartments of her reading room; and, seeing him enter satisfied with his book in hand, her composed visage will always greet him with a ready welcome.

LECTURE LVIII.

THE PLACE AND RITUAL OF WORSHIP.

Let me preface this subject, by insisting upon the necessity of being a worshipper in some place. I can hardly consider that person a good member of society, who declares himself principled against attending public worship in any form. I consider religious institutions so vital to the well being of the community, that every respectable citizen ought to countenance them, were there even no higher motive, than the utility of the example. I heartily respect the public opinion of our country, which almost exacts, that a family, which claims a respectable standing in society, should have its known place of worship. Let unbelievers deride; and flippant and pretended philosophers set up what phantoms they may in place of Christian worship; the human mind rejects the meagre mockery. Revolution upon revolution may substitute the ephemeral empire of deism or atheism, but, as France furnishes a memorable example, the necessities of human nature, the cravings of the heart will restore the Christian altars and worship. The want of such a worship is an instinct of our nature. The more truly philosophical and liberal a people become, the more firmly will they attach themselves to some form of worship; because to look up to heaven, to adore God, to hope beyond the grave — are unchangeable impulses and necessities of human nature. They will not cease to be such, until the power that moulded our frame, in remoulding it, shall leave out these constituent springs from our structure. This can never be, because in the endless chain of being, man is a necessary link, and is constituted by his nature a religious being. Should any of our conscious spirits be privileged to return to the earth, after a thousand generations, they might, perhaps, find the form and mode of worship changed. But the arch would still send up to heaven a universal hymn to Jehovah, and the hope of a happier and an everlasting life beyond the grave would still be the only permanent heritage of the transient race of rational creatures.

Select for your minister a man like him of whom Cowper has presented a finished portrait; a man of christian philanthropy, seriousness and dignity. This man charged with blessings, good counsels and immortal hope; whose deportment demands an unfounded homage of the heart, proportioned to the difficulty of sustaining it, will always display a cheerfulness combined with gravity; his presence will tolerate and brighten the innocent enjoyments of the festal board, and yet ensure the ineffable grasp of affection beside the bed of pain and parting life. Tolerant to every thing, but iniquity and wrong doing, he must be; for I could not sustain, even in contemplation, the idea of a christian minister so little acquainted with the christian scriptures, and the spirit of his master, so little imbued with true philosophy, with the knowledge of poor, erring human nature, and his own fallible judgment and heart, as not to be tolerant to all honest opinions, however wide from his own. I could not endure to hear a frail vessel of clay denouncing his fellows from the pulpit, because, by a law of their natures, they had been compelled to entertain convictions different from his.

I write from no higher inspiration, than the tone of my feelings, as I pass; and, hoping to find indulgence for the frankness, which follows, on the score of the motive, I need scarcely state my conviction, which, I know, is shared by multitudes of the most conscientious men of all persuasions, that the form and mode of worship, entirely distinct from its spirit and substance, are left by the author of our faith to be varied and conformed to the degree of improvement and the changing conditions and wants of society; and that that form is fittest and best, which most conduces to fostering internal piety. Forms may become time-hallowed by association; and the mistake seems to me to be, in the universal opinion, that they always grow in sanctity, as in time, whether in harmony with the spirit of the age or not. I deem, that forms, which have not this harmony, instead of becoming hallowed, may be worn out by years. We have great numbers of ministers of the highest order of talent ; and have more thinking and studious men in the ministry, than in any other profession. Yet call a sermon a lyceum-lecture, and what different associations will it raise ! Scorners will have in their mouths Byron's 'forty-parson power of dulness.' Men will yawn at church, and look at their watches and be lost in reverie, if not in drowsiness, not because ministers are not learned, and endowed, and of the highest order of talent ; but because they tamely follow each other's example, and forget human nature ; and are frigid, and unimpassioned ; and dole out didactic essays ; as if the burning words of the Christian ministry were a chapter of physics or chemistry ; when they ought to be, as they once were, before worldly decorum had interdicted the movements of the heart, appeals to the conscience, plain dealing, showing a patriarchal authority, and a tone and manner, which did not keep out of sight, what sort of creature man is. I appeal to the consciences of those who are best able to enter into their own thoughts, if, abstracted from the music, and their regular presentation in the pew to see, and be seen, and the habit and usage of public worship, too many do not carry to church the idea of penance, and feel a release from confinement at the glad Amen.

I believe, that most persons will admit, that they have entertained a *beau ideal* of a more touching and sublime service, than they can witness in the forms of any existing christian sect. It is unfortunate, that there is too much self-esteem and bigotry in all denominations, to allow the hope, that they will erase their own obsolete and worn out forms, and adopt selections from the more interesting forms of another. Suppose each sect had the tolerance and good feeling, to choose from every other what of their forms is in good taste, and to reject what is otherwise ; might not a more touching and beautiful ritual be combined from the whole, than any we now witness ? There is an unknown energy in words and forms. How immediately the heart swells, and the eyes moisten, when the right key is struck! How impressive is the tradition, that in the primitive days of the church, the simple phrase, with which the minister at the altar commenced service —*Christ is arisen*— often produced such an effect upon the worshippers, that had feuds and quarrels, as instantly to soften their hearts to dispositions of forgiveness.

Might not much be borrowed from the Catholics of their ancient, rich and sublime service, adopted in an age, when the cold frowns of imagined propriety had not yet repressed the cries of the heart? The episcopal church has had the good taste to retain the most beautiful parts of that service; but has borrowed too much, rendering its service, when carried to its accustomed length, tedious; and has adopted, and interwoven too little in conformity to the changing forms of society; to say nothing of the state prayers. It is no longer a question with thinking protestants, even of the strictest sects, that the senses ought to be consulted in a ritual. Every one knows, that man is much dependent upon the impressions of his senses for the free and right exercise of the most purely abstract and intellectual worship. It is useless for protestants so earnestly to decry the gorgeous ceremonial, the paintings, and the Gothic grandeur of the Catholic church, while they enlist so much pride in a glaring, gaudy structure, fitted up, and lighted, and painted in the style of a theatre, with its splendid silken drapery, its gilded organ, its expensive music, and aristocratic sumptuousness of pews.

If we wish to unite spiritual abstraction and simplicity of ritual with an imposing place of worship, fitted up to impress the senses, we may find in the usages of the *friends or quakers*, in their silence, and apparently severe habits of meditation and self-communion, an impressiveness, which every one, who has seen, has felt. From the methodists we might do well to imitate much of their impassioned, fervid and affectionate feeling without its concomitant noise; and copy feeling, which shows, that the heart is enlisted, and that the reception of christianity has that in it, which deeply stirs the affections, calls forth brotherly love, warms the bosom, and opens the hands in charity. Thus might we glean the impressive parts of the ritual and spirit of every form of Christian worship.

Be this as it may, I seldom contemplate a Christian congregation without a train of reflections, which no other earthly spectacle excites. However unmoved, decorous and fashionably indifferent the audience may seem, I cannot help remembering, that religion is either every thing, or nothing. In each one of these tranquil worshippers of all ages and conditions, however young, thoughtless, and fair, however remote from associations of sorrow and decay, I see beneath the apparently unheaving bosom, the germs of the struggle of a thousand passions, like the winds pent in the cavern of Eolus; a trembling, ephemeral insect, exquisitely sensible to honor, shame, hope, fear, and disappointments more terrible than death. I see all they have to sustain in the dark transition from beauty, freshness and pleasure, to debility, wrinkles and gray hairs, with all the terrible intervening relinquishments of those objects, to which the heart holds with most convulsive fondness. I count up their successive trials, exultations and suspenses between the sun lit illusions of hope, and the gloom of despair. I am with them in the bridal festivity, and the sober lessons of experience, that follow. I follow them, as they are successively left of their morning cotemporaries. I see their hopes disappointed, their affections blighted. I see them grope onwards through a wilderness towards the place of graves. Their fading vision and enfeebled senses bereave a world, so fresh and fair to the young and happy, of its beauty and music; and the deep knell of nature warns them, that they are occupying places, which another generation is crowding forward to fill, and invokes them to *arise, and depart*, because *this is not their rest.* I cannot but see the fresh faces and unfurrowed foreheads around me so labelled, as to call up all these thick-coming fancies. A measured harangue, with members disposed after the most received rules of rhetoric, and brought to the most musical close, a well enunciated ethical lecture in the most graceful and fashionably modulated accent and tone, declaring moral truths the most indisputable, seem to me less in keeping with the wants of such an audience, and the deep thoughts, that rise to my mind, as I survey it, than the *E profundis exclamavi* of the penitential psalms, the funeral dirge of Job over the loss of possessions, health, children, friends, and every thing, but God ; the lamentations of the prophet, and all those strains of sorrow in the Old Testament, which utter the spontaneous cry of the human heart to the Almighty under the pressure of those sorrows, that must come to all. What an impressiveness has the episcopal service for the dead, as chanted before the body on its way to its last rest. *I am the resurrection and the life !* Blessed are the dead, who die in the Lord.

LECTURE LIX.

WHAT ARE THE BEST EVIDENCES OF TRUE WISDOM IN CHARACTER ?

In other words, what are the fruits of true wisdom, philosophy and religion ?—for they all mean the same thing. The first deduction of our reason, is, that our Creator placed us here to be happy ; and that in striving to be innocently happy, we fulfil a duty, as well as obey the first law of our being.

The earliest deductions of the reason of man are, that he constitutes a requisite link in an endless chain of being ; and with the whole universe, animate and inanimate, is subject to certain invariable, irresistible laws, which, as far as he can discover, operate alike in every portion of the universal Kingdom of God ; have been in force from a period coeval with the divine being, and will continue to operate forever. Carried onward by the omnipotent energy of these laws, he is conscious in himself, antecedent to reason and intuitively, that he has a certain portion of freedom of action, imposing upon him the great and peculiar responsibility of his being; to study its extent, and render it available for the purposes, for which it was granted. This responsibility involves his most pressing duty to investigate these laws, to trace them in all their bearings and dependencies; and, particularly, to make himself acquainted with his own relations to them. He finds these laws equally unchangeable in whole, and in part, and in the moral as in the physical world. He discovers, that he may as well overturn mountains, hinder the course of the winds, or arrest the flight of time, as evade, countervail, or resist the moral tendencies of human actions.

The first and most marked point of difference between him who understands this, and them who do not is, that he considers it his first wisdom to conform in every respect to these laws. In the ear of his reason, these laws all invoke him, in God's name to search them out, to respect them, to conform to them, to violate them in nothing. They declare to him, that, upon their physical sway, depends the harmony of the whole universe; and that a wish, or an expectation, that any of the physical laws should yield to his desires, or imagined comfort, or convenience, would be only the impotent, selfish and guilty thought of having the harmony of a system, including innumerable worlds, interrupted to meet the wants of a creature, after all, so little acquainted with his real good, as to be seeking in this case what would be injurious to him, even if he stood without any relations to the universe. He is thus interdicted from all unreasonable desires and chimerical expectations. He seeks not the quadrature of the circle, perpetual motion, the philosopher's stone, the secret of rejuvenescence and the elixir of life; nor is he exposed to be duped by any of the vain pretensions and arrogant announcements of quackery. He perceives, that his health and comfort essentially depend upon availing himself wisely of his freedom, in regard to conforming himself to these laws. This is his only secret for obtaining long life and happy days. In the operation of these irresistible and universal laws, which are sweeping him and every thing around him, onward, on the current of time, he sees a wise and benevolent purpose, which he would not resist, if he could; as he plainly perceives he could not, if he would. He therefore repines not, that a young and fresh and joyful generation are rising round him; and that he is growing old and feeble, and becoming a stranger in the midst of them. How would he arrange a world, how can he even imagine a world, in which nothing should change, nothing grow old? He repines not, that his acquaintances,—those so placed, as most strongly to try envy,— are wiser, more beautiful, more fortunate, more opulent, more followed, than himself. Instead of indulging in disquieting comparisons, he enquires, 'what part of my inferiority is my own work, my own folly, my own neglect, my own infringement of the laws of my being?' That part, so far as it still admits a remedy, he sets himself in earnest to change for the better. To repine for the rest, he sees hurts no one but himself, and is as idle, as to murmur that the sun shines brighter than the moon; or that a young and vigorous tree has more graceful branches, and a brighter verdure, than the oak, that has been stripped by the winters, and scathed by the lightnings of centuries.

To increase his motives to calm and quiet submission to this universal order of things, of which he makes a part, he believes it the best possible arrangement — a transcript of infinite wisdom and benevolence, carried into effect by infinite power. Impressions like these produce a serenity, inconceivable to those, who have them not — a resignation to the changes of time, which contemplating all as the ordination of the divinity, ends in the ultimate fruits of piety. There is filial cheerfulness in his submission to a system emanating from the perfections of the Most High; and every statute of which is perfectly conformable to the spirit of the whole law.

In reference to his plans for success in life, he perceives, that by the ordination of these laws, one pursuit, that, for example, of wealth or ambition, offers its peculiar advantages and pleasures, counterbalanced by its inseparable difficulties and pains. Obscurity, retirement and mediocrity, on the other hand, have their appropriate pleasures, and appended sorrows and privations. Each belongs to the intrinsic nature of the pursuit. A true philosopher indulges no unreasonable and chimerical hope, of uniting all the advantages, and avoiding all the pains of these different pursuits. Content to abide by the unchangeable nature of things, he reflects, calculates, compares, weighs advantages and disadvantages, makes his election in no idle hope of uniting incompatible good, and having so elected, is ready to abide the consequences of his choice.

His thoughts and deportment are not less strongly marked, in regard to the indulgence of the inferior propensities of our nature. These were implanted as deeply, and had a voice as clamorous in his bosom, perhaps, as in the hearts of the multitude, who yield to them, as believing, that none can, or do resist their power, because they do not themselves. His enlightened reason and will are high in the ascendant. He has learned, that he has the power to say to them with effect, *peace! be still.* The indulgence of the appetite, kindled to a flame by the breath of roving fancies, burning ill temper, and dark purposes of revenge, fostered under the conviction of real or imagined wrongs, however common, however allowed, finds no place in his heart. He understands the law, which has implanted these inferior propensities within us; and comprehends their true use and legitimate purpose. He is still more clearly aware, that, if allowed to take the place of superior faculties, they become demons, and incubi, preying upon the body and spirit. He has counted the cost of their indulgence; and understands, that however dear to the animal nature, in its ultimate consequences, it *bites like a serpent, and stings like an adder.* Little claim can he have to the character of a philosopher, who has not his animal appetites, his passions and his temper, in due subordination to the superior faculties of his nature.

I am inclined to think, that envy, disguising itself in assumed forms, and taking, perhaps, a less hateful name, is one of the most universal and annoying passions. Few, I suspect, are aware, of the extent of the mischief and misery, it is constantly inflicting. Besides that it is intrinsically base and humiliating, and, like the gnawing of the undying vulture of the poets, neither hurts the envied, nor transfers one of his advantages to the envious, it is the passion of a grovelling animal; is eminently its own tormentor, and finds no place in the bosom of a wise man. In short, his broader and juster views show too much to pity, in the case most likely to tempt envy, to encourage its indulgence.

But aware of the tendency and combination of the influences of the present constitution of society, to call forth this base and degrading passion, instead of copying the common example of display, which tends to awaken it, he is gentle, modest, unassuming; and avoids all show, calculated to arouse it. Knowing, that living and present merit is always more or less offensive, when seen too near at hand, he yields to the necessity of patiently awaiting the stern award of the grave for an equitable estimate; and he expects fair and just measures of reputation not from those immediately about him, not from those, who, as much as in the time of Aristides, hate to hear any one continually called the wise, good and just. He understands, that poor human nature forbids a man to be a prophet in his own country.

Delivered by a calm and reflecting mind, that discerns the true nature and relations of things, from the abject bondage of fear in general, he has been able to rise, most of all, above the fear of death. He sees, that nature was right in imposing the necessity of it, and did not intend it for an evil. He has looked the phantom king in the face. He neither courts, nor fears the last solemn hour; but in the sober watchfulness of reflection prepares himself to meet it.

Such in a word is my view of the outlines of character, that belong to a sage. He sees nothing in life to provoke boisterous merriment and exulting expectation; and as little ground for despondency and tears. He feels it a duty to court happiness, whenever he can find it in union with innocence; and he has preserved the unsated freshness of youth for enjoyment, and the callous sternness of a stoic for suffering. He looks on life with a grateful and pleased pensiveness; and when the Author of life calls on him to retire, he is content to rise from the feast, and give place to another.

LECTURE LX.

CONCLUSION.

We have thus travelled together over wide and varied fields, all calculated to inspire reflections of cheerfulness and piety, alike when lights and shadows coursed over them; for we have seen God in wisdom and mercy presiding over each. This view throws new brilliance and glory over the brightest scenes. It kindles sunshine amidst the apparent clouds and darkness of nature. Every thing is full of God, and therefore of joy or consolation.

Baron Cuvier renders it probable, that our world was originally fluid, that crystallizations were the first formations; next the lowest orders of zoophytes and vegetables; then fishes, reptiles, the emersion of the dry land, trees and vegetables, quadrupeds and birds; but all of which, as species, have utterly perished from the earth. Next were formed the alluvial rocks, in which are imbedded those mysterious organic remains, of which we have spoken, containing the Saurian monsters, the mammoth, megalonyx, and palaiotherium. Last of all appeared on the earth the most finished workmanship of the Creator, man. He, too, walks in a vain show of joy and sorrow, and adds his bones to the organic remains of a world, where life verges to death, and death to life, in a circle of continual alternation. We have a revelation, full of the hope of immortality, which instructs us, that the soul, receiving its impress of light or darkness from its transient sojourn in clay, departs to its source as flame ascends, and mingles with purified and exalted spirits in the presence of God, if it have not been polluted in its passage across our dark planet.

Death, at first view the most revolting and inexplicable of human evils, is seen in the general analogy of nature to be a natural, we might say a necessary condition and arrangement of all terrestrial things. It seems to be an inevitable result of the constitution of all organized beings. The human mind, in the present order of things, can conceive of no other. If organized animal life could have remained unchangeable and immortal from the commencement of time, the visible universe would not have been capable of sustaining the thousandth part of it. To decay, and die is indispensable to reproduction and the rejuvenescence of a young and flourishing existence. In the vegetable world, this law surrounds us with young, budding and flowering forests, in place of the monotony of everlasting full grown woods; with infancy and childhood, and the freshness and the earnest vigor of youth, and gray hairs, and retirement from the scene, like the shifting variety of coming and departing guests at an inn. In this way death removes the old and worn out world of life, and replaces in the scene, the young, the fresh, and the gay to exult, and like their predecessors, retire.

I well know, that the murmuring spirit of man is ready to infer, that to have lived at all, with the taste of life, and the natural horror of death, furnishes a claim to continue to live. I am aware, that nothing is easier to the human heart, than to doubt the possibility of reconciling the necessity of death with the benevolence and justice of our maker. For my part, I have no doubt, that the benevolence of the Creator is as radiant in the seeming darkness of death, as in the freshness of the vernal morn of youth.

In reference to the countless millions of the irrational tribes, we have no reason to believe, that they are more disturbed, or alarmed, or that their enjoyment is diminished by the anticipation and apprehension of death, than a plant or a tree. Life is to them a general, continuous joy; and death the transference of existence to another, without the consciousness of loss in the one that dies. Every circumstance in relation to the mode of their death indicates that the plan of the Creator has been to spare all possible pain that could be dispensed with, consistently with maintaining the necessary order of nature. For example, in natural decay, the animal sinks into insensibility. In violent death, inflicted by one animal in devouring another, the lion and tiger are so formed, both by instinct and construction, that they produce in their victims instantaneous death without pain. The eagle strikes its beak into the spinal marrow of its prey ; and before the victim can feel, sensation is cut off at its source.

Is man the only creature so unsubmissive to the laws of his being, so timid, or selfish, as to cling fast to this state of error and mutability ? A predecessor retired from the feast of life to vacate a place, in which he might sit down to the repast. Shall he not follow the precedent, and cheerfully resign his place to his successor ? Suppose we could live on, like the loathsome *Struldbruggs* of Swift, under the inevitable infirmities and decays of life, how many would sustain the load, until it became an insupportable burden ? If we could live forever in the world, as we now are, who could imagine the sounds of wailing and wo, that would soon fill this bedlam of the universe with a lament more dire, than that, which the Trojan prince heard, when led by the sybil to the threshold of the dismal region beyond the Styx ! Death is a merciful arrangement of our being, an event making a part of the necessary chain of the order of things, which we ought neither to fear, nor desire ; but in humble preparation calmly to await, as a part of the divine plan of transplanting us from the bleak climate of probation to the land of eternal sunshine and spring.

The most cheering and conspicuous feature in God's universe is, amidst all its mutability and decay and apparent disorder, a progressive advancement in the scale of melioration. The progress may be slow, and so imperceptible as not to be apprehended by mortal ken. We have supposed, in the former part of this work, that we have made out wisdom and the forethought of benevolent intention in the laws of the material universe, in the chemical properties and relations of the molecules of bodies, in the habits of plants in the kingdom of Flora and Pomona, and in the forest of giant oaks; in the structure, habits and instincts of animals of all the races, that creep, walk, fly or swim; we have seen it still more in the intellect and moral constitution of man, in his erect form and human face divine; in his capacities, in his adaptation to every country and clime, in his social propensities, in his capability of entering into municipal relations, and combining the strength and intellect of a whole community in such a form, as that it can all be directed by one will to grand national results; in his capacity to invent mechanical improvements, and convert the blind but untiring and prodigious powers of nature to his use, compelling them to become the ministers of his wants; in the evidences which he bears within himself, and to which all the voices of nature bear concurrent testimony, that he is immortal, and destined, having performed his assigned duties, as a link in the great chain of being here below, to be transplanted to another scene, to enter into higher relations, and become a part of another system of the Creator.

Even inanimate nature, the earth and the elements have seemed to concur in the same plan. If it have been purified by fire, it is, that it might come forth in a more improved form. If it have been plunged beneath a shoreless ocean, it is that it might emerge with fairer continents, greener islands, more temperate climates, more prolific soils, and a happier and more fitting abode for man. If strange and monstrous forms of organized bodies, once possessing sentient life, have incorporated with the rocks, and formations of a former condition of our world, we have inferred, that each condition of the earth would of course possess races of animals conformed to its new order. In wind and storm, and thunder, in earthquake and the explosion of volcanic mountains, we have seen fearful, but grand and admirable methods of renovation and improvement. Changing his instruments and modes of operation, we have seen the Creator at one time submerging a world, or raising a continent from the abyss; and at another, performing his purposes equally by putting forth the greatest powers, or employing the meanest instruments, we have seen him raising up islands from mid ocean, by the bidden concurrence of innumerable little animals, so low in the scale of being, as hardly to possess locomotive or sentient life.

If we look at man through the vision of our own vanity, selfishness and discontent, we shall see him stationary or retrograde, indocile, ungrateful towards the attempt to instruct him, unimproved and unimprovable. We shall see him the slave of wealth and power. We shall be ready to believe, that all attempts to instruct and improve him will be thrown away, or repaid with ingratitude and injury. We shall conclude, that since others have deceived him, and rendered him subservient to their purposes, we too are justified in considering him as the fair object of our cupidity, deception and ambitious views, and shall determine, that our great purpose in life is to make the most of him, as others have before us. Such are the inculcations of merely worldly men.

But whether we have been so wise as to fall in with the improving spirit of the age, and so fortunate as to have shared its advantages, or not; whether we have generously thrown our mite into the scale of melioration, or in selfishness, ignorance and envy, withheld it, the process is slowly and irresistibly moving on. The best proof, that the condition of human nature is advancing that we can imagine is, that the duration of human life, in all civilized countries is becoming longer. This may be considered a standing scale of measurement, by which the other improvements of the human condition may be calculated. The general result of the tables of mortality, taken from comparisons of present with past annual mortality in most civilized countries proves the fact. In 1780, the annual amount of deaths in England was one fortieth of the population; in 1821, it was one fifty-eighth. In that country, there are now but two deaths where there were three, no longer ago than 1780. In all civilized countries, human life has increased, within the last half century, in a ratio shown by the diminution of annual mortality from one to forty, to one to fifty-two and a half. Vaccination is undoubtedly one of the great elements in this melioration of the human condition. The great and united efforts for the diminution of intemperance have already done much to the same result, and will continue to do more. The single fact of the prolongation of human life, and the diminution of mortality is worth more than whole volumes of declamation, to prove the progress of true knowledge, a more enlightened reason, and a purer morality. It ought to lead the philosopher and philanthropist to the conviction, that the obstacles of human ignorance and prejudice are not invincible ; and that the human condition is silently but irresistibly improving. In the old world, the thrones of ignorance and despotism are crumbling. The injured many are beginning to understand their rights, and no longer to be the stupid and passive ministers of the pride and pleasure of the few. Who will not utter the aspiration of the poet, ' Swift fly the years, when this darkling dawn of incipient twilight shall kindle to the radiance of understanding the end and aim of our being, enabling man to make the most of his existence, of which it is capable. Then shall he find, in the phrase of the divine writings, *that it is good for him to be here*—good for him to live, while he is moral, enlightened, happy in himself, and the instrument of happiness to others ; and good for him to die, depositing a worn and useless fabric of clay with the general mass of that which once had life, to enter into the light, to assume the relations, and commence the duties of the still onward progress of a higher sphere.

FINIS.