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# INTRODUCTORY LECTURE,

DELIVERED BEFORE THE

## MEDICAL CLASS

OF THE

## University of Maryland,

September, 1840.

By WILLIAM E. A. AIKIN, M.D.

PROFESSOR OF CHEMISTRY AND PHARMACY.

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UNIVERSITY OF MARYLAND,
*September* 8, 1840.

DEAR SIR:

Permit us, a committee appointed by the Medical Class of the University of Maryland, to request a copy of your able Introductory Lecture for publication, to ask your gratification of their wishes, and express the pleasure we feel in tendering to you their acknowledgments; with high considerations of personal respect,

Very truly yours,

H. P. WORTHINGTON,
JULIUS HALL,
T. H. YOUNG,
A. O. GUIDRY,
WILLIAM G. EDWARDS.

To Prof. AIKIN.

UNIVERSITY OF MARYLAND,
*September* 10, 1840.

GENTLEMEN:

In acceding to the flattering request which, in the name of the Medical Class, you have so kindly made, I have only to regret that the brief space allotted to an Introductory Lecture should have compelled me to take so concise a view of such a comprehensive and interesting subject. But will indulge the hope that the little I have been enabled to offer, will stimulate the wish to learn more. Please present my warmest acknowledgments to the Class for the honor they have done me, and accept for yourselves, gentlemen, assurances of the kindest regard of

Yours, &c.

WILLIAM E. A. AIKIN.

To Messrs. H. P. WORTHINGTON,
JULIUS HALL,
T. H. YOUNG,
A. O. GUIDRY,
WILLIAM G. EDWARDS.

# LECTURE.

Gentlemen Students:

The returning season once more finds us assembled to commence our academic year. It is a moment of peculiar interest for teacher and for pupil. Of deep interest to us, for memory brings back the forms of those who in days gone by were assembled in these halls,—who occupied the seats you now occupy, who listened to the scientific truths that will be urged upon your attention, and we involuntarily ask: where are they? Alas! the retrospect is one of pain as well as pleasure. Of the hundreds who have preceded you with aspirations as high, with resolves as firm, with the same noble ambition that urges you to outstrip your compeers in the race before you, some, alas! have been tried and found wanting. Their firmest resolutions have yielded when assailed by the temptations which beset them, and which equally lie in wait for their successors. The allurements of pleasure, the intoxicating bowl, the thousand snares that beset the path of youth, entangled their heedless steps before they could be persuaded of their danger, and recreant to the cause of truth and science, and deaf to the voice of duty, they fell to rise no more. But how bright the contrast if we follow the progress of those who closed their ears, and steeled their hearts, to the song of the syren. Who, like the prudent Ulysses, bound themselves with chains least they should be tempted to linger nigh the accursed shore, and trust their virtue to the enchanting sound. How nobly have they been repaid for their self denial! The approving voice of conscience and the praise of those who themselves are worthy of praise, have amply recompensed them for their exertions; while their Alma Mater points to them exultingly as bright exemplars for the imitation of her young novitiates.

This moment is one of interest to you, gentlemen, as well as to us. For you have now to chose whether you will take no heed to the history of the past, or whether you will profit by its warnings,—whether you will thoughtlessly follow the footsteps of those who have wandered from the right path; or whether you will not rather strive with the self denying ardour of the true votaries of science, for the rewards of fame and of fortune, that are within your reach. And you have incentives still more exalted than the prospect of attaining those, the more immediate objects of your exertions. On the tablet of creation, exposed to our view, we find written in words of light the high and sublime truth, that the human mind, an emanation from the divinity, departs from the eternal order of its nature, if it bends to ignoble influences, and obeys where it should rule. Every error to which it does homage, every prejudice and respect for opinion which are suffered to stifle the free expression of its convictions, every passion whose voice sounds above the calm accents of wisdom, affects not only that individual moment of its history, but degrades it from its high position; and its progress, from that time forward, must be from a lower step in the scale of intelligence. The horizon of its vision is narrowed, and it less clearly beholds in each truth, the connecting links of universal wisdom, and the grand chain of mutual support and dependence which pervades the universe. And if there is one consideration more than another, that should nerve us to pursue our course unfaltering, and make us shrink from every dereliction, it is the thought, that each will sink us in the scale of intellectual existences, and remove our starting point farther from our goal.

The course of studies before you leads to the consummation which has been, or should have been, the end and aim of your best efforts. Continue those efforts unabated, or your progress will stop far short of the point where we would place you. It will not be sufficient, simply to accompany your Professors in the illustrations of their subjects. The season of lectures must be a season of study and reflection. You will be surrounded by multiplied means for acquiring information, which to some of you, perhaps, may never again occur united. And you may now gather a fund of knowledge from every science connected with your profession, which will avail you when deprived of the aids, offered by the well supplied halls of your University. And recollect, that the numberless conveniences within these walls, though furnished directly for your benefit, have also been collected for another object; and the labours of your professors, though exerted directly for your instruction, look far beyond the passing moment. To each of you will be committed a certain influence on the reputation of your Alma Mater, who like the Roman matron, points to her children as her priceless jewels, and lives only in them. Her provident and liberal spirit anticipating your wants, has supplied most ample means, to enable us, her ministers, to facilitate your progress in every department of your studies. And we trust, that you will unite your best efforts with our own, until her re-ascendant star culminates in the firmament of science.

In the department, over which I have the honour to preside, you will find an apparatus in every respect superior, enabling us to demonstrate the remote connexions and dependencies of pharmaceutical chemistry, while the steps which will lead to these results, will no less conduct us to the great principles of science, of which they are but the corollaries. It is only by thus keeping in view the great objects of scientific inquiry, the constitution of nature and its governing causes, that we can attain to an enlightened comprehension of the phenomena, constituting the immediate objects of our investigation. It is only thus we can ennoble research, by exalting it to the dignity of philosophy. Take any other aim, and the experiments of the laboratory become as trifling and unfruitful as the amusements of the nursery. Children in thought, if not in years, our fancied pursuit of science will be but a laborious idleness. The progress of modern science proves the high importance of chemistry; placed first in rank among the natural sciences, it embraces and elucidates every other, and each year brings new proof of its widely extended relations. Subjects formerly supposed the most remote and disconnected, have brought her new distinction, by arranging themselves under her dominion, and calling upon her to explain their phenomena. To one of the most striking examples of this kind as shown in the rise and progress of the science of electricity, I must beg leave to invite your attention at this time. Trusting to the intrinsic interest of the topic, and to its widely comprehensive character, which renders it impossible for the most cursory view, if connected, to be made briefly, as my excuse for taxing your patience somewhat more heavily than custom sanctions, on an occasion like the present.

Our subject will carry us but a few years backward in the progress of human knowledge. The ancients in the days of Pliny, and still more remotely in the days of Theophrastus, 300 B. C., and for aught we know, for centuries before, were acquainted with the simple fact, that Amber, and probably the Tourmalin also, when excited by friction, acquired the property of attracting light bodies. Successive discoveries, the contributions of different observers, of which we will speak more fully hereafter, at last, but not until near the middle of the last century, permitted electricity to assume the rank of a science. From so feeble a beginning and so tardy a progress, what do we now behold? A science so comprehensive, that it claims as subordinate departments, the subjects of galvanism, magnetism, electro-magnetism, and themo-electricity; all of which, once thought distinct, are now known to be mere modifications of that one grand principle, which in various ways is intimately connected with all the phenomena of nature. Until the experiments of Franklin, and the still later and equally important experiments of Oersted, nothing could seem more improbable than such connexion. For ages the resplendent lightning had flashed along the heavens, or hung suspended in the charged cloud;—for ages the storm tost mariner had hailed the compass as his unerring guide over the pathless waste of ocean—for ages the brilliant corruscations of the aurora had swept ominously over the frightened multitudes, who saw amid its fitful gleams the portents of blood and battle, of cities overturned by inundation or by swallowing earthquake sunk, of empires subversed, and nations blotted from the page of time: but no one dreamed that the dazzling flash of heaven's artillery, as it swept from peak to peak the rattling crags among,—that the silent and mysterious influence, keeping the sensitive needle with its life like motion, true to the pole, and the red glare of the merry dancers of the north, would ever be proved dependent on one and the same principle.

I propose then to trace the gradual developement of a science, which, in our day, has been shown so widely comprehensive. From the days of Theophrastus until the beginning of the seventeenth century, more than nineteen hundred years, we have no evidence that any thing more was learned beyond the simple facts already mentioned, as known from remote antiquity. In the year sixteen hundred, Dr. William Gilbert, of Colchester, physician in ordinary to Queen Elizabeth, published a list of substances, which he had ascertained, acquired an attractive power by friction. But little more was done during that century. The celebrated Boyle made some additions to the catalogue of Gilbert, and stated besides, that substances when rubbed frequently, emitted flashes of light. About the same period, Otto Guericke noticed an apparent electric repulsion, generally following electrical attraction; and Sir Isaac Newton, in sixteen hundred and seventy-five, ascertained, that the interposition of a pane of glass would not prevent these effects. But these, with the additional discovery of Hawksbee, at the commencement of the eighteenth century, that electric light is more readily produced in a vacuum, were but isolated facts, disconnected and inexplicable. The true origin of the science should, probably, be dated between the years seventeen hundred and twenty, and seventeen hundred and thirty-seven, while Gray in England, and Du Fay in France, were prosecuting their labours with unwearied assiduity. Gray distinguished all substances as either capable of being excited by friction, and these he termed electrics, or incapable of such excitation, and those he termed non-electrics; electrics he found to resist the passage of the fluid, and thence gave them the name of non-conductors; while the non-electrics, affording a ready passage, were styled conductors. The French philosopher soon detected the cause of the apparent difference produced by friction, in the experiments of Gray. He showed that all substances were capable of excitation, if insulated: that is, cut off from all contact with conducting bodies. Du Fay made the more important discovery, of the existence of two distinct electric fluids, possessed of peculiar properties; the investigation of which, led him directly to the law of electrical attraction. He announced, that bodies dissimilarly electrified, attract; and, similarly electrified, repel each other: thus dispelling the mystery of the repulsions, noticed by Otto Guericke. The next discovery was the first that connected the subject with the science of chemistry. About the year seventeen hundred and forty-two, the German electricians succeeded in igniting ether, and some other inflammable bodies by the electric spark. But this merely demonstrated its possible application as a chemical agent, rather than introduced it as such, since no attempt was made to employ its powers, for more than half a century afterwards.

In the year seventeen hundred and forty-six, there occurred one of those accidental discoveries, which are occasionlly presented in the history of experimental science, and which, by attracting the attention of the learned, the wonder of the ignorant, and the curiosity of all, are admirably calculated to give an unusual impetus to research. Such was the discovery of the Leyden jar, by Messrs. Muschenbroeck, Cuneus, Alemand, and Winkler, and which, according to Dr. Priestly, contributed more than any preceding discovery, to give eclat to the science.

The effects of the jar, as narrated by those who first experienced them, were well calculated to excite surprise and consternation. In the language of Winkler, the first time he tried the experiment, he found great convulsions by it in his body, and it put his blood in so great agitation, that he was afraid of an ardent fever, and was obliged to use refrigerating medicines. He also felt a heaviness in his head, as if a stone lay upon it; and twice it gave him a bleeding at the nose. Muschenbroeck testified, that he felt himself struck in his arms, shoulders, and breast, so that he lost his breath; adding, that he would not take a second shock for the kingdom of France. In an age less enlightened than our own, and less familiar with the mysteries of nature, such accounts would naturally excite astonishment; they became at once the subject of general conversation, and every one was anxious to see, and even to feel the experiment, terrible as it had been represented. But it was reserved for an American philosopher, our own Dr. Franklin, to furnish the first rational explanation of the action of the Leyden jar. In the year seventeen hundred and forty-seven, he examined its properties by a series of the most ingenious and diversified experiments, and so connected his explanation with his peculiar theory of a single electric fluid, that each contributed to give currency and celebrity to the other.

Dr. Franklin's fame as an electrician, rests upon three grand discoveries, the analysis of the Leyden jar, the rapid dissipation of electricity by points, and the identity of atmospheric electricity with that obtained from the machine. These constitute a remarkable era in the history of the science. They ennobled the investigations of the closet by connecting them with the grandest phenomena of nature, and widely extended the scope of future inquiries. Electricity ceased to be merely the means of scientific amusement, and stood forth as one of the great links in the chain of cause and effect, which connects all the phenomena of nature in one eternal circle. The importance of Dr. Franklin's discoveries, and their attending circumstances as he has related them, render them the most exalted triumphs of inductive philosophy, if we consider their results, and at the same time exhibit him in his artless narration in all the simplicity of a great mind, forgetful of himself and absorbed by the magnitude of his inquiries. He tells us, he was struck with the resemblance between the effects of lightning and the electric spark, as first observed by the Abbe Nollet; both exhibiting the same zig-zag course, both showing a tendency to strike high and pointed objects, preferring good conductors, and avoiding non-conductors, both igniting combustibles, melting metals, and fracturing brittle bodies, both occasionally, inducing blindness, and lastly, both destroying life. Impressed with the importance of these facts, he proposed to connect a conducting apparatus with an elevated point, and to collect, if possible, the electricity of the atmosphere: but while waiting the erection of a spire, a simpler mode occurred. We may imagine, though we can hardly realize his feelings, when the suggestion first crossed his mind, and the simple sports of childhood, as once before in the case of Newton, became again the instruments of a most splendid discovery. Newton, with his pipe and bubbles, prosecuting his researches on the theory of coloured films, and Franklin, with his kite, regardless of the pelting of the storm, might well have excited the sneers of ignorance; both might have been called childish, but oft when the wise appear not wise, they work the greatest good.

Truly it was a spectacle of the moral sublime, when Franklin went forth to meet the rising thunder storm, and placing his simple apparatus within its influence, stood waiting the proof of his speculations; what intensity of interest, what a life of excitement in the suspense of that moment; while the whole intellect was concentrated around that one point, where so long its energies had been directed. The cloud rises, and his frail mechanism is lost behind the dark veil, but the chord is irresponsive to the touch—the fleecy vapour passes, and still no reply is vouchsafed to his daring appeal. He is beginning to despair, but the heavy prelusive drops have wet the string, and rendered it better fitted to conduct the subtle agent—soon the hempen fibres start up, as if instinct with life; he sees the truth written in fire from heaven, as the lightning descends at his behest; he collects and imprisons the celestial spark, and his task is accomplished. Henceforth, his name is inscribed upon the records of science, in characters of light; and henceforth, like his prototype, the fabled Prometheus, who stole the glory of the gods, and bore the gift to mortal man, to diffuse the beams of knowledge through the cloud of barbarous ignorance, he is to be hailed as a benefactor of his race. Ten thousand spires rose at once by his direction, to disarm the threatening clouds of their terrors; the destroying bolt was arrested in its course, was diverted through channels, where its energies were confined and rendered powerless; and like the winged winds, and the unruly waves, was compelled to do homage to man. The awful and mysterious instrument of punishment and revenge in the hands of the heathen deities, was exhibited as a natural agent, subject to well ascertained and intelligible laws. The energies of his intellect no longer depressed by the vague and anxious dread of this unknown and resistless agent, man ceased to fear what he could control if he could not wield. The electric kite of our philosopher, also, dispelled many a fanciful dream of the half-learned, who, to explain the phenomena of the thundercloud, had invented acid and alkaline effluvia, and sulphurous exhalations, contending and inflaming in the upper regions of air. The probable origin of atmospheric electricity, soon followed the discovery of its existence; heat, pressure, contact, combustion, the friction of currents of wind, evaporation and condensation, were all found to contribute to its accumulation. If a single drop of water will give evidence of electrical action, during its conversion into vapour, what must be the effect of the constant evaporation from the whole surface of the ocean, where the daily vaporization can only be measured by the immeasurable flow of the countless streams that daily pour their floods into her bosom.

From the days of Franklin, the science advanced with still more rapid strides. Lord Mahon followed, in the year, seventeen hundred and seventy-nine, with a series of beautiful and decisive experiments upon the nature of electric atmospheres. He demonstrated, that the electricity in the air around all electrified bodies, is always of the same nature as their own; that it varies in quantity with their size, and the varying intensity of their condition, and steadily and constantly diminishes, inversely, as the square of the distance from their surface: hence, the reason why, the atmosphere cannot possess any sensible electricity, at any considerable distance from the electric: and hence, as a legitimate consequence, the important discovery of the returning stroke. The next series of discoveries, was by Coulomb, in the years, seventeen hundred and eighty-five, and seventeen hundred and eighty-six. He contributed to the science, three important truths, constituting the first principles of all electrical theory: first, that the intensity of electrical attraction and repulsion, is always inverse, as the square of the distance between the object attracting, and that attracted. Next, he examined the condition of insulated charged electrics, and determined exactly, how much of the escaping charge passes along the insulating material, and how much is carried off by the air. And lastly, the astonishing fact, that in all accumulations of electricity, the whole is deposited upon the surface of the body and none penetrates into the interior. Thus proving most conclusively, that the fluid cannot accumulate in consequence of any affinity it might be supposed to have, for any particular matter. Coulomb's labours left the science pretty much where we now find it; since his day nothing of any consequence has been done in that department which has reference more particularly to the fluid furnished by the ordinary machine.

But we have yet to note the origin and progress, of several associate departments, unknown in his time. In the year seventeen hundred and sixty-seven, a German by the name of Sultzer, in a work styled "The General Theory of Pleasures," mentioned a singular sensation perceived, when a communication was made between two slips of different metals, placed one above and the other beneath the tongue. He considered it as the effect of a vibratory motion, excited by the contact of the metals and acting upon the nerves of taste; and content with this loose explanation, pursued the inquiry no farther. The powers of the electrical eel, had been known to the inhabitants of the shores of the Mediterranean, from remote antiquity. Oppian, a Greek poet of the second century, had commemorated them in verse:

"The hooked Torpedo, with instinctive force,
Calls all his magic from its secret source;
And through the hook, the line, the taper pole,
Throws to the offending arm his stern control:
The palsied fisherman, in dumb surprise,
Feels through his frame the chilling vapours rise;
Drops the vain rod, and seems in stiffening pain
Some frost fixed wanderer o'er the icy plain."

But the cause of this magic was unknown, until seventeen hundred and seventy-two, when it was investigated by Walsh, who showed its identity with ordinary electrical phenomena. This announcement gave rise to many fanciful hypothesis respecting the universal agency of electricty, and its identity with the nervous fluid, but they excited no particular attention at the time. The experiments of both Sultzer and Walsh, were, however, recalled to the attention of the learned, by an accidental observation of Galvani, in seventeen hundred and ninety. The anecdote connected with his discovery of the motion produced in the limbs of a dead frog, by contact with two dissimilar metals, is too familiar to need repetition. These motions were perfectly inexplicable, upon any known principles, and falling under the notice of the illustrious Bolognese, opened a rich and illimitable field in physical science. He repeated and varied his experiments, until he fancied he had discovered the cause of the movements, and thought himself warranted, in announcing the existence of a peculiar agent inherent and innate in living animals, which he termed animal electricity and others termed galvanism.

The celebrated professor Volta, of Pavia, took an entirely different view, and proved conclusively, that no new agent need be assumed to account for the results obtained. He showed that an electric current, is created by the contact of three bodies, of dissimilar conducting powers; whether those three are two metals and a fluid, or two fluids and a metal. And it was subsequently ascertained, that the contact, even of dissimilar non-metallic bodies, would induce feeble electric currents; and hence, Volta referred the convulsions of the recently killed animal, to the passage of electricity through the nerve. Misled by the plausible indications of animal electricity, physiologists had thought it sufficient to explain, all the phenomena of animal life; nay, life itself was thought dependent on the circulation of this imaginary fluid, between the muscle and the nerves. While these notions were prevalent, experiments on animal irritability were infinitely multiplied, and even the human form in the bodies of recently executed criminals, was subjected to the influence of electrical combinations, until scarce a trace of humanity could be recognised in the distorted mass. These experiments have long since lost the deep interest attached to them, by conflicting views. Necessary as they were at one time to convince men of their errors, they are no longer required for any of the purposes of science, and their repetition in our day, to gratify a misguided, if not a depraved taste, cannot be too strongly reprobated. Volta recalled the attention of the scientific world from its wanderings, and demonstrated, that the same principle, long known as electrity, was the sole cause of all the phenomena of galvanism. Reasoning from the effects produced by the contact of two slender metallic rods, it soon occurred to him, that a repetition of the metallic series, would produce a multiplied effect, and furnish more striking results; and by a most successful prosecution of his idea, for nearly ten years; he at last, in the year eighteen hundred, gave to science the pile which bears his name: an instrument, which, in the hands of succeeding chemists, by the sagacious application of its unlimited powers, has given results, of which, says Dr. Ure, it would be difficult to speak, in the cold language of philosophy; surpassing in importance, as they do in splendour, all preceding discoveries. It was hailed by philosophers with an enthusiasm commensurate with its importance, and employed with a degree of skill, attention, and assiduity, as unprecedented, as the success by which it has been attended.

When Volta constructed his electrical battery, he could not have anticipated the revolutions it was destined so rapidly to effect. His invention was communicated in a letter to Sir Joseph Banks, in March, eighteen hundred, and in the following May, Messrs. Nicholson and Carlisle exhibited its analytic power in the decomposition of water; an effect, well characterised, as the first dawn of a spendid era in electrical philosophy, which has been advanced by it, from the glimmer of twilight to the unclouded brilliancy of open day. The active and grasping mind of Davy, was at once struck with the circumstances of the decomposition, and he was at once led to institute that series of masterly inquiries; where, guided by the strictest logical induction, and supported by the most beautiful and ingenious experiments, he revealed the general laws of electro-chemical decomposition. The same train of thought, subsequently, in eighteen hundred and seven, produced his great Bakerian lecture on the chemical agencies of electricity. In this, he gave as the first fruits of his theory, an account of the production of the metallic bases of the alkalies and earths, by subjecting those compounds to the intense decomposing energy of a powerful voltaic apparatus. Time will not permit us, on this occasion, to go fully into a detail of the immediate consequences of these discoveries; it is sufficient to state, that the English philosopher revolutionized the science of chemistry, and although the whole of his electro-chemical theory has not received the assent of his successors, his fame is inseparably interwoven with the history of his favourite pursuit. In the language of a cotemporary, it will ever shine forth on the diadem of English science, a companion gem to the diamond of Newton. Simultaneous with the labours of Davy, were the investigations of Wollaston in relation to the identity of the effects produceable by the voltaic apparatus, and by ordinary electricity. He was equally successful in the field of his peculiar research, with his illustrious friend and coadjutor. He proved those effects unequivocally referrible to the operation of a single cause, and pointed out most clearly, the great distinguishing characteristics of the two varieties of apparatus; the peculiar action of the voltaic battery being referrible to the circulation of a great quantity of electricity of low tension, while the ordinary electrical machine, furnishes the fluid in small quantity, but of great intensity. Like the experiments of Franklin, Davy's results led to immediate, useful, practical applications; his suggestion in reference to the copper sheathing of vessels, to protect it from the corroding action of sea water, was a legitimate deduction from the principles he had laid down, and only failed for the strange reason, that the protection it afforded was too perfect. A certain degree of corrosion being found requisite to preserve the copper from prodigious accumulations of shell fish which attached themselves to the bright metal, and seriously impaired the sailing qualities of the vessel. Since the time of these illustrious men, but little has been done in voltaic electricity, except some more or less important modifications and improvements in the apparatus employed in illustrating its principles.

We have now traced electricity from its meagre beginning, through its several stages, until we have found its boundaries suddenly and almost infinitely extended, by the labours of Volta and his cotemporaries. But, as has been truly said, however expanded may be the circle illuminated by the light of science, the circle of darkness beyond, will be enlarged in the same degree. We have to pass over but a few years more to witness a still wider range, as suddenly, and as unexpectedly given to scientific vision. I allude to the labours of Oersted, of Copenhagen, who linked together with indissoluble bands, the kindred departments of magnetism and electricity; or rather, who revealed the connecting links which nature had established, but which man had never before been able to discover. But we shall better understand the value of his observations, if we take a moment's retrospect, to note the progress of magnetic discovery, to the moment when he began his labours.

We need not stop, to inquire whether the greek root of the word magnet, is itself derived from the name of Magnes, a shepherd on Mount Ida; who, it is fabled, first observed the attractive power of the loadstone, on the iron of his crook: or from Magnesia, a Lydian province, where it may have been first discovered: the name Lapis Heracleus, often given to the native magnet, by the ancients, from Heraclea, the capital of Magnesia, renders the last conjecture most probable. The attractive power of the magnet has been known from the remotest ages, but the directive power, is a discovery, of comparatively, modern times. It is difficult to determine, the degree of credit to be attached to the statements, regarding the familiar use of the compass needle by the Chinese, for nine or ten centuries before the Christian era. The first unequivocal notice of the mariner's compass occurs in the works of Frode, an Icelandic historian, who wrote in the latter part of the eleventh century. In his history of the discovery of Iceland, he states, that Vilgerderson, a renowned sea king, departed from Norway to seek, Iceland, some time in the year eight hundred and sixty-eight; he carried with him three ravens as guides, and to consecrate them for this purpose, he offered up a sacrifice in Snorsund, where his ship lay: for, says Frode, in those times, seamen had no loadstone in the northern countries. We next find it mentioned in a poem by Guyot of Provins, about the year eleven hundred and fifty, in describing the ways by which navigators are guided in their course, after mentioning the pole-star, he adds:

They possess an art which cannot deceive,
By the virtue of the mariniére,
An ugly and brown stone,
To which iron willingly adheres,
They can look to the right point;
When the night is dark and murky,
When neither star nor moon is seen,
Since they are in doubt,
They illuminate the needle,
Towards the star turns its point,
By which the mariner understands
The right way:
This is an art which cannot deceive.

These concurring testimonies completely invalidate the claim of the Neapolitan, Flavio Gioia, who has generally been regarded as the inventor of the compass, in the thirteenth century, and they prove it to have been used in Europe, more than an hundred years at least, before he lived. During the thirteenth century, many isolated observations of much interest were made. De Marcourt, a Frenchman, gave a description of the loadstone, noting the means for finding its poles, and the reciprocal attraction between the opposite poles of different magnets. Peter Adsiger, about the same period, was the first to mention the declination of the needle: take notice, says he, that the magnet, as well as the needle which has been touched by it, does not point exactly to the poles; but that part which is reckoned to point to the south, inclines a little to the west; and that part which looks towards the north, inclines as much to the east.

This discovery of the variation of the needle is generally ascribed to Columbus, who, during his first voyage, in the language of Irving, when about two hundred leagues from the island of Ferro, on the thirteenth of September, fourteen hundred and ninety-two, perceived about nightfall, that the needle instead of pointing to the north star, varied between five and six degrees to the west, and still more on the following morning; struck with this circumstance he observed it attentively for three days, and found that the variation increased as he advanced; he at first made no mention of this phenomenon, knowing how ready his people were to take alarm, but it soon attracted the attention of the pilots, and filled them with consternation: it seemed as if the laws of nature were changing as they advanced, and that they were entering another world, subject to unknown influences; they apprehended that the compass was about to lose its mysterious virtues, and without this guide, what was to become of them, in a vast and trackless ocean. Columbus tasked his science and ingenuity for reasons, with which to allay their terrors: he told them that the variation was not caused by any failing in the compass, that the direction of the needle was not to the polar star but to some fixed and invisible point, which, like the heavenly bodies, had its changes and revolutions, and every day described a circle round the pole. The high opinion the pilots entertained of Columbus as a profound astronomer, gave weight to his theory, and their alarm subsided. It is evident from this passage, says Dr. Brewster, that although Columbus may not be entitled to the credit of first dicovering the variation of the compass, he was the first to notice the variation of the variation; or, that the variation was not a constant quality, but differed in different latitudes. The next contribution of any note to the common stock, was that of Robert Norman, of London, who in fifteen hundred and seventy-six, detected the inclination of the needle, on its tendency to dip; he found the dip at that time and place, equal to nearly seventy-two degrees. And the next observation, was that of one Julius Cesar, a surgeon of Rimini, who in fifteen hundred and ninety, first noticed the spontaneous conversion of iron bars into magnets, in the case of a bar of iron, which, for many years, had supported a piece of brick work on the top of a tower of the church of St. Augustine.

In the year sixteen hundred, Dr. William Gilbert, in his treatise on the magnet, which has been already mentioned, as containing all that was then known on electricity, brought together all the disconnected observations on magnetism, and added several interesting experiments of his own, on the effect of heat, in destroying and inducing magnetic properties. He attempted to explain the phenomena of declination, by supposing the dry land magnetic, and the ocean not, and consequently, wherever the land was, there would the needle turn, as towards the greater quantity of magnetical matter. In the year sixteen hundred and eighty-three, the celebrated Dr. Edmund Halley, published his theory of magnetism, and was the first to suggest the necessity of four magnetic poles, two near each pole of the earth, to account for the variation of the needle; his work is principally interesting now, as showing the extremities to which men of eminently acute reasoning powers, have at times been driven, when without sufficient data, they have attempted to explain natural phenomena. His idea of four magnetic poles, we shall find actually verified in after years, when by the aid of numerous labourers, magnetic observations had been multiplied, at innumerable points from the arctic to the antartic circle. The fanciful part of his hypothesis was, that our globe consisted of a hollow shell, having within it a solid globe, with a space between them filled with a fluid: the inner globe, and the outer shell, both revolving about a common centre of gravity, in nearly, but not exactly the same time; and both possessed of a north and south pole; when the variable declination of the compass might be explained, by the want of correspondence in their times of revolution. The important discovery of the daily variation, is due to Mr. Graham, a mathematical instrument maker, in London, in the year seventeen hundred and twenty-two; and for the true law of magnetic action, we are indebted to Michel, who in seventeen hundred and fifty, by means of his valuable torsion balance determined, that the intensity of magnetic attraction at different distances, varied inversely, as the square of the distance. In seventeen hundred and fifty-nine, Epinus of St. Petersburg, published his theory of magnetism, the first rational theory, which had been offered upon the subject. His main error was, mistaking the law of magnetic action, as ascertained by Michel nine years before.

About the year seventeen hundred and eighty-six, we find Coulomb, who was so successful in his electrical researches, turning his attention to the phenomena of magnetism, and ascertaining the important law of magnetic distribution, he proved, that the magnetic fluid exists only upon the surface of bodies without penetrating their interior, and that it is, consequently, independent of their mass: and in eighteen hundred and two, he demonstrated, that all bodies whatsoever are subject to magnetic influence; sufficiently so, to admit of actual measurement. Hitherto Iron, Cobalt, and Nikel, had been considered as the only substances, capable of being rendered magnetic, but Coulomb exhibited the magnetic properties of all the metals; of glass, wood, chalk, bone; and in short, of every substance, tried, organic and inorganic, and was thus the first to remove one of the great barriers between these two departments of natural science. So long as electricity was known to be communicable to all bodies, and magnetism believed to be confined to three, the idea of seeking for a common cause to explain the phenomena of both, would hardly be suggested. Next in chronological order, we have to notice the invaluable labours of professor Hansteen, of Christiana, published in an enlarged form in eighteen hundred and seventeen. Aided by the observations previously made upon the declination of the needle, to which he added innumerable others, made in every part of Europe, and throughout Siberia, where he journeyed for the purpose, he rendered in the highest degree probable, the existence of four magnetic poles, as first suggested by Halley. In the paper published by that eminent astronomer, in the Philosophical Transactions for sixteen hundred and eighty-three, upon the theory of four poles, he concludes in these words: "But whether these magnetic poles move all together with one motion or with several, whether equally or unequally—whether circular or libratory, if circular about what centre—if libratory after what manner, are secrets, as yet, utterly unknown to mankind, and are reserved for the industry of future ages." It was reserved for Hansteen, one hundred and thirty-four years after this was written, to establish the position of these poles very closely, and very closely to approximate the times of their respective revolutions around the poles of the earth. In regard to the cause, he thought it probable, that the illumination and heating of the earth during its diurnal rotation, might produce magnetic tension, as it does electrical phenomena; a suggestion singularly confirmed by subsequent observations.

The next valuable contributor, was Professor Barlow, of Woolwich, whose efforts were not inferior in magnitude or utility, to those of any of his predecessors. By his invention in eighteen hundred and eighteen, of a mode for correcting the error of the compass, arising from the attraction of the iron on shipboard, his name became enrolled among the names of the illustrious benefactors of the human race. This local attraction, first noticed, but not understood by Captain Cook, and afterwards explained, but not remedied by Mr. Bain, had been the cause of many strange and fatal accidents. In eighteen hundred and fifteen, the Thames, a large Indiaman, with a cargo of more than four hundred tons of iron and steel, after leaving Beachyhead in sight at six o'clock in the evening, on her outward passage was wrecked upon the same spot, between one and two o'clock in the morning, without the least apprehension of being near shore. And a few years after, the Thetis, a British national vessel, on the second day out from Rio Janeiro, when all hands thought themselves clear of land, the ship running at the rate of nine knots and all sails set, the first intimation they had of their true place, was the instantaneous and total destruction of the ship by striking against a high perpendicular cliff.

Mr. Barlow's correcting plate was as simple as it was efficient—he determined by direct comparison of the compass on shore and on shipboard, the amount of variation produced by the local attraction of the ship's iron, and then by actual trial, ascertained the two positions, where an iron plate would exactly neutralize, or exactly double this effect. These once found, would be invariable for the same vessel; and would enable the mariner, by adjusting the plate, to determine at any moment how much his needle deviated from the magnetic meridian: the importance of this was at once apparent to every one. We hail the advance of science with enthusiasm, but it is an idle admiration compared with the feelings of those, whose very existence has at times depended, upon the success or failure of an experiment. Surrounded by the home comforts of our genial climate, imagination vainly strives to follow the northern navigators, on their adventurous track—where the horizon bounds but one vast circle of ice, and where the crushing of the mountain masses, as they threaten destruction to the frail bark, or their sullen plunge as undermined by the wave, are the sole dreary sounds that break the oppressive silence of the long polar night. Nor can we conceive their feelings, when the toils and sufferings of months endured, and when approaching the object of their exertions—behold, the guide which alone was their safeguard plays false, the needle has become useless to save them from the quicksand or the rock—varying with every accidental impulse, it trembles on its pivot, and refusing its guidance, no longer points to the pole. Now nothing can save them but ceaseless, unremitting vigilance, anxious days and sleepless nights, must be the price of their return, unless science steps forward, and with a single, simple plate of iron, neutralises the disturbing cause—when the needle again traverses true, and they are safe. These were the men to hail the name of Barlow with enthusiastic gratitude, as one who had so materially lessened the perils of their daring enterprise: and nobly have they borne testimony to the merit of their benefactor. Nor could there be a more beautiful exhibition than this, of the truths of inductive reasoning, or the vast power of the human intellect, which, amid the most abstruse speculations on general principles, can thus find amelioration and blessings for the human race. While the science of magnetism as a distinct department was rapidly advancing, under the auspices of its numerous and distinguished followers, many, at different times, had been led to suspect its connexion with electricity. The effect of lightning in imparting magnetism, in destroying magnetic properties, and in reversing the poles of the needle, was familiarly known; many adventurous attempts had been made to prove, that magnetism and electricity were but modifications of the same principle, but the facts furnished by experiment, were apparently so contradictory, and the conclusions to which they led, apparently so irreconcileable, that theorists and readers were alike bewildered. In the year seventeen hundred and seventy-four, the Bavarian academy, offered as the subject of a prize dissertation: "Is there a real and physical analogy between electric and magnetic forces: and if so, in what manner do these forces act upon the animal body." Professor Van Swinden, whose essay on the subject was crowned and published by the academy, came to the conclusion, after an elaborate investigation, that the similarity amounts merely to an apparent resemblance, and does not constitute a true analogy, and accordingly infers, that the two powers are essentially distinct from one another. Beccaria, in seventeen hundred and seventy-seven, and Ritter afterwards, were both engaged in the same inquiry, but neither seemed fully to appreciate the value of their own results, and the solution of the mystery was reserved for the Danish philosopher, who laboured most assiduously for seven years, before he was rewarded with complete success.

In eighteen hundred and nineteen, Oersted announced as the result of his labours, that a current of electricity, while passing through a wire, possessed the power of attracting and repelling a magnetic needle placed near it, and that this influence was exerted in a constant manner, and in obedience to a definite law. The new branch of physics which was thus originated, he styled electro-magnetism, but it was soon found, that two wires through which electric currents were passing, exhibited the same influence upon each other, and the term electro-dynamics was substituted. The ingenious theory of Oersted, explanatory of these motions, need not detain us, since it has given place to the more satisfactory one devised by Ampere. Ampere assumes, that all bodies possessing magnetic properties, the earth included, owe these properties to currents of electricity continually circulating among the parts of which they are composed, in one uniform direction, and in planes perpendicular to the axes of the parts. And he considers the mutual attractions and repulsions of these currents, as the fundamental fact, to which all the facts of magnetism and electro-magnetism may be reduced; the electric currents attracting each other when they move parallel in the same direction, and repelling each other when they move parallel in opposite directions. It will be impossible, on this occasion, to give any detailed exposition of this most ingenious and most satisfactory theory; such explanation must be reserved for a future time; it is sufficient now to state, that all the known truths of magnetic action, appear to flow as direct and necessary consequences of Ampere's views. The action of electric currents upon the magnet and upon each other, the action of the earth upon these currents and upon magnets, the action of magnets upon each other, the phenomena of the process for making artificial magnets, the singular facts attending the division or fracture of a magnet, are all fully explained by this theory, even to their minutest details.

The application of the theory to the phenomena of terrestrial magnetism, was happily accomplished by Professor Barlow, in eighteen hundred and thirty-one. He procured a wooden globe, and adjusted around it a long, covered copper wire, so that an electric current transmitted through this should represent, as nearly as possible, the currents supposed to be circulating around the earth, and imparting magnetic powers—the result was in the highest degree satisfactory. In the language of Mr. Barlow, the artificial globe represented very exactly on a small scale, all the phenomena of terrestrial magnetism, affecting a delicate needle suspended over it, at different points, exactly as the compass needle is known to be affected on corresponding parts of the earth's surface, and exhibiting most clearly, all the phenomena of magnetic dip and declination. Thus proving most conclusively, the existence of a force competent to produce all the phenomena, without the aid of any object usually called magnetic; and equally proving, that magnetism as a distinct quality, has no existence in nature. The only objection which occurred to Barlow, the difficulty of conceiving the existence of electric currents passing around the earth, has since his day been happily obviated. Such electric currents are no longer matter of conjecture, they were demonstrated by Fox, in eighteen hundred and thirty, in his experiments upon the metalliferous veins in the copper mines of Cornwall, and the new department of thermo-electricity, originating with Professor Seebeck, of Berlin, in eighteen hundred and twenty-two, points clearly to their cause. Seebeck found an electric disturbance produced by the partial heating of a series of dissimilar metallic conductors, arranged in a circuit, while the electric current thus obtained, exerted the same magnetic influence, as that furnished by the voltaic battery. The whole earth may be but one vast thermo-magnetic apparatus, where the polar ice and snow and the intertropical heat, produce the requisite irregularity of temperature: while the diurnal and annual changes in the variation of the needle may be conceived, owing to corresponding changes in the position of the earth and its different parts, during its diurnal rotation and its annual revolution around the sun. The recent discovery of two poles of greatest cold in the northern hemisphere, not far distant from the two northern magnetic poles, and the close coincidence between the isodynamic and the isothermal lines, would seem to show still more clearly, the close connexion between temperature and terrestrial magnetism. Besides the heat derived from the sun, there is a much more energetic source deep seated in the earth, cooperating with the sun beams, in producing electric disturbance—and if the heat of a lamp applied to a metallic bar, a few inches in length, affords perceptible results, how shall we appreciate the effects produced upon the rocks of the northern regions, at one place in contact with the boiling caldron of Hecla, and for thousands of leagues beyond, deep buried beneath the eternal ice of the pole. The very agent believed to be most active in maintaining the high temperature of the central parts of our planet, and feeding its inextinguishable volcanic fires, the galvanic action of its superimposed strata, would also create electric currents of corresponding intensity. And if a few square inches of beet root and walnut wood in a voltaic pile, will set in motion this subtle agent, what limit can we affix to the energy of a series, produced to unknown depths, and as extensive as the surface of the globe.

Before dismissing our subject, we should notice the singular discovery made by Arago, in eighteen hundred and twenty-four; and fully elucidated by the subsequent researches of Christie, Barlow, Babbage and Herschel. When a disc of Copper, Zinc, Silver, or various other metals, was made to revolve rapidly in the vicinity of a magnetic needle, this was at once affected by the revolving plate; and when a powerful magnet was made to revolve in the vicinity of a metallic disc, freely suspended, this soon acquired the motion of the magnet. But a magnetic body was required to exhibit the results, no magnetism being developed by mere rotation, independent of induction—that is, one non-magnetic mass revolving, would not affect another non-magnetic mass in the vicinity. These facts are worthy of notice, not only as showing the universality of magnetic influence, but as forming the basis of one of the grandest theories of magnetism yet offered. They have been thought sufficient by some, to warrant us in conceiving the magnetic properties of the earth produced by its rapid diurnal rotation, the sun bearing to it the same relation, that the artificial magnet does to the revolving disc; while the magnetism of the sun thus assumed, has been referred to its rotation, under the influence of some still more distant centre.

But such inquiries will be more profitably discussed at a future day, when more widely multiplied observations shall have made mankind better acquainted with the invisible and imponderable agents of nature, and shall have strengthened the already strong grounds for the belief of some subsisting mutual connexion, between heat, light, electricity and magnetism, which pervade in so mysterious a manner, all the realms of space, and exert so powerful an influence over all the phenomena of the universe.

We have thus hastily sketched the progress of these departments of natural science, once believed to be distinct, but now happily blended. Originating in different ages and in distant regions, like mountain rivulets, they pursued their devious path, sometimes hidden, occasionally obstructed, but constantly swelled by new accessions, until they have become noble tributaries to one grand stream. The capacious mind of Newton was sufficient to resolve the inexplicable motions of the stars, as gathered from the accumulated records of preceding ages, and all the mechanical phenomena of the universe, into the operation of the one simple principle of gravitation. It has required the conjoint labours of master minds, in different ages and distant countries, to arrange and simplify the complicated phenomena of electrical action, and to render their dependence on one common principle, plain and palpable—the work was accomplished when the illustrious Dane, after his seven years toil, cried out: Ευρεκα! I have found it! How beautifully then was verified the remark, long since made, that the more human knowledge is perfected and extended, the more readily is it acquired, and the more easily is it remembered; the labour of years is condensed into the labour of days; instead of innumerable and apparently irreconcileable facts, our attention is turned to a few simple principles, and the confusion of imperfect knowledge, is replaced by the order and simplicity of truth.

And may not some facts, now imperfectly understood, point to a simplicity still more sublime, than that already attained. The illimitable power of the voltaic battery, in the production of heat and light—does it point to any connexion between the cause or causes of heat and light, and that subtle principle whose history we have been tracing? Are they identical? And are we yet to verify the bold conjecture of Davy? Is attraction in any or all of its modifications, an electrical effect? Is the bright orb of day, the grand centre and source of all our imponderable agents, itself dependent on some brighter and more distant centre, perhaps, the throne of the Omnipotent? Even if it prove a dream, it is still a glorious dream, to suppose such connexions may be revealed by future researches.

The Argus eyes of science never slumber, her Briarean hands are never idle. Her votaries appear upon the fitful stage of life to labor in her cause for their allotted span, content to add their contributions to the common stock; and confident, that these, whether solitary or connected, whether intelligible or inexplicable, whether hailed by the acclamations of the crowd or unnoticed and disregarded,—so that they are truths, will in the end equally aid in the construction of the fair fabric of universal knowledge, and the elucidation of those mighty and mysterious laws of nature, which equally simple and majestic, equally local and comprehensive, pervade, inform, unite and consummate the universe. Truth is never obscure; however poor her followers may appear in this world's estimation, however wanting the factitious aid of rank, of fashion, of title, or of wealth, if assiduous in her cause, they possess a jewel which the world's wealth cannot purchase, and may rest secure, of immortality in her imperishable records, as benefactors of the very beings who were incapable of appreciating their labours. With the eloquent Roman, "they desire no other reward for their toils and dangers, but praise and glory; take but this away, and what is there left in this short, this scanty career of human life, that can tempt them to engage in so many, and so great efforts;—

surely if the mind had no thought of futurity, if she confined all her views within those limits which bound our present existence, she would neither waste her strength in so great labour nor harrass herself with so many cares and watchings, nor struggle so often for life itself: but there is a principle in the heart of every good man, which, both day and night, quickens him to the pursuit of glory, and puts him in mind, that his fame is not to be measured by the extent of his present life, but that it runs parallel with the line of posterity."

Gentlemen, would you insure success in your future career—let us create for ourselves a standard of ideal excellence, that *semper melius aliquid*, which will lead us to dwell, not upon what has been done, but upon what yet remains to do, and which will furnish light for our pathway, not from the splendour of the past, but from the brightness and the vastness of what is still before us. In this spirit let us enroll ourselves as neophytes in the temple of Nature, to study her sybilline volumes. Let no discouragement arrest our progress; for our difficulties can be none other than those our predecessors overcame—are we restricted in our means, so were they—are we destitute of all conveniences for experimental research—so were they, until their own ingenuity supplied all deficiencies—do we lack the time for investigation, how easy to lengthen the day by robbing the night, and how many important truths have been obtained, by researches carried on in moments stolen from slumber, and in the brief intervals of the labour required for the supply of physical wants.

The pleasure of our pursuit will be our continual encouragement, while the career of those great minds, whose work has just passed in review before us, will urge us to emulate their lofty fame. In whatsoever direction we turn, their trophies are before us, and pointing to them, I would appeal to you in the language of Demosthenes, when pleading with his countrymen in behalf of the threatened liberties of the Rhodians, he invoked the memory of the illustrious dead, and pointed to the monuments of their valour, to rouse their sons to the same noble achievements. Think, says he, that your ancestors erected these trophies, not that the view might barely strike you with admiration, but that you might imitate the virtues of the men who raised them.