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FRAGMENTARY PAPERS

BY THE LATE

SIR H. HOLLAND

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FRAGMENTARY PAPERS

ON

SCIENCE AND OTHER SUBJECTS

BY THE LATE

SIR HENRY HOLLAND, BART.

EDITED BY HIS SON

REV. FRANCIS J. HOLLAND

LONDON
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PREFACE.

In his 'Recollections of Past Life,' my Father writes as follows :—'There is little probability of my ever publishing again ; but I shall leave behind me a volume of manuscript papers consigned to the care of my sons, to deal with as their judgment may suggest.' Reference is here made to certain short essays upon various subjects, which are enumerated in p. 330 of his 'Recollections of Past Life.' He describes them as 'the thoughts and speculations of former years ; reduced into more definite form as regards the subjects, and studiously rendered as concise as possible.' And a little later on he speaks of them as written for possible publication : 'The papers thus denoted have furnished a very agreeable as well as salutary occupation for those leisure hours which in later years have been more largely at my disposal. But to bring them together, in shape and fitness for publication, would require a more laborious revision than I should probably be able to bestow.'

These words were written in 1872, and it would

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seem that in 1873 my Father, perceiving in himself no intellectual decline, made up his mind to bestow upon the papers this 'laborious revision.' For, during my last journey with him in Italy, in the autumn of 1873—a journey from which he only returned to die two days after his arrival in Brook Street—my Father often spoke of this as his intention; and in a manuscript book which he had with him at Rome I find the following entry, which I give here in full, both because it is an excellent comment upon the essays published in this volume, and also because it is the very last of the writings of Sir Henry Holland:

Rome: October 8, 1873.

I put the first pen here to a volume which I shall continue at intervals, if health of body and mind be still continued to me. The following is the object proposed:

In my desk are numerous papers or essays, chiefly written within the last ten or twelve years. The subjects they treat of are, partly, the discoveries and speculations of modern physical science; partly, those great problems of human life in its various relations to the world around, which have been touched upon in all ages of philosophy, but have become better defined in our own day, in effect of those stricter laws of induction which have been imposed upon human thought however directed.

In writing these papers I made it a chief object to define as far as possible, for my own instruction, the knowledge actually attained on each subject; the direction and possible attainments of the future; and the limits which in their very nature are impassable by human reason or research. Looking recently over these papers after the lapse of some years, I find that many of them would need to be rewritten to meet the demands of fresh discovery or more exact knowledge; while the questions involved in others have been so largely handled in modern controversy, that my treatment of them would have little other novelty than perhaps a closer *concentration* of the argument upon the conclusion sought for. Such method indeed, explicitly followed, has especial value in questions of the kind here alluded to. Strong or crucial proofs are enfeebled by contact with weaker ones, and an argument may be prolonged until it loses all its pith and purport.

Judging, then, that the larger part of these papers could not be published in their present shape, and seeing that needful changes could not be incorporated without rewriting the whole, which at the age of eighty-five would have been an impossible task, I have thought it best to summarise in a more abridged form what may seem worth retaining of their contents, with such additions as are suggested by the progress of recent research. Such summary indeed I cannot feel to be an easy one. Discovery has been largely at work of late in every branch of human knowledge, and even these connexions and correlations in the physical sciences, now so extensively developed, while concentrating physical phenomena, whether of living or lifeless matter, round certain foci, have virtually extended the field of research by bringing into view not only new classes of facts, but also those profound laws of force and motion upon which these interrelations depend. The horizon of our knowledge continually, though unequally, expands—obscure in its boundary on every side, and ultimately defined by limits impassable to human reason. One man by genius or happy accident may press more closely than another towards this horizon; but the ultimate limit is the same to all, involving those mysteries of Matter, Force, and Creative or Governmental Power, to which all other problems are subordinate.

Seeing then the magnitude of the subjects touched upon, all that I can venture to draw from the papers I have written must be desultory in character, and very imperfect in its handling of each. All that I can expect to afford is a summary of our actual knowledge on some of these great topics, denoting especially what may be considered truths conclusively proved, as distinguished from what is hypothetical or presumptive only. Much, probably more than we care to acknowledge, comes under the latter head . . .

With this unfinished sentence the pen of my Father was laid down for ever; and that these closing words are thoroughly characteristic, will be felt by every reader of the Essays here brought together. Sentence after sentence could be quoted from them, as also from his other writings, to show how he understood, and ever earnestly taught, that 'those whose researches and thoughts go deepest are best prepared to endorse the words of Laplace, "Notre ignorance est immense," as the expression of a truth underlying all our knowledge.'

I feel that no further preface is needed for these Essays. As they were left in the MS., so are they now printed for the first time without any material alteration.

To the papers not hitherto published have been added three reviews which Sir Henry contributed to the 'Edinburgh Review' in the years 1864, 1871, and 1873.

FRANCIS J. HOLLAND.

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ESSAYS.

PROGRESS OF HUMAN KNOWLEDGE.

No one can have lived to his eightieth year (my present age) without an occasional revision of the events which have been comprised—*compressed* one might well say—within this time; and amidst many that are extraordinary, none are more so than those which mark the progress of human knowledge, and especially of the physical sciences, during the period in question. When travelling over continent or ocean under the power of steam—when looking (and I never do so without a certain awe) on those wires and cables which make the electric current the instantaneous messenger of man over the globe—or on the light of the electric lamp, emulating that of the sun—or on the photographic creations of the sun itself—or on the brilliant metals extracted by the chemist from the dullest earths—or on those spectrum lines which have made known various new metals on our own globe, and even disclosed many of the constituents and physical characters of the sun and stars—when looking at these, and many similar things, showing the new mastery Man has obtained over Matter and its moving Forces, the thought runs back, almost startlingly, to that earlier yet not remote time, when these powers were all hidden from our knowledge as completely as if having no existence in the natural world. In the boyhood of my own life some of them now mightiest in our hands lay dormant and purposeless around us. The period which has disclosed them to our knowledge and senses must ever rank high in human chronology.

More than sixty years ago Davy showed me, at the Royal Institution, the minute globules of sodium and potassium just obtained from the fixed alkalis. In the same laboratory, the birthplace of so many great discoveries, I witnessed his first experiments on the chemical actions of the voltaic current—an era in chemical science. Very few years later I heard Dalton expound for the first time that Atomic Theory, which (whatever the antecedent suggestions) gave the earliest impulse to those researches, of which organic chemistry, present and prospective, is the most wonderful exponent. Yet later, in the theatre of the Royal Institution, I was one of a small party to whom Faraday showed the spark he had just succeeded in drawing from the magnet; so feeble then as to require an effort to see it, but the forerunner of those marvellous powers which have since been elicited from the same source. These dates, though belonging to my own life only, tell in some part what this century has done for physical science.

In an article of the 'Edinburgh Review,' some ten years ago (since republished), I sought to delineate the progress recently made in this great department of human knowledge. Such records from time to time, even if imperfect, have their use in denoting the several stages of advancement marked not only by new facts but also by new methods of enquiry. The latter is the point I would chiefly keep in view in what I am now writing. Laplace has said, and truly, that the methods which have led to discovery are often not less useful to science than the discoveries themselves. And nothing so well deserves note in the attainments of the present age as the various new resources, mental and material, which have been brought to bear on the advancement of human knowledge—of the physical sciences more especially, but even of those enquiries into invisible things, which have perplexed men from one age to another. The stricter demand for proof, as applied to the material world, has borne some fruit even in this obscure region of speculative thought.

What I am about to write on this subject will have little novelty for scientific men, or those who have reflected upon it, but may serve to give others out of this pale some general ideas of the actual attainments of our time, and some presage of what lies beyond it in the future.

The better determination of what is *solved* and what *unresolved*, and the same discrimination applied to the higher question of what things are *resolvable* and what *irresolvable* by human research, are points which may first be noted as characteristic of the science of our time. Truth and certainty are more clearly defined as the objects sought for under the conditions just stated. These conditions, however, must not be received without limitation. The lines between the *known* and *unknown*—between the *possible* and *impossible*—are not always drawn as distinctly as these terms assume. The boundaries are perpetually shifting, and at no period so rapidly as in our own day. Arago says: 'Celui qui, en dehors des mathématiques pures, prononce le mot *impossible*, commet une imprudence.' Twenty years ago who would not have declared it impossible to detect and define metals in the sun and fixed stars, or to transmit within a few minutes a message from London to New York? Physical science in its progress affords many such examples, though none more striking. But even here, and much more still in the physiology of life, in mental philosophy and theology, there are problems insuperable in their very nature, which men of highest capacity, willingly or unwillingly, feel as such, and submit to the limitation. The field, indeed, is ample enough for all labourers in physical science within the boundary thus defined; and is ever enlarging in its compass. Each discovery made shadows forth new questions to be solved, often of higher import than the discovery which suggested them. Those most deeply versed in the phenomena of the natural world best apprehend the large future which lies before them. It is only in the dark circle of ignorance that knowledge is regarded as certain and complete.

The ancient and mediæval philosophers, careless, or unable to define the true objects and limits of enquiry, have left us a large legacy of vague or incongruous language in philosophy and science, from the thraldom of which we are hardly yet emancipated. I need not speak of the tyranny which mere phrases often exercise over the understanding, even of the wisest. It is one of the best marks of present progress that, in natural science at least, so much has been done to rescue the mind from this tyranny of words, the coinage of older times and imperfect knowledge. Much, however, remains to be done in reforming and settling the language even of the purest sciences. Their vocabulary has of necessity been much enlarged by their very growth, while the fact that almost all are in progressive or transitional state, renders this vocabulary in many cases conventional only, awaiting those changes which more perfect knowledge will require. Chemistry especially is in this condition, with the embarrassment of four or five rival nomenclatures to express the same existing facts.

The release from the bondage of old opinions is still more marked than the changes of language. Ancient authors are now quoted, not as authorities for truth, but as indicating those earlier efforts to attain it, which form one curious page in the history of mankind. We read the 'Timæus' of Plato as a tissue of strange hypotheses, utterly wanting in the elements of proof. We have a more faithful interpreter of nature in Aristotle (τῆς φύσεως γραμματεὺς), eminent far above his age as an acute and zealous observer, but not recognised as such during the darkness of the mediæval centuries. The scholastic philosophy of that period embraced only the worser part of the great works he has bequeathed to posterity.

Partial knowledge often perplexes more, and furnishes larger material for false philosophy, than does sheer ignorance. It is the better understanding of the nature of *proof*, and the cogent demand for it, which characterise the science of our day. Taking the total circle of human knowledge, we find in this single condition the source of all recent progress, and the foundation of what is to come. The inductions of ancient philosophy, with rare exceptions, were drawn from evidence at once shallow and incomplete, unchecked by experiment or multiplied observations. The change since made forms a signal step in the intellectual advancement of man. While doubtless due in great part to the rigid demands of physical science, the influence has collaterally extended to other and less defined branches of human knowledge. The whole may best be described as a growing demand for Truth, put before us as the end and measure of all evidence, to whatever subject directed. So in a general sense it must ever have been regarded. But the Ἀλήθεια Θεῶν ὁμόπολις of the ancients was Truth in the clouds, or seen through the mist of vague theories which no right methods of research came in aid to dispel.

It must be owned, however, that there are still many who live in this cloud-land of imperfect knowledge and visionary belief. The phantasms of mesmerism, and the still worse follies or frauds of spirit-rapping, table-turning and clairvoyance, often wrapped in the phraseology of real science, deceive not only the many credulous of the world, but even some men who in other matters can justly appreciate the evidence of truth. Such incongruities of belief belong to every age; but the counterfeit never gets the lasting stamp of the genuine coin. The followers of these fancies are prone to pass from one to another, allured by novelty and more mysterious pretensions. It is a matter of mental temperament; and, after considerable experience in life, I find myself generally able to indicate the persons most liable to be thus deluded. Of these mockeries of science the greater number in my time have been of imported origin; and it may further be said that the most recent are the most preposterous —as offensive to religion as to science and common sense. Happily the progress of true knowledge is little retarded by these vagaries, which speedily efface one another. Each is destroyed in turn by the same credulity which begot it.

This stricter demand for proof in every part of modern science is at once a consequence and the cause of experiment, as a main agent in research. The simple history of experiment, in its negative as well as positive incidents, is in itself a curious record of mental progress. The necessities or uses of life must have led the earliest and rudest races to *tentative means*, in dealing with the raw materials of food, raiment, ornament, and defence. But, even when we come down to the Greeks, we find no distinct recognition of the nature and value of experiment; and encounter the strange fact of a people subtle in observation and thought, and aspiring to higher knowledge, yet failing to seize upon a method so necessary, and seemingly so obvious, for its pursuit?[1] If reason did not suggest it, one might have expected accident to do so. Coming down yet later, we find still only a vague understanding of the term; and scarcely half-a-dozen names (Roger Bacon foremost among them) break forth as lights of discovery amidst the darkness of many centuries. The researches of the alchymists were blind and next to profitless. Lord Bacon first designated the value of experiment, yet scarcely with a full appreciation of all its methods of proof. Though in England alone we have the names of Harvey, Boyle, Gilbert, Hales, Hooke, and the greater name of Newton, belonging to the same century, yet was the progress of this principle still partial only, and hampered by adhesion to many errors of early date. And the same remark applies generally to the science of France, Germany, and Italy at this period; great though some of the men were who adventured on new fields and methods of enquiry.

Chemistry, in its successive stages, is the science which has done most to develope experiment as the great instrument of progress. Electricity, indeed, and optics (the latter in the mighty hands of Newton), furnish early examples of its employment. But chemistry, in dealing with the relations and interchanges of matter in its most subtle shapes of atoms and molecules, comes by compulsion to experiment as the sole means of fulfilling its objects. Analysis and

[1] The exceptional instances of the researches of Archimedes—the experiments of some of the Pythagorean school on the vibrations of bodies, and a few others, do but render the general fact more striking.

synthesis are the two great functions of the science, and thus only can these functions be rendered effective. In its present state, and irrespectively of ulterior results almost certain in prospect, chemistry is the most wonderful exponent of the power of experiment in giving man access to the inner secrets of nature and those laws which govern the material elements around us. Organic chemistry, especially in its synthetic part, has justly been called a system of *atomic architecture.* Working by the most refined processes of addition, abstraction, and substitution of atoms—of different kinds, but ever in definite proportions of weight or measure—the chemist has been able to elaborate and arrange, in determinate series, numerous products either wholly new or created heretofore only by the hidden workings of organic life. Recently these secret processes have themselves been brought into partial subjection; and, starting from the same simple elements with which Nature works, the chemist obtains in his laboratory a long series of substances, identical in type and composition with the products of animal and vegetable life. This may be ranked among the greatest achievements of modern science. It is due to experiment as the instrument of research—experiment so elaborate and refined, that its mere methods become a science, irrespectively of the results attained.

Analysis, though not exercising this creative power, signally attests in its present exactness the progress of experimental science. Quantities and proportions before inappreciable are now brought into strict account; and, what is yet more worthy of note, new methods of analysis, subtle almost beyond conception, have been furnished collaterally by other sciences. To the spectrum analysis we owe already four new metals, and the detection of others before known, in combinations under which their infinitesimal proportions had hitherto concealed them. The analysis by *diffusion* and *dialytic separation*, due to the researches of Mr. Graham, is another of these new methods, the more interesting from its direct relation to the atomic constitution and molecular changes of matter.

Electricity, though still a mystery in certain of its most elementary facts, has been a field for the highest refinements of experimental research; illustrating by wonderful results the new and mighty power now submitted to the will and uses of man. Heat, as one of the great motive forces of the universe, has been similarly the subject of experiment, creating what might be called a science in itself, were it not so closely linked with other phenomena of the natural world. Light, that sister 'offspring of heaven,' has afforded to man one of his greatest triumphs, through those beautiful experimental researches, aided by the higher mathematics, which have disclosed to us the sunbeam as the most marvellous object in the natural world, and carried our knowledge yet beyond, to the sun itself—to its elements and unceasing changes of state. All parts of physical science yield similar if less striking illustrations. All are so connected by physical relation of matter and force, that a successful experiment in one science often discloses the secrets of another seemingly far removed.

The perfection of the instruments now applied to experimental research deserves study in itself, as an attestation of human progress. Seneca somewhere deprecates all manual methods and inventions as beneath the dignity of philosophy. Modern science dignifies and hastens to appropriate them, whatever they be. A common catalogue would contain all the admirable inventions of apparatus serving the purposes of each science, and enabling one science to minister to the progress of another. Look, for instance, at the various aids which electricity has rendered to all the sciences, through instruments depending on its phenomena—such as the thermoscope, the electric lamp, the electric apparatus connected with telescopes for transit observations, the electric telegraph, and the many admirable devices by which this wonderful agent—its current simply cut off or restored—is made to record almost instantaneously, whatever the distance, the words of human intercourse, and to register the most subtle phenomena of the natural world. The various apparatus by which the electric element itself is evolved, directed, and multiplied in quantity or intensity, illustrate equally well this instrumental perfection. Strange that it should have been thus far attained, while we yet are ignorant what electricity really is! [1]

What has been said of experiment as bearing on

[1] The researches of Matteucci, Du Bois Raymond, and Helmholtz on animal electricity, and on the rate of transmission of the nervous agent through the nerves, muscles, and brain, have required and produced instrumental apparatus of the most consummate delicacy as well as complexity. The same description may be given of the instrumental means employed by Wheatstone, Foucard, and Fizeau to determine the velocity of electricity and light.

the progress of physical science applies also to the knowledge got by *observation.* Here, again, the genius of the age has invented instrumental aids, so augmenting the natural powers of the eye as to give access to that which is *greatest* and that which is *least* in the world around us. The telescope and microscope, both modern creations, have attained what may almost seem the limit of perfection. But, apart from these instrumental means, the whole theory and practice of observation has undergone a conspicuous change. Phenomena, in every part of the natural world, disregarded before, are now registered in the great volume of Science—the simplest and most familiar often disclosing truths which are denied to more recondite research. Observation in its methods and records has become almost a science in itself. The senses even have been so tutored into obedience to the intellect as in some degree to augment their natural powers; while the instant embodiment of every new fact observed in some record of prior knowledge gives both motive and direction to those who labour in this large and fertile field.

These new and various resources of physical enquiry have not merely extended all the sciences of older time, but have given origin to others unknown as such. Electricity, including the cognate phenomena of Magnetism, is the most striking example; since the very power itself, though pervading our globe, and probably worlds beyond, may almost be deemed a recent discovery. Though dealing with elements more familiar to the senses, the sciences of Light and Heat are virtually the creation of the last two centuries. The knowledge of the fossil world, vast though its scope and attainments now are, has grown up in the course of a single lifetime. When I was at Edinburgh, from 1809 to 1811, an angry contest existed between the Plutonian and Neptunian schools of Geology. The 'Ossemens Fossiles' of Cuvier had been published a few years before; but this great topic scarcely found place in the controversy. Its value as an index to geological ages and successions was barely understood, and its future greatness as a science wholly unseen.

The term *prediction*, in its strict sense, belongs almost exclusively to the science of our own day. Except in a few astronomical phenomena, the knowledge of the ancients never reached to this highest expression of intellectual power and progress. The faculty of predicting, through known phenomena, others yet unseen and unknown, needs no epithets to mark its import. It is, in fact, the nearest approach made to those higher laws through which the Creator acts in the natural world, and is due mainly to that increasing exactness of experiment and observation, of which number, weight, and measure are the practical exponents. *Savoir pour prévoir* is the key to all scientific predictions. Every branch of physical knowledge is rich in examples of them. Astronomy, Optics, Chemistry, and Electricity furnish the most striking—such as the elliptic polarisation of light—the discovery of new metals by spectrum analysis—the discovery of Neptune through the perturbations of Uranus—the discovery of numerous chemical compounds through the laws of atomicity and definite proportions, &c.

While recognising these results of the human intellect as best marking man's place in creation, it is needful to note how few there are capable of reaching them. In comparison with men thus endowed, able to bring their endowments into action, how endless the multitudes of all times and races of men, the cyphers of creation, who tenant the earth in successive generations, without leaving traces of their existence behind!

A clearer perception of the *instantiæ crucis*, growing out of the more rigid demand for proofs, is one of the characteristics of modern science. The value of these cannot easily be overrated. Kept closely before the mind, they give stability to actual knowledge, and starting-points for its future extension. There is no single well-assured truth, however limited its seeming import, which may not become the germ of others. It is a part of wisdom to store the mind with instances of this kind, which appertain to general philosophy and theology as well as to physical science. The simpler such instances are the better. If encumbered with details, their pertinency and practical value are proportionally impaired.

In a record of the progress of the physical sciences it is fitting to note the curious *halts* or *arrests* often occurring in connexion with some particular theory or fresh discovery of facts. Many retrospective instances might be given of these unstable resting-places in our knowledge. The doctrine of Phlogiston in its origin and fate is one of the most familiar. The doctrines of Elective Affinity held by the earlier chemists, and the theory of an acidifying principle derived from the discoveries of Lavoisier, are other examples in point, as is also the Emission theory of Light, long implicitly held and successfully applied to the solution of many phenomena. I would cite the Primitive Cell theory of our own time as another instance. Physiologists exulted in the discovery of this common germ of all vital organisation, as though it were a terminus in this line of research, not duly considering that cells themselves are a product of organisation, and that they contain matter which has better claim than its receptacle to be regarded as *germinal* to the wonderful varieties of life issuing therefrom. Without noting other such instances, we may set them down generally as mere pauses in the march of science—often, indeed, as convenient resting-places whence to obtain more distinct views of the objects to be sought for beyond.

The vast accession of knowledge to man from study of the elements of Matter and Force in the universe necessarily implies some change in the amount, as well as methods of use, of his intellectual powers. I have already spoken of the more perfect understanding of what is Truth as founded upon evidence. *Inventiveness* is another faculty of mind awakened and enlarged by the researches of experimental science, as well as by that spirit of competition which civilised life engenders and sharpens. The mind grows within itself by exercise of its powers; and we have some reason for supposing that this growth may become hereditary;

not indeed by any obvious or certain law, but under conditions analogous to those by which bodily likeness is transmitted to successive generations.

I have been illustrating the progress of human knowledge chiefly through the physical sciences; and this, in truth, is almost a necessity of the subject. It can hardly be affirmed that mere speculative thought, apart from material research, takes a wider or bolder form than it did in the ancient philosophy. There is scarcely a single hypothesis, whatever the subject, which has not some prototype, more or less defined, in one school or other of the Greek, Roman, or mediæval ages. Man, Mind and Matter, Life, Death and Futurity, the Nature of the Deity, the Origin of Evil, &c., furnished to them, as to us, problems upon which all who have capacity for thought are in some sort compelled to exercise it. But these great questions were then more loosely propounded and vaguely pursued. Physical science in those times lent little aid either by facts or methods of enquiry, and inductions were drawn from evidence the most incomplete. The condition of the world too is changed. Thoughts and speculations are no longer solitary and exclusive, or limited to particular schools and forms. Knowledge has become a common heritage, expanded and enriched by free and rapid intercourse over every part of the habitable globe. Nevertheless the difference just denoted is ever present to observation. The physical sciences have rapidly and universally advanced. Metaphysical questions, though better defined in their purport, remain unsolved in their ultimate truths, and are so transmitted from one age to another.

One other indication, and that a striking one, of the recent progress of natural science, is still to be mentioned. I allude to the much closer connection established, not merely among the labourers in this great field, but also among the objects of their labour. Sciences which, as we formerly comprehended and pursued them, seemed to have no common kindred, are now seen to be linked together by relations depending on those higher laws of matter and force which govern the natural world. These new relations (or *correlations*, to use an adopted term) are not only of deep interest in themselves, but they open a way towards that profound philosophy which seeks to give a certain *unity* to the whole. To what extent the bold aspiration of Laplace in this direction may hereafter be realised, it would be hard to say. He has himself used the pregnant phrase, 'Notre ignorance est immense.' But that we shall approach much nearer to this attainment than we have yet done, is testified by the whole history of modern science—a history which continued half a century hence will, I feel assured, embody results far beyond all present contemplation. Electricity and Atomic Chemistry alone are volumes leaving ample space for the records of future discovery.

I may notice, before closing this paper, those bold generalisations in science which occur from time to time, marking the genius of the men propounding them, and often serving a higher purpose as regards science itself. Take, for instance, the expression of

Kepler, '*Nego ullum motuum perennem non-rectum a Deo conditum esse*'—or that dogma of Leibnitz, that nothing in nature occurs *per saltum*, or without a sufficient reason why it should be so rather than otherwise—or Pascal's definition of cases where, though two contraries are severally inconceivable, one must necessarily be true—or a more specific generalisation in natural history, that there is no living being whose form is geometrically regular, nor any living form having plane faces. . . . Such generalisations, of which many others might be cited, have their value even in the exceptions and contradictions they evoke. The discussion of these often leads to still higher laws, embracing the very exceptions which create the controversy.

UNITY OF THE CREATIVE POWER THROUGHOUT CREATION.

[Written in 1867.]

As a general question this is answered by general belief. But what we call belief in the world is often only vague conception or unmeaning assent. It is well to hold in hand, for ready use, some special evidences for a truth thus momentous—one so closely connected with the attribute of individuality and design in the Creator.

Astronomy, through its wonderful interpreter, Light, gives answer for that which is most remote in universal space. The most minute telescopic stars, the faintest forms of nebulæ transmit light to us, and are known to exist solely by this transmission. If there be any elemental power, having true and proper unity, it is that of light as it comes to us from the celestial bodies. The laws of its reflection, refraction, and polarisation are the same, as well as the rate of motion through space, shown by the phenomena of aberration; while the photographic image of Sirius (a star having a parallax of little more than a quarter of a second) gives proof of a chemical action of light from this enormous distance identical in kind with that of our sun, or of the artificial lights we create for experiment in our lecture-rooms.

Nor does the argument for Unity, derived from light, stop here. Recent researches have disclosed in the spectra of several of the fixed stars certain lines, exactly corresponding with lines in the solar spectrum. The latter, by an admirable series of experiments and deductions, has already shown the existence in the sun of various elements, chiefly metals, familiar on our own globe—a discovery which ratified at once the boldest assumptions of hypothesis. Conjectures, invited to the question by the analysis of aerolites, and by other considerations, have now been realised, not for our solar system only, but for worlds and systems so remote in space that their light takes years to reach our globe. Waves of light which quitted the surface of Sirius thus long before make known to the human enquirer the identity of certain material elements there with those familiar to him by every day's sight and use on the earth. Other stars, similarly examined through the identity of these spectrum lines, extend the same presumption to other parts of sidereal space; while light itself, in disclosing thus far the sameness of material out of which those vast works of creation have been elaborated, declares its own identity throughout the universe, as their exponent and interpreter. Taking the whole together, it is an argument for the unity of creation more perfect and more profound than seemed within the power of man to attain.

Light, then, the fountain of all our knowledge of the universe without, might alone almost suffice in demonstration of the truth we seek for. But the mechanism of the heavens also, as it comes interpreted to us by matter and motion, and signally by that great force of gravitation on which these motions depend, is another explicit declaration of the Unity pervading the most remote parts of space. The accordances here shown to exist, and in some cases even predicted, are such as to exclude all idea of fortuitous relation. A common cause of power can alone be brought to the explanation of effects thus universal to our knowledge.

And other great forces also, as Heat, and Electricity in its different forms, concur severally as well as conjointly in the same proof. Heat, as an agent, we can scarcely dissever from light in our own solar system; and we have every reason to presume the relation to be the same wherever light exists.[1] Of electricity, whether under its condition of magnetic force or in other forms, we must speak with less assurance; yet with strong presumption that this element, whatever its intrinsic nature, is largely concerned in the phenomena of universal creation. Take a single fact in evidence, and this from beyond the confines of our own system. When we find iron as a constituent of so many of the fixed stars, how can we justly suppose that a metal so strongly characterised by its magnetic properties on earth should be devoid of these relations in any region of space however remote? If this inference be just, it involves collateral conclusions over which we can scarcely impose a limit. The magnetic force existing in these stellar worlds denotes the pre-

[1] Since this was written, the admirable methods employed by Mr. Higgens with the thermopile have given well-assured proofs of heat derived from Sirius, Arcturus, and others of the fixed stars.

sence and action there of that great electric element which, from the universality of its functions on our own globe, we might well assume to be a cosmical agent in the larger sense of the term; expressing as such the unity as well as grandeur of the creative power.

If there be doubt as to electricity or magnetic power pervading other systems than our own, there can be none as to that great power of gravitation—an attribute of all matter; and by its determinate laws interpreting to us the movements not solely of our own planets and comets, but of many of those numerous double and multiple stars which the telescope grasps and defines. Orbits and periods depending upon this law—'the pendulums of eternity,' as they have been called—are calculated for worlds a million times more remote from us than we are distant from the sun.

In our own system Laplace has applied his 'Calcul des Probabilités' to the modes of motion of the several planets and satellites; and he expresses by the ratio of four millions to unity the presumption of a single original cause producing these motions. Such presumption to human reason is equivalent to a certainty. No doubt, indeed, can disturb conclusions as to unity of origin derived from these phenomena. None but a single *Creative Power*, define it how we will, can be concerned in evolving laws thus congruous, universal, and absolute.

Another argument, though less cogent, is furnished by what may be called the *sidereal series* of the universe, ascending from our sun and planetary system to other suns and their satellites or companions, disclosed to us by the telescope—from these subordinate stars or systems, scarcely numerable by man, to the Milky Way, which embodies them all—and from this again to other nebulous systems, whatever their nature, now counted almost by thousands in the vault of space. The relation here, as far as reason can compass objects thus vast, is that of a Unity of Creative Power.

All this evidence comes from the universe without. That derived from our own globe, though different in the scale of the objects and actions concerned, is not less conclusive. In its most general form (that which we are now seeking to obtain) we find this evidence in the *mutual and uniform relations* of the different kinds of matter on the earth—relations *inter se*, as well as to those elemental forces of Heat, Light, Electricity, Gravitation, &c. ever acting around or within them, under precise laws and with mutual and constant equivalence of effects. The whole series of chemical phenomena, and especially of organic chemistry, as construed by the atomic theory and the law of definite proportions, gives continuous and complete proof of the Unity of the scheme, complex though it be, to which these actions belong. One original source of power can alone be concerned in effects so perfectly congruous and co-ordinate. The farther we advance in the science of molecular physics, the wider becomes the scope of the evidence which retains its constancy, even when thus derived from the most secret recesses of the natural world.

The argument for Unity is the same when we look to those elements and actions through which the various forms of organic life come into being, and severally fulfil the conditions of their existence. The typical characters so strongly marked in this great scheme, equally among existing and fossil forms, show a common power and intention pervading the whole. The mutual adaptations, uses, and instincts of animal life more especially, and the relations of this life to the varying conditions of the outer world, all enforce the same conclusion. It is not enfeebled by the doubts now thrown on the origin and perpetuity of species. If these be evolved, not by specific acts of creation, but by successive changes from a few primitive types, the argument still stands good for a single original power, endowing organic life with that capacity for progressive change which science is now seeking to explore.

Neither does the mixture of seeming ills and imperfections in animal life on the earth annul the conclusion at which we arrive. The good and the evil, taking our imperfect judgment of what belongs to these names, are closely interwoven in the same work—whether from an unknown necessity, or from mere contingency, or from some unseen higher purpose, no natural philosophy has yet fully explained. The question, in fact, merges in the higher one of the Origin of Evil in the world—that problem which has perplexed the wisest and most devout minds in all ages. But whatever view be taken of it, we need not recur to any Manichæan doctrine of an antagonistic power to meet the difficulty. The argument we have dwelt upon for the Unity of creation fully suffices to refute any such hypothesis, which could not indeed solve the problem for us if adopted.

This argument, I may add, does not go a step beyond the affirmation of unity. All that regards time, material, and method in the acts of creation may be put apart, as knowledge to be reached only relatively and remotely. What human enquiry may rightly seek to attain is a larger knowledge of phenomena, and of those correlations among them which go to establish more general laws, and, by removing anomalies, to give still higher conceptions of Unity in the universe—lofty functions in themselves of human reason, and sufficient in scope to employ the genius and industry of ages to come.

PLURALITY OF WORLDS—ARE OTHER PLANETS INHABITED?

A question not of curiosity only, but, if capable of being answered, even presumptively, one of profound interest to our conceptions of the universe and of its Creator. Life, physical and intellectual, is highest among the wonders of creation. To gain the conviction that it is not limited to the globe we inhabit, is to enlarge our views of that Supreme Power which designed and brought it into being.

Neither in the Old or New Testament do we find a distinct answer to the question, though perhaps a few inferential allusions to it. The same may be said of the classical writers: Plato, Aristotle, Lucretius, and Seneca, as far as I can recollect, are silent on the subject. Pliny, who grasps at everything known or imagined, is equally so. The explanation of this is doubtless to be found in the grand error of all ancient astronomy as to the *locus standi* of our globe in the planetary system and universe at large.

The argument for life existing in the planets of our system is summarily this. The earth, tenanted, as we see it, by man and innumerable lower forms of life, is but one in the series of satellites of the sun; intermediate to the others in distance and size, but without any marked specialty in its astronomical relations. All are alike in general configuration, all subject to the same laws of gravitation, revolution, and rotation on axis.[1] Solar light and heat are common to all, with diversities only of degree. Reflected light is conveyed to several of them, in some proportion to their distance from the sun, and by the agency of moons.

It is hardly conceivable that such physical relations and resemblances as these should exist without the presence of life, and intelligence also, in the worlds so related to us. Can the earth be thus peopled with all its various living forms, and the other planets be mere brute globes of matter, with no breath of vitality upon them? The argument, as one of strong presumption, might almost be vested in this simple question. If a single case were taken for special illustration, it might be that of Venus and the earth. The magnitude of the two planets is almost exactly the same. The earth is seen from Venus, as Venus is by us; the only difference depending on Venus being one-third nearer to the sun. The mass and density of both globes are nearly alike. The time of rotation on axis differs by forty minutes only. The larger reception of light and heat by Venus, and the appendage of a moon to the earth (facts not perhaps without relation to each other), are the sole physical differences obvious to us between the two planets. Can one of them be devoid of all life, while on the other it is swarming so variously and

[1] In his 'Calcul des Probabilités,' Laplace shows that there are 4,000,000 to one in favour of the forty-three motions of rotation and revolution of planets and satellites from east to west being produced by one and the same original cause.

profusely, culminating through a long series of gradations in the supremacy of man?

The diversity in the physical conditions of the several planets, great though it be, does not seriously affect our conclusion. Many of these differences are of degree only; and even as regards the material composition of these great globes, recent discussions have shown us that the same elementary matters exist throughout, however various the manner of their consolidation or their proportion in each planet. But whatever the physical diversities in parts of the system, it is still a system, and brought into being by that Power which, in endowing the earth with such various faculties and forms of life, has almost attested to us the same will and power directed to other worlds than our own. The vast distance between Mercury and Neptune is bridged over by intervening planets and their satellite moons—the latter themselves a volume of argument in the question. Is it likely that the earth, intermediate in the series, and marked by no obvious specialty of position or physical characters, should alone have the prerogative of life upon it?

The objection that to people the other planets with living beings we must suppose very different endowments from those which belong to life on the earth, is one that goes far to answer itself. The full admission of this fact need in no way impair our belief. We have but to look at the endless and wonderful diversities of life which surround us here, and to the changes from physical causes of which they are severally susceptible, to see that no limit can be set to special adaptations, where the prevision and power to adapt are so manifest to our reason. The various climates and conditions of the earth itself interpret to us in their effects endless possibilities of existence in other worlds than our own.

The arguments which serve to this conclusion regarding the planets do not apply to that mighty central globe, 'lo ministro maggior della natura,' which fulfils the great function of keeping all in their orbits and giving light and heat to all. We cannot prove or presume anything beyond this, nor indeed conceive a habitable world in this great focus of illimitable forces. But the argument again opens upon us, when proceeding further into the depths of space, and discovering, among what we call the *fixed stars*, numerous systems of suns and satellites, having kindred with our own in the phenomena of gravitation and revolution. Telescopic vision tells us distinctly of these wonderful and complex relations in what to the naked eye are but the single and immovable stars of heaven. The light which solely gives us knowledge of their existence, though taking years for its transit through intervening space, reaches the earth with properties essentially the same as the beam coming direct from the sun—not, indeed, affording sensible heat, save in a few instances, to the keen scrutiny of modern research, but yielding photographs by its chemical action, and certain of those spectrum lines, which tell of material elements in those remote worlds analogous to, in fact identical with, some of the components of our own globe. This last wonderful attainment of human research is prolific of suggestions as to that unity of creation which embraces in itself the argument we have in hand.

These proofs then are strong in presumption, though less cogent than the argument as applied to the planets of the solar system. It would be going back to the very infancy of human intelligence to suppose these innumerable stars, thus far known to us, to be mere barren masses of unorganised matter, with no higher destiny belonging to them. Can our conceptions of the Deity, based upon what we see in our own little world, justify any such conclusion? Theology may be silent on the subject, but such silence need not enthral those higher conceptions which astronomy furnishes of the unity as well as grandeur of the creation.

The only author who with any ability seeks to impugn the opinion I am defending, is my excellent friend the late Master of Trinity. In his volume, whimsically entitled the 'Plurality of Worlds,' he ably urges all that can be said against it, dwelling especially on the fact that the earth itself was left during incalculable ages as a lifeless globe, or maintaining only those lowest conditions of life which, though members of the series, and even agents in forming many of the strata on which man has his abode, do yet feebly represent that higher vitality which now exists on our globe. The argument thence drawn is simply this: If the earth did thus exist through ages, why may not the other planets remain in the same state to perpetuity? The question is best answered by another. If the earth, passing through these preliminary stages, has become, either by a designed method or by conjectured causes of change, the abode of the higher animals and of man, why may not the other planets have passed through the same or analogous conditions and attained the same result? Both questions are of presumption only. The latter, I think, has greater weight in the argument; and we cannot reasonably admit any dogma of ancient theology or inference from Scriptural language, which some have brought into it, to annul the conclusion so obtained.

Taking the whole problem in its simplest form, it will be seen as one never to be solved by absolute proof, but admitting of strong presumptive evidence, which is likely to become still stronger with increased knowledge of the physical conditions of the planets themselves. The track of recent discovery has lain in this direction, and no limit can yet be assigned to its further pursuit.

MATTER AND FORCE, IN PHYSICAL PHENOMENA.

ALL physical science and philosophy are concentrated in these two terms. They have furnished, of late more especially, the text for much and various discussion—discussion, to which the obscurity as well as grandeur of the ultimate truths involved in them has given additional zest. The two words have been seized upon, indeed, with a curious avidity, and made to subserve speculations at once vague and incongruous. I can count a dozen books, and many more articles, which during the last few years have dealt with the questions they involve. Some speculators (for speculation it must still be called) merge matter wholly in force. Others see force only through the conditions of matter. Without assuming to add anything new on the subject, I take it up as one on which I seek to get some understanding of what has already come, or may come, within the scope of human enquiry.

The need of a just definition of the two words is that first felt. Force, or power, that acts; matter, that which is seen, or sensibly known, to be acted upon—these are the elements of the problem, but too general in their expression to be of much service to us. We are met *in limine* by questions hard of solution. Is force really an entity of power distinct from matter?

or is it but an abstraction, an expression for matter under different modes of existence and action? Or speaking of what are termed forces severally—mechanical, chemical, calorific, electrical, &c.—seeing that they are for the most part mutually convertible, and under equivalents of power—for this power is never extinguished—may there not be some yet undiscovered *unity* for all, modified by the conditions under which it acts, and possibly including even gravitation and vital force in the one category?

Such questions carry us to the extreme verge of physics, if not indeed beyond. They have perplexed schools of philosophy in every age, and inevitably so. Matter, the substratum of all that is present to the senses, is seen at every moment to undergo changes from powers, of which the senses give us no cognisance. What are these unseen forces—call them *δυνάμεις*, *ἐνέργεια*, *vis viva*, potential energy, plastic force, Kräfte, or whatever the diversities or the impotence of language may suggest—which thus give movement and change to the material world? What is the matter itself, thus acted upon? Is it something brought into existence by a Creative Will of higher date—or is it eternal in itself, and that with which the Creator worked in evolving and giving laws to the visible universe? The questions thus denoted struck the ancient philosophers as they do us, and were answered with greater audacity from the absence of those checks which inductive science imposes. The terms *τὸ πάσχον* and *τὸ ποιοῦν* briefly express the groundwork of the problem in the Greek philosophy.

Cicero and Seneca denote the points in question clearly and compendiously. They have furnished food for thought and speculation to our own age under the stricter conditions of inductive philosophy. The enquiry, in truth, is pressed upon us as a necessity of our reasoning faculties; but it has become a privilege also, by giving the mind access to higher laws and relations than ever entered into the conceptions of ancient philosophy.

To recur to the relation of Matter and Force as the great question of all, we may at once put aside the enquiry whether matter be eternal or created, as one unapproachable by reason. Its existence through all time, or its creation at a given time, are alike incomprehensible. Equally must be put aside all that concerns the definition of matter in the abstract, and that relation of its existence to the percipient mind, which has been the metaphysical wrangle of ages. When Mr. Mill says that matter may be defined as 'the permanent possibility of sensation,' we see, though dimly, what he means, but gain little by the definition. For all purposes of reason and research we must be content to deal with its forms and properties, as they reach us, through the senses, and convey perceptions to our consciousness. Subject matter to metaphysical pressure, and it is lost to human reason. Fortunately physical science has not been led astray by these vagaries of philosophy. It regards matter in a real sense, as made up of parts or atoms of inconceivable minuteness and mobility—each atom, whatever its elementary nature, having its individual properties and relations to others, whether similar or different in kind—which properties and relations brought into action by what we call the forces of nature, give origin to all the motions, combinations and forms of matter, living and lifeless, which we see around us. Few of these general definitions in science have much real value. That just given expresses at least all the essential facts; and if omitting one recent doctrine, viz., that it belongs to all material atoms to be *ever in motion*, this omission is justified by the impossibility of ever reaching the conclusion by proofs.

If it be difficult to define Matter, not less difficult is it to give an unexceptionable definition of Force. The very word carries with it a harsh compulsion of use. We cannot dispense with some such term in physical science, nor find perhaps in common language any that is better. The need is to express a power, or powers—immaterial for aught we can affirm to the contrary—by which matter is put and kept in state of motion or change. Difficulties of conception, ambiguities of language, and problems imperfectly solved, meet us here at the very threshold. One such question I have already noticed. Are these forces or powers, engaged in the actions of matter (and we shall see how numerous are the forms they assume), really distinct from it? or are they but properties or conditions of matter itself, evolved through the relations and interchanges of its elementary parts, and mutually convertible, so that action or force is never lost or lessened in total amount, but simply translated from one form to another? Modern science shows a leaning towards the latter belief. Heat, for instance, is interpreted (long ago by partial conjecture) as one mode of motion in the molecules of bodies, communicable in the same form, or convertible into other forms of power, with an exact mensurable equivalence of each and all.

This convertibility and equivalence lead us forward to what seems to be a great natural truth. They express the principle, that force, whatever it intrinsically be, is, like matter, never *lost* in the world—perhaps we might say in the universe—around us. Translated or altered in mode of action it may be, but not annihilated. This is a vast and bold conclusion, yet so far pressed upon us by experimental facts, that it cannot logically be evaded. It moreover connects together the different kinds or exponents of force by a strong natural link—one expressive of some higher unity, to which science is now more than ever tending. Heat, electricity, chemical affinities, and the mechanical powers come more especially under this connexion; and are subjected to formulæ, which not only expound but predict results. The indestructibility of matter is an ancient tenet of philosophy[1]—that of force may be called a discovery of our own time; indicated indeed by Newton, as a result of reason, but now amply attested by experimental research.

[1] We gather from Plutarch a dogma of Pythagoras:—

. . ῥύσις οὐδενὸς ἐστὶν ἑκάστου,
'Αλλὰ μόνον μίξις τε διάλλαξίς τε μιγέντων.

To this may be added the well-known lines of Lucretius:—

'Haud igitur redit ad Nihilum res ulla, sed omnes
Discidio redeunt in corpora Materiai;'

and elsewhere he states that the *Summa* of Matter remains ever the same.

The subjection of both matter and force, in the common comprehension of the terms, to this great law of indestructibility, and the correlation of certain forces in every act of physical change, press upon us the conclusion that they are in their very nature *a necessity to each other*—a phrase the most positive we are entitled to use in a matter thus perplexing to all philosophy. Force, apart from something on which it acts, is an unmeaning word. Boscovich, as well as some later philosophers, have sought indeed to give to it a more distinct identity; and to regard all material phenomena in reference to centres or lines of force as existences *per se*. Such mode of regarding the subject has a determinate value, considered as a *method* of enquiry. In like manner, motion may be dealt with mathematically, apart from matter or force. But neither in the so-called science of kinematics, nor in the doctrines of abstract force, do we find a solution of those profound problems which these several relations involve. We cannot separate, save for especial purposes of enquiry, things thus closely and indissolubly bound together in the natural world.

I have spoken of this relation of matter and force as one of mutual necessity of existence. It has been sought by some, as already stated, to carry the identity farther, and to consider each form of force as a particular mode or condition of matter. This conception, if it could be generalised as a truth, would bring us nearer to the kernel of the question. But we are still far from such attainment, and fresh obstacles occur at every step. Granting that the states and changes of matter are the sole exponents of what we call forces, we still cannot annul the notion of power, *other than the matter itself*, as initiating and evolving these actions. Refine upon the atomic theory to the uttermost, and show the mutual convertibility of forces by the different material media through which they act—high achievements these of our own time—the question still presses upon us, How are *initiated*, how maintained, these various and unceasing motions of matter, in masses or molecules, lifeless or organised into life? Would they not, if depending solely on causes intrinsic to matter itself, neutralise each other in process of time, and subside into absolute repose? Must we not then look to some cause of action from without—some power or powers to which no material attributes can be assigned, and which may possibly operate in other effects, not yet grasped by human observation?

It is hardly possible to deal with this subject otherwise than interrogatively. Take heat, for example—a power familiar in one form or other to every moment of our existence, and closely connected with the molecular theory, both by thermometric conditions and by the more obscure conditions of radiant, specific, and latent heat. If, in compliance with modern views, we regard heat as one *mode* of motion of matter, we come upon the question,—whence originated the movements, propagated thus endlessly, in every form and degree, by and through the atoms or molecules of the material world? Is it a condition *native to*, and embodied in, matter, and expressed to our senses and instruments in the various acts by which calorific equilibrium is broken or restored? Or must we, as stated above, bring in some cause, extraneous to matter itself, as originating those atomic motions which we characterise as the phenomena of heat? To go to the great fountain of heat in the sun, is but to shift the question a step higher. And it is not a mere verbal question, since we cannot construct a theory of heat without recognising, not solely the modes of motion of matter, but also the existence of forces on which these motions depend. It might almost seem here as if reason got into a trap of its own making. We call in powers from without, to which matter is subordinate, though necessary for their manifestation; and invoking these powers, we are left with the problem of their nature unsolved.

This illustration presents fresh difficulties when we come to the phenomena of *latent heat*, and propound the view, now generally adopted, that heat, as a force, imbibed originally from the sun by vegetable life on the earth, and following the conversion of the latter into coal, has been stored up *latently* for untold ages in a mineral form, to be developed in the furnaces of our own day. We cannot disprove this, or bring other more conceivable solution of this great natural problem. But when we speak of heat as a force consisting integrally of certain atomic motions in bodies, which force may be pent up for ages within these atoms, ever ready for extrication, we are bound to look fairly at the abstruse conceptions these things involve; if indeed they can be truly understood in any other sense than as a method of expressing phenomena.

The word Force, with all the adjuncts that have been impressed upon it, still looms before us, as a mysterious symbol, rather than an intelligible reality.

What I have said as to heat applies alike to other forms or agents of force, into which it is more or less directly convertible. The manifestations of these powers are in matter, but we cannot affirm that they are identical with or originate in matter. In truth, the material theory of heat, so ably expounded by Tyndall, embodies more of proof than we can bring to any other of the so-called natural forces. In chemical actions, indeed, including crystallisation, we interpret the phenomena through atomic motions and changes, strictly defined by laws of number, proportion and figure. Though we know that light as an agent pervades and affects matter in its intimate atomic structure, the evidence here is less complete than that regarding heat. Of electricity as a force I have spoken in another of these papers. In all these innumerable and subtle phenomena of attraction, repulsion, polarisation, &c. we see a general concurrence of actions, derived from what we must call force, in default of other and better name. If this be primarily resident in the atoms themselves, still must we recognise it by some name as a principle of motion and change.

Mechanical force, whether derived from gravitation or other cause, has been a favourite topic even from the infancy of science—partly from its practical value, partly because lending itself to certain abstruse conceptions, grateful to the genius of ancient philosophy; and indeed descending, by a sort of compulsion, to our own time. The terms, potential energy, actual or dynanic energy, tension, *vis viva*, &c. (Spanne-Kräfte and lebendige Kräfte) express conditions which we must needs admit, by whatever name we designate them. I have already alluded to the phrase of *latent heat*, and the difficulty it involves is the same when it is applied to power or energy of any kind, stored up in a quiescent state for development into future action. We know from ample proof the infinite minuteness of the ultimate parts of matter, and also the enormous energy of the forces on which their atomic actions depend. But while recognising these truths as necessary to any theory whatsoever, they give us no conception in what such latent power consists; whether in some physical condition of the atoms themselves, or in some unseen and nameless element of force to which matter in all its forms is subjected. These questions and complex relations, which it perplexes language to express, might well be deemed inscrutable, were it not a wrong to science, already advanced beyond so many seeming limits, to suppose it incapable of reaching higher generalisations than those now attained.

In looking to the chance of bringing the several natural forces to the unity of some such higher law, we cannot omit consideration of two of them which stand in some sort apart from the rest, though ever acting in concurrence with, or relation to, them. I mean gravitation and the vital force—powers widely different in themselves, both unknown to us in their intrinsic nature and origin, but well-defined, respectively, by their wonderful phenomena, and the laws which govern them.

Of vital force—that which gives form, function, and transmission of like qualities to successive living organisations—I have spoken in others of these papers, for the topic is one closely connected with some of the most profound questions of our time. The term *vital principle* has been reprehended as denoting what is unproven and needless, and certain writers have banished it from their philosophy. But that there is some power or force, name it as we will, working upon matter as its subject and instrument in the creation and maintenance of the various forms of life, cannot be denied without at once casting aside all argument on the subject. To say that a *nisus*, or power inherent in matter itself, can create a series of living beings, of definite forms and functions, is either a mere naked assertion utterly without proof, or a virtual admission of vital force under another form of words. The generation of life from life is, and perhaps ever will be, one of the insolvable mysteries of philosophy. But that it involves some special power distinct from matter, and not identical with any of the other forces known to us, must, in my mind, be taken as a truth furnishing a fair resting-place for our present knowledge. If asked what this vital force is, we may answer by the counter-questions, What is gravitation? What that force which puts the ether of space into those marvellous movements which we receive as light and heat? These problems are all of the same character, including questions with which no reasoning or conception can cope.

And among these questions comes one of deep interest, closely connected with the theory of vital force, viz., the *force of the will*, an entity not less real in its action on matter than those other unseen powers which we have been denoting. Whatever definition of force be adopted, this comes integrally under it. Nothing is gained in the way of distinction by bringing the word *spiritual* into the argument. This presents the mystery of force under another phrase, but leaves still unresolved that problem as to nature and origin which regards force in its every form. The word looms before us as an incomprehensible abstraction, yet, logically considered, as much a reality as the matter on which it acts.

Much has been thought and written on the subject of gravitation; and this is not surprising, seeing that it brings the relation of matter and force into the most simple and explicit form. In this simplicity, however, there still lies the same profound obscurity. A force pervading the universe, and so known in its great laws, that through them the astronomer can predict the existence and place of planets yet unseen, is nevertheless hidden from us in its origin, in its manner of transmission through space, and in its *mode* of relation to the matter on which it so universally acts. One might describe it as a power inherent and incorporate in matter itself, were it not that such terms are little more than a shelter for our ignorance. We can more clearly denote it, as a force of comparatively little energy where minute particles are concerned, but deriving from concentration of *units of power* that higher energy which renders it the great motor in the universe. It combines with, or is modified by, other motor forces, as in the rotation of the earth, but we cannot correlate it with any of those which exhibit polarities or dualities of action, and are mutually convertible under equivalents of change. Gravitation still stands alone in the simple sublimity of its one great law. If we ever get nearer to a true theory of the power, it will probably be through some new knowledge of the atomic conditions of matter. To these infinitesimal parts, and their attractions and repulsions, we may best look for the source of a power universal and permanent; and however vague the conception, there is none other to which we can attach belief. The theory of Mosolti (anticipated by Œpinus) taking this foundation, sought in mathematical forms to derive gravity as a residual power from a balance of attractions and repulsions, with the postulate of an electric atmosphere to each atom. This hypothesis, like that of Lesage, has lain dormant ever since. It wants the evidence of facts, though justified, I think, in thus seeking through individual atoms the origin of a power so manifestly derived from the concentration of individual forces.

But even could proof be pushed thus far, there still remains the crucial question, What is the power producing these atomic conditions or actions, which, concentrated more or less, we call gravitation? It is in effect the same question already applied to other modes of force. Are they actual powers extraneous to matter though acting upon it? Or may we generalise yet farther, in supposing a single force in the natural world, modified by the matter on which it acts? We pass here, however, into the region of metaphysical subtleties, and the most daring hypothesis is lost in a wilderness of words. Yet it is a tempting track; and the most sober philosophers have exercised themselves on the questions collateral to it. How is this force of gravitation concentrated, and how propagated through space; giving power to the sun to contain the planets in their orbits, and bring back the comet from its distant aphelion—agitating and raising the oceans of our own globe by an influence thus unseen and remote? The law of proportion to distance we know; but this tells us nothing beyond the presence of the power, whatever it be, at each and every point of intervening space. Newton strongly expresses the impossibility of conceiving that one body can act upon another without the interposition of *something* to convey continuity of force. To satisfy this demand for a material medium for other elemental forces, the aid of ether has been invoked—a mighty invocation, since as regards gravitation and light at least, it must extend to all known celestial space. On this subject I have written in another of these papers. It may well be termed a transcendental branch of science, comprising some of the most profound problems on which human reason can exercise itself.

I have spoken above of atomic or molecular attractions and repulsions, and I recur to the latter of these terms, as indicating another of those questions which perplex the theory of forces to our understanding. We speak of the attraction of gravitation as a force.

Must we not apply the same term to those *repulsions* which occur in the material world—most obviously in the atomic actions and changes of matter, and in electric and magnetic phenomena; but even, as we have some reason to suppose, in cosmical changes beyond the limits of our own globe? Boscovich admitted this as a part of his theory of forces, and some later physicists have followed him in the same view. Other forms of power, again, we designate by this one short word, so familiar in use, so difficult of scientific definition. The centrifugal force, though defined only as an antagonism, must still be admitted into reality as such. The force of cohesion, denoting perhaps only one mode of action of a larger power, must yet be recognised as an exponent of phenomena which cannot otherwise be understood.

The difficulties thus pressing upon every abstract conception of force in the universe are not abated when we bring the question to particular physical questions—such, for instance, as the *velocity* involved in the action of forces. We know from astronomical facts, with the recent concurrence of actual experiment, the velocity of those undulations which bring light and heat to the earth. We know that the velocity of electrical transmission, and therefore of magnetic force, has a close parity with this wonderful rate of motion of light. But though transcending all human conception, we are compelled, if adopting the conclusions of Laplace, to suppose an incomparably greater velocity in the force of gravitation. Time, in truth, is virtually annulled in estimates of this nature;

and *instantaneous transmission* offers itself as a phrase of readier adoption, though not relieving us from the necessity of admitting a medium of transmission, and a *rate* of propagation through it.

Reading over what I have written, I am more than ever impressed with the conviction that we cannot deal with this subject of force otherwise than as a method of expounding material phenomena. That there are powers (or I rather willingly say, *Power*) at work, distinct from matter itself, can hardly be denied. But human reason is incompetent to grasp in their entirety these great problems of the natural world. We record innumerable appearances attesting the relations of matter and force; and determine certain primary conditions necessary to their development; and research, thus directed, will doubtless attain yet higher results. But speculations which discard these sober methods, and seek to enter *per saltum* into the secrets of nature and creation, generally substitute words for realities, and are for the most part upset by the progress of science itself. It is a wise saying of Pascal, 'L'univers nous écrase. C'est le privilége de l'homme de savoir qu'il est écrasé.'

ON MATTER, FORCE, AND MOTION IN SPACE.

Though this topic has close kindred with that of the preceding paper, it embraces certain special questions in relation to the great phenomena of the natural world, which this general title may serve to designate. In using the three words, Matter, Motion, and Space, we touch upon the most profound problems of physical science, verging in part on metaphysics, yet open to research under those stricter methods which belong to the inductive philosophy of our day. The expression of 'matter moving in space' includes actions which range from the movements of suns and planets in the seeming void of the universe, to those motions and changes which pervade matter in its ultimate atomic forms, and which are *possible* only through this infinitesimal minuteness. The unity of science requires, even now, that these phenomena, however seemingly diverse, should be brought into some common relation. And the connexion so required is ever becoming closer and more apparent.

Nevertheless, parts of the subject may be viewed separately, and the remarks I here make relate chiefly to those motions in *outer space* which connect our globe with other portions of the universe, and more especially with the planetary system to which we belong, a field large enough to expatiate in, even without regard to its continuity with space and worlds beyond.

And first, as to space—that great recipient and container of all things which are the subject of human sense, and, through the senses, of human science. Putting aside the metaphysics of the Infinite, as thus applied, and the old subtleties of the *plenum* and *vacuum* controversy, the question presses upon us in this form: 'What is contained in space, beyond, and apart from, those aggregates of matter, great or small, of which our senses and other means of observation give us knowledge?' As early as the times of Empedocles and Aristotle the question of the τὸ μεταξύ—some medium between the objects of sense and the percipient being—forced itself upon philosophy. Modern science, dating here, as in so many other cases, from the era of Newton, has given more definite form to the enquiry; and taking certain of the great powers of nature as interpreters, has shown from these the necessity of supposing a *material medium* as the sole conceivable means of their transmission through space.

What there is of theory in this matter has been well borne out by observation and experiment. The interplanetary spaces of our own system, as the most accessible and fruitful field of research, have been zealously worked upon, with results which rank among the most wonderful attainments of science. Light, heat, and gravitation, those great elemental forces or powers, in the relations they establish between the sun and the earth, first gave a scientific character to the question, 'What is contained in space?' It was seen, under a sound philosophy, that the transmission of these powers from distant sources—as from the globe of the sun—and their modes of action on terrestrial matter could only be explained by supposing a medium through which power and action are conveyed. The same necessity leads to the belief that this medium must be *material*—a conviction which can only be escaped by affirming the case to be one incomprehensible altogether.

But physical science does not submit to be thus summarily treated. The instances are numerous where natural phenomena are interpreted by numerical expressions of space and time, and by modes of action, which no conception can follow, yet where conclusions are attained of almost mathematical certainty. If instances were needed, they might well be drawn from the marvellous divisibility of matter as attested by its atomic conditions—still more from the wonderful facts on which is based the undulatory theory of light. It is from the latter phenomena more especially that we deduce the necessity for a medium capable of receiving and transmitting movements of undulations or vibrations—conditions which matter alone can be conceived to fulfil. Such medium must from the same necessity occupy the total space between the propelling bodies and those recipient of the motions they conveyed; and in the case of light, at least, this conclusion carries us beyond our solar system to that universe of space, tenanted by other suns, and systems of suns, which send their light (if not heat also) to the earth, by the self-same laws of transmission. We are stopt *in limine* in this research, and the undulatory theory falls from under us, unless recognising some medium through which these laws may have effect.[1]

The question then arises, 'What is this medium thus universal through space, and how best to be defined?' We assume it to be material from the necessity just stated, and the term Ether has been adopted to satisfy, provisionally at least, the need of a name. From the senses we obtain no direct information as to its existence or properties, and the indirect conclusions of reason are drawn from a limited source. Imponderable we may call it, only in the sense that we cannot weigh it, since, if truly material, we must presume it subject to the common law of gravitation. We may affirm that as a material medium it is of infinite tenuity—the matter composing it being probably simple and elementary in kind, and its atomic parts (for we must needs so name them) of such perfect mobility as to convey the most complex and delicate undulations impressed upon them. Under the same view we may speak of the intense elasticity of the medium we are seeking to comprehend. On this point, and in regard to the existence of a self-repulsive force among the ultimate particles of ether, various hypotheses have been proposed, some of them, as those of Mosotti, aiming at a mathematical form. But no laws have

[1] Aristotle, speaking of the τὸ μεταξύ, adds, ἡ διὰ τούτου κίνησις ἐστὶ ἡ ποιοῦσα τὸ ὁρᾶν.

The experiments of Balfour Stewart, indicating a certain heating effect on a disk of aluminium rapidly rotated in an air-pump vacuum, require repetition before being brought in direct proof of a material ether.

been reached, save such as are based on a speculative foundation, and therefore inadmissible into pure science.

Another condition may more safely be assumed regarding ether, viz., that it is everywhere equal in quality and manner of distribution through space, except when coming into connexion with matter of grosser forms. This condition, though not always regarded, is seemingly essential to the functions which ether is invoked to sustain. A medium unequal in density or mobility of its parts, or fluctuating in other of its properties, could hardly fulfil the conditions essential to the theory of light. And the same remark applies to the other offices for which we invoke this medium of ether, as the sole method of expounding the actions and influences upon each other of bodies widely remote in space, and that retardation in the motion of certain comets which the keen eye of modern astronomy has revealed to us.

Justified in speculating thus far on the endowments of ether, as the occupant of space, we can scarcely go farther without *forcing* that barrier which, if passed at all, can only be so by patient progress of research. Mathematical analysis bridges over many chasms, and tells us under what conditions a given elastic medium may fulfil the functions we attribute to ether. But it does not enable us to conceive the infinitesimal minuteness and mobility of the atoms concerned in these actions, or to comprehend their elementary nature. It tells us nothing of those interstitial spaces which must co-exist with atoms to give them free motion and elasticity, and which become a new vanishing-point to our reason.[1] Nor does it touch that more fundamental question, namely, the actual nature of that mysterious Power which gives origin and impulse to these wonderful waves of ether, interpreted to us by light, heat, and chemical phenomena.

Difficulties of this kind are in nowise lessened when regarding ether, not merely as the medium of propagating impulses through outer space, but as interpenetrating and permeating other forms of matter, such as our atmosphere and the various grosser bodies on the earth. The phenomena of light, as expounded by experiment and by mathematical enquiry into the laws of refraction, polarisation, transmission, &c.—enquiry so searching as in some cases to have anticipated results yet unseen—all compel the admission of this belief, which conception vainly seeks to realise.[2] The atomic elements of luminiferous ether and of the more palpable forms of matter—solid, fluid, or gaseous—which ether pervades, are alike beyond the reach of the boldest hypothesis.

In denoting the ether of space, as the medium for transmission of power or motion from one part of the

[1] The question whether matter can exist *continuously*—that is, without parts or interstices—is so far removed from all possibility of proof that it leads to little more than a play upon words. To suppose the affirmative might solve some difficulties, but would engender others. All analogy from what we know is against it.

[2] No science is more ennobled than Optics by the names attached to it. Those of Newton, Hooke, and Huyghens have foremost place in date; but the present century has carried enquiry far beyond all prior limits, and the labours of Young, Fresnel, Arago, Herschel, Brewster, Wheatstone, Hamilton, Foucault, &c. have resulted in discoveries unsurpassed in any other branch of science.

universe to another, we do but give scanty description of the functions it is required to fulfil. The beam of solar light thus translated by a series of pulses rapid beyond conception in time and sequence, is in itself the most wonderful of compounds. Newton, full of the discovery he had just accomplished of the solar spectrum, quaintly describes it as 'the oddest, if not the most considerable, detection which hath hitherto been made in the operations of nature.' The more perfect analysis of this spectrum, now attained, has disclosed to us not solely the different physical properties of the vibrations producing the different colours, but also those invisible rays which by their respective refrangibilities evolve heat and chemical power—these latter actions attaining their maximum respectively beyond the opposite extremities of the luminous spectrum. Then came the further complexity of those numerous dark lines in this luminous portion, from which was inferred the non-emission of waves of colour corresponding to these lines—a naked inference now clothed with a positive cause. But the knowledge of the cause thus acquired, marking one of the most extraordinary steps in physical science, does in nowise lessen the wonder of these great natural phenomena. Putting aside the unsolved question as to the nature of the primary propelling power—(if we say it is the sun we do but screen the difficulty)—we have to look to our ether as the sole conveyance for these multitudinous waves, thus complex in their properties as expressed by their various action on matter, but complex also in the act and manner of their propagation, seeing that the modes of undulation, as regards both time and space, are different for the different coloured rays, and still more divergent in those which evoke heat and chemical effects. Add to these conditions the actual velocity of light (185,000 miles in a second), the yet more inconceivable frequency of the oscillations transmitting it, and the nature of these vibrations—transverse to the direction of impulse—and then bring the phenomena thus denoted to the conception of a material medium evolving them through all time without change or interruption, and we have this great natural problem, the occupation of space, fairly before us for contemplation.

Still taking our illustrations from light, we have to encounter the fact that this great agent in the universe is transmitted to us, possessed of the same properties, *i.e.*, is transmitted to us in the same way, from innumerable stars, single or aggregated into groups or nebulæ, the light from each one propagated in all directions through surrounding space. How is this endless intermingling of oscillations in the medium of transmission compatible with the individuality and clearness of the images they severally convey to us? Or, giving the question its greatest generality, how do these undulations, issuing, primary or reflected, from every luminous body whatsoever, within or without our sphere, traverse space in all directions without *conflicting*, so as to intermix and confuse sensible objects to the eye? The undulations of sound offer some important analogies here. But it is the higher prerogative of mathematics to have faced these difficulties, and through methods applicable to the whole theory of undulations to have attained conclusions which no common reasoning or experiment could reach—methods which render the very multiplicity of the actions involved an exponent of their congruity and constancy. There is a certain analogy here to those researches of Lagrange and Laplace, which submit even the secular perturbations of the planetary system to a principle of mutual compensation, acting through vast periods of time, but ever tending to maintain the order and permanence of the whole. It is by researches and results such as these that man may be said to be raised above his humanity.

But the ether of space must be looked to for other functions beyond the transmission of light, and its adjuncts of calorific and actinic or chemical rays. Science taxes it still further as the possible, though improved, medium for transmitting the forces of gravitation and magnetism through space. We can only conceive the propagation of these forces by intervention of matter. Newton held this explicitly as to gravitation. Everything we know of the magnetic or electric element connects this also with matter, and by far more complex relations of evolution, conduction, induction, and chemical action. Gravitation, to our present knowledge, stands alone among the great forces of nature. If it be ever brought into correlation with other powers, I am inclined to believe that the magnetic element will be the first to come into this conjunction, with the possible intervention of ether as a part of such correlation. I incline the more to this speculation from its concurrence with a persuasion I have long held, that if there be any special material element producing the phenomena of electricity and magnetism, that element will be found in the ether of which we now speak—occupying not solely the regions of space around us, but permeating the grosser forms of matter, and in their conjunction undergoing changes of which electricity may be one manifestation. All this is pure hypothesis at present, and insusceptible of proof; but that a closer approximation exists among those forces than has been yet discovered, is one of those presumptions well warranted by the whole course of modern enquiry.[1]

In any case, however, if gravitation and magnetism be transmitted forces, we cannot well look elsewhere than to ether, provisionally so called, as the mode of transmission. A necessary existence to the explanation of other phenomena, we cannot bring into conjunction with it another occupant of interplanetary space, the properties of which as a medium could be even more inconceivable, thus blended, than those we assign to ether alone. As regards gravitation, indeed, we have one difficulty to surmount, which if accepting the premises, may well be deemed insuperable. Laplace has concluded from certain considerations that this attractive force must have velocity of transmission some million times that of light—an expression which plunges us at once in the gulf of the Infinite, forcing us to regard this wonderful power, acting unceasingly in the uni-

[1] In the 6th and 7th Definitions of the 'Principia,' Newton especially uses the magnet to illustrate some of the fundamental laws of gravitation.

verse, on suns and atoms of matter, as a solitary mystery, unapproachable by the reason of man. Yet, if transmitted at all, some medium must be concerned in the transmission; and we may best invoke the aid of that which brings to us the light of sun and stars, and interpenetrates all matter around us. The problem is a sublime one, whether ever to be solved or not.

Research has been so largely given to the phenomena of magnetism, that some more complete theory might have been expected of its relations to space. But though experiments tell us of lines and curves of magnetic force, in proximity to the bodies from which it is obtained, we cannot yet carry direct evidence to spaces beyond. Speculation, however, as to magnetic connexions of the sun and earth has been sanctioned by various recent observations, which are still in progress. The phenomena observed are in part at least of periodical character, and so blended with terrestrial magnetism, that time and a very copious average of observations are required to sift and verify the results. Assuming, however, the bare fact of electric relations existing between distant bodies in space—and the assumption is fairly warranted—and knowing this element to have mensurable motions in time, closely akin to those of light, we are again brought to our hypothetical ether as the medium of transmission—adding thereby to the complexity of its functions, yet embarrassing the reason less than would the hypothesis of another agent of transmission.

It is a grand conception, or rather conclusion, of modern science, which thus makes ether—an exquisitely subtle material medium—the occupant of space throughout the universe. The unprofitable questions of *ponderable* and *imponderable* are put aside by the conviction that such medium is necessary to the existence of recognised phenomena. But of the interplanetary spaces, those with which we have most concern, ether is not the sole occupant. Recent observations, every day augmenting upon us, show the presence of matter in motion, under different forms of aggregation, in these interspaces; subject doubtless to the general laws which govern the planets and satellites, but with special anomalies not yet fully explored. The various phenomena of meteors, some of them seemingly connected with rings of nebulous matter having periodical revolutions round the sun—comets, zodiacal light, aerolites, &c.—all attest the large presence of matter in this ethereal domain; the residue, it may be, of those successive condensations from which we suppose the different bodies of the solar system to have derived their several forms and place in the heavens. Such intervening material elements, we have much present reason to believe, do not differ greatly from those familiar to us on earth. But whatever their nature, they doubtless have definite physical relations to the medium in which they move. The phenomena of certain comets afford evidence of this, while at the same time furnishing argument for the existence of the medium itself.

We have hitherto been regarding chiefly what may be termed the ether of outer-space. Every difficulty is augmented when we regard it in closer connexion with terrestrial matter. Look at all we have to conceive when these complex ethereal pulses reach the region of our atmosphere. Three gases, besides aqueous vapour in ever-varying degree of condensation and change, become blended with them in the self-same space, under what physical relations no philosophy can tell. Nearer to the earth other matters, organic or mineral, are variously diffused through the atmosphere; and the atmospheric vibrations ministering to sound become commingled with the undulations conveying light to heat; each system of waves, under their several velocities, amplitudes and refrangibilities, moving in the same portion of space—not indeed without conflict, as shown in the various modifications of the calorific and actinic rays, as well as of the lines of the visible spectrum—but still under laws, seen or unseen, which limit disturbance and control the whole. Conception labours in vain to follow these infinitesimal functions of matter and force. And the difficulty is enhanced by the conclusion pressed cogently upon us that the great agent under our review, the ether of space, exists in and permeates the most solid bodies of which we have knowledge—a medium or agent in those intestine molecular changes which, in one condition of action or another, form the subject and foundation of all physical science. Our knowledge of the infinitesimal divisibility of matter helps us to the conception of ether pervading it no farther than by the analogy of another great natural fact, closely related, equally inconceivable, yet proved to be true. This topic, however, does not now come before us.

Looking to the whole subject just discussed, we are forced to admit, notwithstanding all the genius and labour given to it, that the ultimate truths it involves are still wanting to us. Our reason here lies very much at the mercy of language. We have got hold of certain words needed to express the great elements acting in the natural world. Of these strangely-fated terms which we employ to expound the deepest mysteries of nature, the word *Force* is the most mysterious—expressing a reality of action in time and space—present wherever matter and motion are, and known to us but through these—emanating from life and mind as well as inanimate nature—yet strictly speaking a *name* only to our understanding. It is a name, however, betokening relations on which the highest philosophy may fitly employ itself; subject to those restrictions which only the highest philosophy can discern and submit to. It is matter of curious speculation whether future research will ever bring us to a clear comprehension of the power or powers we thus denominate—of their relations to matter throughout the universe, and of the connexions they establish between more material phenomena, and the higher attributes of life, mind, and will. No avenue is yet discernible to this ultimate truth. Fresh analogies may come to light, and new correlations of phenomena; but the question of primary cause still unceasingly starts up, 'What is Force in itself?' to answer which question truly and intelligibly is hardly, I think, permitted to the present powers of man.

DIVISIBILITY OF MATTER.—ATOMIC THEORY.

Physical Science, in all its parts, is ever furnishing fresh instances to amaze and bewilder our conceptions on this subject. They tax heavily the belief of common minds, though sustained by evidence irresistible in kind, as compulsory as mathematical demonstration. Examples of the divisibility of matter are now so numerous and familiar that it is needless to dwell upon them; yet a few may be cited *instar multorum*, and these derived chiefly from recent researches.

Take sodium as indicated by its coloured lines in the spectrum. Calculation, based upon the diffusion of a salt of this metal in a given atmospheric space, shows that 180-millionth part of a grain of sodium may be detected by this subtle analysis. In the sodium salt thus employed other experiments prove the presence of one ten-millionth part of iodine as an ingredient. Take aniline as an example from modern chemistry. A single grain gives a rose-pink colour to ten million times its weight of water, by diffusion of the innumerable molecules of aniline of which this grain is composed. In like manner a strong ruby tint is given to a volume of fluid by a quantity of gold not exceeding $\frac{1}{500000}$ part by weight.

Matter, organised into life, furnishes illustrations without end. The living and fossil infusoria—the ova of fishes and insects—the red corpuscles of the blood (estimated microscopically by billions to the cubic inch) —the odours of flowers—the millions of germs diffused from the puff-ball of a single fungus—these suffice for examples, expressing in their units the marvellous divisibility of matter; and a further marvel in the consideration that these units are themselves organised compounds of smaller and more elementary atoms, each endowed with properties giving it a part in the mechanism of the natural world. In no case have we absolute proof that the ultimate atoms or monads—the μεγέθη ἀδιαίρετα—have been reached. In the case of compound bodies, their molecules by division carry us yet farther in the scale of minuteness, until thought becomes involved in that metaphysical web of the Infinite and Indivisible—the *terminus* to all enquiry.[1]

The admission, or rather re-admission, of the atomic theory into all our views of the material world is perhaps the most marked step in the science of our day. The facts as well as the requirements of chemistry have

[1] Lucretius, wonderful both as a *thinker* and poet, approaches this abstruse point of the infinite divisibility of matter with his wonted felicity in subjecting philosophy to verse (lib. iv. 616). It is one of the many instances where his power of thought (based doubtless in part on prior philosophy) has pointed to conclusions verified more or less by the most recent researches of our own time. Without citing others, I may briefly notice two instances which I have not seen mentioned elsewhere, viz., the passage (lib. ii. 288 *et seq.*) in which are foreshadowed the recent discoveries of Graham and Tyndall on the diffusibility and penetrability of different kinds of matter; and that (lib. ii. 447–50) indicating the exact order in which stone, bronze, and iron implements are now shown to have come into the uses of man.

had the largest share in this act of progress; though the general conception is one which might well be derived from observation of the diversities of matter, and of those endless changes and interchanges which can only be effected by particles of infinite smallness. The microscope, too, though far short of its present perfection, had already disclosed organisms so minute, yet so perfect in their several forms, as to suggest at once an elaboration from atoms—the *ἀμέρη τὲ ἀλάχιστα* of matter. But the doctrine of Definite Proportion in chemical compounds, well established, made that of atoms a direct necessity; and the principles embodied in this doctrine have derived from the genius and labours of chemists a certain mathematical character even in the formulæ used for their expression. A period of little more than sixty years, dating from the first rude outline of Dalton, comprises all these signal discoveries—best expounded by terms which denote their dependence on the properties and relations of atoms, such as isomerism, isomorphism, allotropy, substitution, types, homologous series, atomic weights, &c. These terms may hereafter merge in others more general; but meanwhile they are needed to express phenomena forming that great body of connected science which under the name of Chemistry (a name of feeble origin for what it now denotes) deals with the infinitesimal parts of matter in all its forms—with their mutual actions and affinities, and their connexions with those great natural forces, light, heat, electricity, &c., which call these relations into activity. Forces act upon matter by changing in one way or other the inter-relations of its component atoms. These atomic changes are such in kind as to show the *individuality* of the parts so-called, however inconceivable their minuteness.

To this individuality are attached some of the most profound questions in modern science. First comes the old metaphysical difficulty. Is there any thing actually indivisible? Can we speak of, or conceive, a material unit without parts? Remitting this question, as may well be done, to that *limbo* of the Infinite in which so many others are merged, we encounter various problems more capable of solution, but not yet thoroughly solved. What, for example, are those properties or endowments, manifestly inherent in the very nature of the ultimate fractional parts of matter, giving them their affinities, repulsions, &c. *inter se*, and in their relation to the forces which put them into action? Are there absolute intrinsic differences in the nature of atoms or monads, corresponding to our received catalogue of elementary bodies? Or must we receive the latter as an approximation merely to fewer and simpler elements, to be determined as such by a future more subtle analysis? How are we to regard the phenomena of allotropy occurring in substances hitherto deemed elementary? Or the atomic phenomena of crystallisation and their various relations to light, heat, and electricity? Or the strange fact, necessarily blending itself with the atomic theory, that the properties of substances may in many cases be distinctly altered by admixture with infinitesimal proportions of other matter, sometimes not exceeding a millionth part of their weight?[1]

Nor are questions of this kind limited to what we may regard as simple atoms. They apply alike to those endless atomic compounds, of the same or different kinds of matter which make up the natural world around us. These compound atoms, now distinctively termed *molecules*, we may assume to be larger and of less simple figure than the atoms composing them, though this conclusion is one rather of inference than of experimental knowledge. Appreciation by measurement, or other direct means, of these infinitesimal parts is as impossible as to conceive them by effort of thought. There are, indeed, some recent experiments (made by subjecting simple and compound gases respectively to equal increments of heat and pressure) which tend to show that all gases, under similar conditions, contain equal numbers, and therefore equal sizes, of constituent atoms or molecules. But this is one of the many questions alluded to as awaiting solution.

The glory of chemistry as a science depends especially upon its researches into molecular properties and combinations. The endless number and variety of chemical compounds, their tendency to types and determinate series, and the mastery now obtained over them by synthesis as well as analysis, show how vast

[1] Sir W. Thomson (1870) assigns four physical proofs of limits to the smallness of atoms and molecules—one derived from the *contact* and *electricity of metals,* the others from the doctrine of capillary attraction and the kinetic theory of gases, giving the *certainty* that there is a *limit* to the molecular size, however exceeding all conception in minuteness.

are the problems the atomic theory brings before us, and how bold and successful have been the steps of science in this direction. The conception, perhaps the proof, of the class of bodies termed Compound Radicals marks one of these steps, useful in progress if not certain in sequel. It illustrates, indeed, as an example, the present aspect of chemistry as regards organic compounds—a redundance of curious and well-determined facts, awaiting some certain principle of correlation and nomenclature to give them that cohesion which the ultimate ends of science require. Unity is the true *Euthanasia* of the several chemical systems now existing among us.

Dismissing for the moment these more general views, we come back upon the question, already propounded, as to the intimate nature of atoms, and the properties which may be predicated as belonging to them, irrespectively even of differences in the nature of matter itself.[1] I have hitherto spoken chiefly of their infinitesimal minuteness. Every speculation as to their nature, every fact or theory regarding their mutual relations, includes, and must include, this postulate. No explanation of the most common phenomena is possible without it. Those intestine actions and changes which take place within the most solid bodies, inscrutable to any mode of observation, can be effected only through infinitesimal minuteness of the parts composing them. Necessity here becomes the

[1] Nowhere is the question of the necessary attributes of *indivisible atoms*, as well as that of the infinite divisibility of space, reasoned out more profoundly than in the writings of Pascal.

measure of minuteness—the sole measure we have ; fo the instances already given, and the many that might be added, marvellous though they are, do not make it certain that we have reached what is ultimate in the atomic scale. If we come to ether, as a material medium, occupying universal space, we are forced for the fulfilment of its offices, from actual phenomena, to assume a degree of divisibility of matter which no statement can convey to our conception.

The exquisite *mobility* of atoms is another condition, equally necessary and collateral, indeed, to that just stated. It is a condition expressed not solely through motions and changes obvious to sense, or such as occur in fluid or gaseous states of matter, but with equal certainty through the changes produced in the densest bodies by the various action of light, heat and electricity, &c.—atomic motions real in themselves, however produced. When we speak of telegraphic communication, next to instantaneous, between London and Edinburgh or across the Atlantic, we denote the assured fact that every single atom of the intervening metallic wire has undergone for the moment some specific change, whatever it be, in this wonderful transmission of force. A figure solid—a crystal, for example—may be wholly altered in its internal or atomic structure, without any appreciable change of outward form. The proof of such intestine motions of atoms is as perfect as if the eye could discern them. The microscope discloses many marvellous facts in this direction of research, but there is a microcosm of movement and change which lies far beyond its reach.

The experiments of Karsten and Grove in fixing on a plate of glass the image of a coin simply laid upon it and electrified, shows, as do the phenomena in photography, the exquisitely minute changes which molecules undergo in ways utterly inappreciable by human sense or conception.

In subjects of this kind one question follows another by instant suggestion. It may be, and has been asked, is matter in any of its forms, from the invisible atom to the great globes of heaven, ever really at rest? Is not mobility, as an inherent property and function of matter, actually expressed by the unceasing motion of its parts, whatever their mode of aggregation? Astronomy would seem to answer in the affirmative for all that belongs to its vast domain. Organic life, in its every shape on earth, tells the same story of unceasing motion and change in the atomic elements on which life depends. Inorganic substances do not afford the same direct evidence. Yet if that be, as now commonly supposed, a simple induced condition of atomic motions in bodies, such motion, in one degree or other, must ever be present in all matter, altered more or less whenever bodies of unequal temperature come into proximity. The doctrine of *latent heat* somewhat obscures this conception; but the doctrine and phrase are provisional only for the expression of a very obscure physical fact. In gases more especially we obtain strong presumption of incessant movement in the atoms composing them. Recent researches on their interdiffusion and subjection to pressure go far to justify this belief—one subject, however, to those elementary difficulties, which here, as so often elsewhere, stand stubbornly in our way. The word *Motion* itself is one of these. No conception of it can be formed which does not include *relation* to something else than the atom, or aggregate of atoms, moved—a relation so complex as regards the matter of forces in action, that all conclusions must be accepted with reserve. If we suppose compound forces acting in this invisible world of monads—and the condition is a very admissible one—*rotatory motions* would be the probable result; and such hypothesis is, in truth, more applicable than any other.

Leaving this speculation, we come again to what may be regarded as the integral or necessary properties of ultimate atoms. To those of infinite minuteness and mobility may further be added that of *definite figure*—a postulate almost essential to any interpretation we can put upon them as components of matter—the only key to the phenomena of definite proportions, isomorphism, substitution, and all besides which constitutes chemical science. It is impossible to suppose that atoms, shapeless and indeterminate in figure, can be instrumental in changes and combinations determinate as mathematical facts. Adaptations so perfect and constant can only co-exist with primitive forms equally perfect and permanent. But admitting these premises, what system of atomic morphology can be constructed to meet the conditions of the problem? More than sixty kinds of matter are still elementary to our knowledge. Are we to suppose different configuration of the component atoms of each of these, and of others that may yet be discovered? Or, in sight of this difficulty, may we presume that many of the number are really compounds of simpler elements, though possibly beyond the reach of discovery as such? or allotropic conditions of the same element, as Dumas conjectures regarding chlorine, iodine, and bromine? The whole question enters so deeply into the *theory* of the material world, that we are bound to follow it as far as reason and analogy will carry us, awaiting those future disclosures which time is sure to afford. That they will contract the catalogue of elements, up to this time constantly increased in number, is my confident belief.

Seeking aid to this enquiry from other parts of science, Crystallography is perhaps that most fertile of suggestion. It deals with determinate figures, created by the mutual actions of atomic parts, the simple atom or the compounded molecule. This atomicity—to use a recent term—in the structure of crystals is expressed not only in their modes of aggregation, but also in their optical axes and other relations to light; and further, in those internal changes of structure, already noticed, which occur without change of outward form, and those more special cases where the primitive form of the crystal determines its mode of change when subjected to heat. Other instances might be given, justifying the notion of definite figure of atoms from the analogy of crystalline accretions. If we have mathematical forms of crystals, we may fairly presume such to exist in the ultimate atoms composing them. If we can reduce the primitive forms to three only, the same assumption may be applied to atoms. Or, if we go further and consider, with Wollaston and Mitscherlich, all the forms of crystallisation as explicable by the opposition of simple spheres or spheroids with an intervening elastic or compressible medium, whatever its nature, we come more closely to the elements of an atomic theory, and to a view more plausible perhaps than any yet propounded, of this part of the nature of primitive atoms.

With every aid, however, of analogy and hypothesis, we cannot yet go further in the solution of a problem complicated by the different kinds of matter itself. Recurring, however, to the more general view of the properties of atoms, some things still remain to be noticed. In admitting their *fixedness* of figure we necessarily deprive them of individual elasticity. This property in its various degrees can only depend on the manner in which atoms are amalgamated or grouped together in mass—a condition which may be said to determine generally their relation to impulses from without, and their mobility as one of the most important of these. It is not too much to conceive this property—the capacity and velocity of motion—as being very different for atoms of different kinds, or for atoms of the same kind differently aggregated. Recent researches on gases and vapours afford fair sanction to hypothesis on this subject. The gaseous form of matter is that which indeed aids more especially in the enquiry, giving their most active and mobile condition to its atomic parts, through the interpenetration of those forces by which this wonderful machinery of atoms or molecules is put into work. The evidence that under equal pressure and temperature every different gas contains in the same volume the same number of molecules, is one striking result of research thus directed. The experiments of Graham on the inter-diffusion of gases and liquids have thrown much curious light on the subject, and coupled with other considerations go far to justify the hypothesis, propounded by himself, that the atoms or molecules of all gases are spherical in form, incessantly in movement in every direction, but with varying velocity in different gases. Granting this to be hypothetical only, yet are the conditions resulting from experiment such as to make it difficult to supply other interpretation. We feel in a certain proximity to the truth, though the conclusive and final steps still remain to be made. Similar anticipations are frequent in other parts of science, cheering as well as directing the labours of research.

To gases and vapours, as already mentioned, we may especially look for elucidation of the forms and properties of molecular compounds, founded on their varying relation to those *radiant forces* (as we must conventionally call them) which govern the intimate motions of matter in all its shapes. The strong presumption already existing that compound atoms, or molecules, must differ from simple atoms in size, or figure, or both, has been strikingly confirmed by the experiments of Tyndall, showing the large absorption, or stoppage, of radiant heat occurring in its passage through compound gases, compared with what happens in those of simple elementary kind. These results, like those derived from his later discovery of the chemical reactions produced by light passing through compound gases, concur with Mr. Graham's various researches in pointing at a *molecular mechanism*, a definite principle of embodiment of atomic figures, forces, and motions, destined hereafter to become a special department of science—closely allied, however, to chemistry by those principles of analysis, synthesis, substitution, &c. which have so marvellously interpreted to us the intimate constitution of all compound bodies. Chemists are still not agreed as to the best mode of tabulating or symbolising the results which enrich this part of their science. Of the schemes propounded (and four are now on the table before me) each has its appropriate value. And in this very fact we find evidence that they are but provisional, and steps towards some perfect system even now looming before us and well-nigh certain of attainment. Founded as it must be on strict numerical proportions, it will probably disclose or suggest relations of atomic figure also, as exponents of the combinations and changes matter undergoes when thus reduced to the infinitesimal parts in which all material action really resides.

The future progress of this enquiry will doubtless elucidate more completely the physical distinctions of elementary atoms and molecules, both as to their nature and effects in action. The present theoretical distinction is that best expressed by Wurtz in the words given in the subjoined note.[1] This definition shows, what

[1] L'atome est la plus petite quantité d'un élément qui puisse exister dans un corps composé, comme indivisible par des forces chimiques.

indeed was already recognised, how much of future knowledge, not merely as respects particular facts, but general laws, is wrapped up in this molecular theory. It is through the infinitely small that we may best reach a comprehension of the architecture, organic and inorganic, of the material world.

Without discussing in detail the several bearings of molecular philosophy, I may notice one cardinal point important from its relation to others, viz., the fact that in proportion as a compound is more complex in its parts it becomes more unstable, more liable to dissolution. All the most explosive compounds of which we have knowledge come under this general law. So, it may be—though here we must speak more doubtfully—do those strange phenomena of ferments, of animal and vegetable poisons, and of the specific poisons of certain epidemic diseases. In the latter class of facts we have the most striking proofs of the infinite divisibility of matter, and of those wonderful relations of its infinitesimal parts which, by a slight change in their proportion only, can convert an innocuous substance—even an article of food—into one which becomes an instant cause of disease or death. Physiology, as a part of general science, has much yet to learn here, though it may probably never be able to tell us in what physical changes that immunity consists, which renders a person who has once had the smallpox permanently insusceptible of infection from the virus of this disease.

La molécule est un groupe d'atomes, formant la plus petite quantité d'un corps simple ou composé qui puisse exister à l'état libre, entrer dans un réaction, ou en sortir.

In treating thus far of the divisibility of matter, and of the atomic theory as resultant from it, I have said but little of those imponderable agents which we can in no way dissociate from matter, and cannot easily define otherwise than as functions of it, yet which severally involve atomic actions and conditions peculiar to each. Light and heat come perhaps in closest relation, as connected with these conditions; and the discovery of a constant proportion between the specific heat of bodies and the atomic weight of their particles is one of the exponents of relations which may well be called very profound, seeing how far they go beyond the region of the senses or the bare conjectures of thought. How important, again, in its connexion with the atomic theory is the curious fact (established as far as experiment has yet gone) that the power or index of refraction of light in compound bodies is the sum of the indexes of refraction of their component parts. We may further fairly presume (and this is confirmed by Tyndall's later researches) that the undulations of light—the 'luminous waves of ether'—have definite relation to the atomic conditions of the bodies they permeate. If simple light can unite with sudden explosion the atoms of hydrogen and chlorine, we may well anticipate its action in other cases in dissociating the molecules of compound bodies, and with some relation, it may be, to those differences in luminous waves on which the differences of refrangibility depend. Of electricity, under its various forms, as one of these great agents in the world of nature, it may be said that atoms in motion either constitute this power, or are pervaded by and give conduction and other action to it. With the view I entertain of the relation of electricity to the ether of space—of which I shall speak more in another paper—I think the latter the more probable interpretation. The phenomena of electricity in vacuum-tubes show the exquisite tenuity to which air and other vapours must be reduced before they cease to give passage to the electric current.

Of gravitation in its connexion with the atomic theory I have spoken in another of these papers. We may describe it as a property inherent in all matter, but such phrase adds nothing real to our knowledge of this great force, gives no conception of its origin in individual atoms, of the aggregation of units of force, or of its transmission through space. The relation of the ponderable to the imponderable, of matter to the powers acting upon it, forms indeed that mysterious volume which science has opened, but has not yet been able adequately to decipher.

Although the doctrine of atoms was a mere speculation in ancient philosophy, yet, even as such, it is worth noting how far human thought, working by itself, advanced towards those conclusions which have become the recognised truths of our own day. Without recurring to the doctrines, so often quoted, of Anaxagoras, Democritus, Epicurus, &c., or to the great poem of Lucretius which gives so magnificent a framework to all atomic speculations, it is enough to say that we find pervading the most remote philosophical antiquity a general notion of indivisible, indestructible atoms—the material of all creation, either by inherent energy of their own, or acted upon by a creative power from without. It cannot be said that any important advance has been made upon these views until approaching closely to our own time; though the great names of Bacon and Newton enter into the discussion, the former expanding and extolling the doctrine of Democritus on the subject; the latter, in one of his wonted pregnant sentences, denoting those qualities of ultimate atoms which he deems essential to the uses for which God created them. The monads of Leibnitz and the living organic molecules are little more than variations of the same ancient theme—naked hypotheses, without any show of verification by facts. The doctrine of Boscovich regarding the attractions and repulsions of matter as associated with mathematical points, or centres of force, is better worthy of note, not solely to our present purpose, but as one of those large views which concentrate around them numerous facts otherwise insulated or anomalous. The atomic theory of gravitation of Le Sage, and that more recently propounded by Mosotti, belong to the history of this enquiry, but have done little to advance its progress.

It is, indeed, as already stated, to the chemical discoveries of the last half-century that we owe what may now be fairly called Atomic Science. Studied through the multiplicity, yet mathematical fixedness, of their combinations, atoms and molecules, though unseen as such, have become intellectually *realities* to our knowledge—first by analysis, and more recently by synthesis. Chemists are tracing and following them in their most secret operations; and the latter method has lately obtained a signal success in producing organic compounds from those simple elements the incipient combinations of which had heretofore been wholly hidden from us. It is hard to say how far this success may hereafter be carried, but it is certain that the halting-place has not yet been reached. We are still ignorant—and here there is no obvious path to discovery—of the actual *intimate structure* of molecules. The *proportion* of number and weight of the atoms comprising them we can tell, but not the manner in which they are built up into those definite forms, so numerous to our knowledge, in theory next to innumerable. We cannot penetrate into the atomic attractions and repulsions which govern these phenomena, or prove the exact relation of such atomic properties to the great natural forces in constant action around us. We use the general term *polarity*, and Dr. Prout and others have sought to give it a more specific application to atomic theory; but all such views, however plausible, are still without proof, nor in any case do they yet meet all the conditions of the question.

In addition to those already cited I might name many other problems in science which can only be approached through the atomic theory. Such are the phenomena of catalysis—the greater energy of certain elements, as oxygen and hydrogen, at the moment of their evolution from compounds—the questions regarding ozone and other allotropic elements—the effects of electricity on the surface-molecules of bodies, as shown in the experiments of Grove and Karsten—the curious facts described by Prout under the name of *Sterorganisation*—the conditions (denoted by Hoffman under the terms univalent, bivalent, &c.) which decide the different combining powers of chemical elements, &c. All such problems are closely blended with others of like import; and the progress of enquiry is ever multiplying these connexions, and making them subserve to mutual illustration and ulterior discovery.

THE ELECTRIC ELEMENT.

1867.

Electrical Science, in its present state, curiously shows how far the knowledge of phenomena may go, without knowledge of the true nature of the agent producing them. The first letters are wanting to the alphabet of the science. We speak of positive and negative electricity, of poles and currents, of induction, of quantity and intensity, but we conceive and define these conditions solely by their effects. Other phenomena and names come in, denoting the magnetic aspects of the electric element, but still failing to interpret to us the nature of that power which gives origin to the whole. This *elementary ignorance*, common to many parts of science, is more striking here from the wonderful command obtained over the electric force in its various modes of evolution, concentration, conduction, and application to the uses of man. We make what we needfully call its current, a messenger swift as light itself, to the most distant parts of the earth—create, check, suspend, and re-create this current as fast as human fingers can move—and from either end of the electric cable, lying in the depths of the Atlantic, can detect the exact place of a fault in the wires a thousand miles from land!

But with all this mastery over the agent, we are checked at once by the question, 'What is it? What is electricity?' The problem is one beset with difficulties, but with seductions also; seeing the likelihood that hereafter some conclusion will be reached closer than any yet attained. I have long interested myself in the speculation; and with a growing persuasion that if there be any distinct material element concerned in, and producing, electric phenomena, the ether, pervading all known space, is that best satisfying the conditions required.

The assumption may seem a rash one, seeing the vastness and complexity of these phenomena, and the want of any direct evidence to justify what is assumed. But it must be kept in mind that no other physical theory has been brought to solve the problem, or tell us what electricity really is. If anyone had title to utter an opinion on this point it was Faraday. He declares that 'of the intimate nature of electricity we know nothing; whether it is matter, force, vibration, or what.' His description of it as 'an axis of power having contrary and equal forces in opposite directions,' denotes particular phenomena, but not the power producing them.

In addressing myself to this question I would first seek to simplify it by limitation. Electric action, however manifested, must be either a special condition of motion of the atoms of sensible matter, as we suppose in the case of heat, or it must be due to some individual element or agent, distinct from the matter, on which and through which it acts, an agent we must denote as itself *material*, seeing that we can in no way describe, or even conceive, the phenomena apart from this relation to a material cause.

I cannot hesitate in believing the latter view to be that best warranted by our present knowledge. The methods by which we elicit, accumulate, and conduct electricity, whatever theoretic difficulties they involve, are far better understood under the hypothesis of a special material agent, than as proceeding solely from atomic actions of the bodies electrically affected. To speak of polar states, or chemical changes in the atoms of matter, as *constituting* electricity, is but to hide the real difficulty, leaving unsolved the cause whence these conditions are intrinsically derived. The phenomena attending the transmission of electricity through wires bear cogently on the question. The differences of effect produced by the varying material, length, and thickness of the conductor can hardly be reconciled with other views than that of a specific agent acting in a certain ratio to its quantity and concentration, and capable of being estimated under these relations. These terms of *quantity*, *intensity*, and *concentration within determinate spaces* especially characterise electricity, and associate it intimately with those actions and conditions by which material elements are designated to our knowledge.

If the individuality of the electric element be admitted as distinct from the matter through which it acts, the question at once arises, can we identify it with any other known element in the natural world? As postulates in the enquiry we need, first, some agent *cosmical* in character, since our actual knowledge of electricity, especially under its magnetic conditions, shows it to be an influence spreading widely over the universe, and connecting us physically with the sun at least, if not with other more distant worlds. We need also some element capable of expounding those relations of electricity to matter of every kind, so intimate and constant that no changes of substance whatsoever, chemical or mechanical, can occur without electric manifestations in some form or degree; and no substance, as far as we can see, but is acted upon in some way or other by the electricity thus evolved. This universality of relation led Faraday to conjecture a direct connexion between the force of gravitation and the electric power. But he failed to find any experimental proof justifying this hypothesis. Had such proof been attainable, he of all philosophers would have been the most likely to reach it.

But failing in this, is there no other known agent to satisfy, in part at least, the conditions required? Before hurrying to the theory of a new and special power (a bare assumption, complicating yet more the great problem of the elementary forces) we are bound to see whether any of the elements already recognised in the natural world will not equally well interpret the phenomena. And this, I think, may fairly be affirmed of that element, so to term it, which under the provisional name of ether we recognise as a necessary existence in the universe around us—*necessary*, because we can in no other way explain the transmission through space of those wonderful wave-motions, of which light and heat are the chief exponents to our living world. Though forced to use the term *imponderable* for this element, yet does its function needfully imply the material nature of the medium, as well as its diffusion throughout every part of the solar system, and even through those other systems of worlds which send their light to us from the depths of space. It is a *cosmical element* in the largest sense of the word; not merely diffused through the universe around us, but interpenetrating, as optical and other phenomena attest, even the densest bodies of our material world.

Vast and complex though the recognised function of ether be, need we or can we suppose it the sole one which this element fulfils in nature? Admitting in the outset its materiality, may it not, or *must it not*, when coming into contact and interpenetration with the atmosphere and still grosser and more palpable forms of matter, assume other conditions and properties than when diffused equably and continuously through outer space—be condensed, accumulated, evolved, conducted in currents, and otherwise modified by the kind of matter it pervades, and by the changes matter itself undergoes from other forces acting upon it?

Say that these questions are vague and lead to presumptions only. But presumptions may fairly be made an integral part of science in cases where certainty is unattainable or has not yet been attained. They are steps to rest upon, if not to aid in rising higher. In the case before us the general presumption is one that almost compels assent. An exquisitely subtle agent, such as we must presume ether to be, cannot be supposed to impinge upon, interpenetrate, and occupy the various forms of sensible matter without involving relations and actions, equally subtle, between this element and the atoms or molecules of which matter is composed. We cannot conceive changes of any kind in the latter without some equivalent change or manifestation in the former. Without assuming to indicate what may be *cause* and what *effect,* in these infinitesimal actions, we may at least deem it next to certain that the agency of ether cannot be limited to the phenomena expressed by light and heat only; or that its elasticity, velocity of wave-motion, and other properties remain unaltered when coming into that close atomic coalescence which all analogy tells us to be the condition of most energetic physical action.

If, failing to bring direct proof of the presence and action of ether in these subtle phenomena, the question suggests itself, have we not its substitute and representative in electricity—in those wonderful phenomena, evolved and apparent to our tests, even in the most minute atomic changes, and capable both by natural and artificial means (but always in connexion with atomic disturbance) of being raised to a high degree of intensity and quantitative power? What is there, in short, to forbid the conception that electricity is the ether itself?—not existing as in its more equable diffusion through interplanetary and stellar space, but from its embodiment in terrestrial matter, solid, fluid, and gaseous, quickened into new conditions, acting or acted upon in all atomic changes, and in certain of these extricated in such quantity and manner as to become a powerful and prolific agent in the hands of men? Can an element such as we must suppose ether to be lie dormant in the innermost interstices of matter, while the smallest change of condition, even the simple opposition of different bodies, awakens another power within them into life and energy? Is it probable, or possible, that two distinct elements should co-exist in the same space, with separate relations to the matter thus closely environing them? Allowing much for our ignorance of matter in its infinitesimal parts, can we suppose two agents thus energetic pervading these parts, yet independent in nature and action? I put these points interrogatively; but they are surely such as may well sanction hypothesis in default of any more absolute answer to the question, 'What is Electricity?'

For, in truth, no theory yet propounded can go further to satisfy the very difficult conditions of the problem. Look cursorily at the phenomena which this wonderful element of electricity brings before us—its various modes of evolution, including that by induction—its opposed conditions of positive and negative electricity—its manner and velocity of conduction—its connexion with magnetic phenomena in all their aspects—its presence, either as cause or effect, in all that we term chemical action—its relation to vital functions—its agency in all meteorological changes—and its connexion by exact equivalents of power with the other great forces of the natural world. These various phenomena concentrate themselves under the same single question, 'What is Electricity?'

Science, as we see, has hitherto given no certain answer. Though presuming that some single elementary agent is concerned, and this *material* in its nature, yet can we bring no absolute proof of its being so, or conceive those material properties through which it fulfils the several conditions just stated. What we have before us, then, is purely a question of presumption and probability. No other and higher probability can be produced to refute the opinion that the ether of space, under the conceptions we necessarily attach to it, comes nearer to satisfy these conditions than any other known agent, or any new element which can be imagined for their fulfilment. Though the hypothesis is barren of direct evidence, there are yet glimpses of light in this direction, giving guidance, it may be, towards another of those *unities* which it is the special object of science to attain. A wrong theory is often the parent of a right one.

In weighing the one before us it must be explicitly repeated that we are not called upon to vindicate it as applied to all the details of electric phenomena, where every other has failed to compass their interpretation. The problem of the two electricities and their polarities, under the well-recognised fact that one kind of electricity is never present without evolving an equivalent of the other, is perhaps the most arduous of these, departing from all recognised properties of other powers, and still a barrier even to the boldest conjecture. But there is nothing here to contradict the view of ether as the agent concerned in these subtle phenomena; nothing certainly to establish the claim of any other element. The difficulty being equal and alike under any hypothesis, may fairly be eliminated from the argument. And the same may be said generally of all the problems which electricity puts before us.

I have only cursorily alluded to those wonderful magnetic relations of electricity which almost embody a science in themselves. But they present no fresh difficulties to our hypothesis. On the contrary, all the phenomena of magnetism and diamagnetism, of magno-crystallic action, of magnetic lines of force, and of the direct action of the magnet on electric currents, testify their dependence on an agent pervading matter throughout its ultimate atoms, giving polarity to masses by polarising particles, and variously modified in its action and mode of evolution by the *kind* of matter it permeates. This is a point to which our regards may more especially be directed, since all recent enquiry tends to prove that the motions and relations of the ultimate atoms of matter depend upon, and are governed by, the polarities of these atoms. The phenomena of crystallisation, and even those of the lightest gases, hardly admit of other interpretation. Electricity, so strikingly manifested in its polar conditions, however evolved or applied, comes into instant and almost certain relation with these infinitesimal atomic actions. And this forces us again upon the question, Can we suppose these wonderful actions ever going on in the intimate recesses, and among the *διαίρετα σώματα* of matter, independently of another agent (itself material, from the very definition of its functions), pervading and acting in this very domain?

To suppose some agent other than the ether of space fulfilling these conditions, is simply to invent a new name, giving no new or deeper insight into the profound problems which this part of science involves.

And here I may state my belief that any advancement of our knowledge in this matter will probably come from experiment on these inter-relations of electricity and magnetism—such researches, in fact, as have already engaged the genius of Faraday, De la Rive, Tyndall, Weber, Plücker, &c. The polarities of magnetism, the positive and negative electricity, and the relations of these severally to the kinds and forms of matter in which they are embodied, and to the light and heat so variously present in these phenomena, offer still a wide field to the experimental philosopher. Happy he who, working amidst this intricate network of curious but insulated facts, shall discover the clue connecting and giving unity to the whole!

As respects the relations of ether to such eventual discovery, though it be impossible, perhaps, to bring the element, so termed, within the scope of direct experiment, yet its admitted and even necessary properties of exquisite tenuity and elasticity eminently fit it, as far as we can see, for undergoing those changes of form and force and direction which are known to us in electric phenomena. Newton, in his discourse on light and colours, explicitly denotes his belief that ether is altered in density and other properties when brought into penetration of grosser matter. And Faraday, conjecturing that it may be the medium of transmitting the magnetic force, adds that, if there be an ether, 'it is likely to have other uses than simply the conveyance of radiations.' Conceptions like these give fair foundation to the hypothesis I am seeking to enforce.

But this hypothesis justifiably extends to more remote distances in space. If there be, as we have authority for believing, direct magnetic or electrical connexion between the sun and earth, a material medium must exist furnishing this connexion. Why may we not suppose the electric element itself to be this medium, occupying space under the conditions we attach to the name of ether, and fulfilling by its endowments those wonderful functions in the natural world which we invoke the conception of ether to illustrate and explain? Why suppose another and distinct element pervading space, when we have one familiar to us in a thousand experiments, so proportioned that none other can be conceived equally capable of expounding the phenomena? In the supposition that ether itself is the electric element thus diffused throughout our solar system—and, upon the theory of light, to stellar space beyond—we obtain presumptions extending to many of the great cosmical problems on which science is now engaged.

The velocity of the electric current through certain conductors, in its close approximation to that of the ether waves of light, may fairly be admitted into the argument for identity. All such facts give evidence of the astonishing subtlety and mobility of the element thus propertied, and of its capacity to assume very different physical conditions, especially when brought into conjunction with the more ponderable forms of matter.

The meteorological relations of electricity in nowise contradict our hypothesis. That the ethereal medium has physical and probably complex relations to our atmosphere can hardly be doubted, though, unless under the supposition of its identity with the electric element, we are wholly ignorant of their nature. But this very ignorance becomes itself an argument for identity. I know no theory better fitted to expound the various aspects and conflicts of atmospheric electricity than that I have stated. The interaction of the two circumambient agents, ether and the atmosphere, and the connexions of both, but especially of the ether, with the solid matter of the globe, afford relations various and complex enough to meet any theoretical demand.

In dealing with this hypothesis it will be seen that I have put all the main points interrogatively, as befits a matter in which there is nothing yet susceptible of proof. It is not, however, too much to hope for a time in the future when some higher mastery may be obtained over these abstruse problems, and when the great forces that move the material world, including gravitation among them, may be submitted to some more general law, giving *unity* to phenomena which are incongruous or dissevered to our present knowledge.[1]

In a letter to Sir J. Herschel (July 1870), in reply to one from him on this subject, I summarise as follows the purport of the foregoing paper.

[1] The hypothesis I have sought in this paper to uphold has found a powerful advocate in M. Savowing, whose excellent memoir, *Sur la Physique Moderne* ('Revue des Deux Mondes,' November and December, 1866), I have just perused. There are points in his argument which he has put more forcibly than I have done. There are certain points in my statement of the question to which he has not adverted.

The phenomena of electricity in their largest scope (and especially those of evolution, conduction, and accumulation) give reason to believe that a *material element* is concerned in producing them. Can we conceive other element better fitted to fulfil the conditions required than the *ether of space*, from its admitted properties as the transmitting medium of light and heat—from its pervading as such all grosser forms of matter—and from the strong presumption that its property may or must be altered by the various conditions of the matter it pervades?

This is the outline of the argument. To these points, and to the others dwelt upon in the paper, must be appended the remark, needing to be kept in mind, that however unable upon this hypothesis to solve the most perplexing of problems of electricity and magnetism, the same objection exists, in at least equal degree, to the hypothesis of any other special element as concerned in these phenomena.

Note added in 1873.

See *Edling's* remarkable paper (translated in 'Philosophical Magazine,' August 1872, on *Electricity as a Function of Ether*, indicating this hypothesis (*algebraically* as well as otherwise) in its application to the most difficult problems of electricity especially. See also *Clarke Maxwell's Lecture at the Royal Institution* (February 21, 1873), and the report of it in 'Nature,' February 29, and March 6, 1873, particularly the latter, in relation to Faraday's '*great discovery of the electric magnetic rotation of light.*'

MENTAL OPERATIONS IN RELATION TO TIME.

1867.

Despite the endless treatises on the Mind, its faculties and functions, there are still methods of studying it less regarded than they might be, seeing the curious and instructive analysis they afford. The method I now seek to suggest comes amongst these. It involves no metaphysical theory, and admits of being stated in plain language. Its purport is simply to examine the operations of mind in their relation to time—viewing them as a series or succession of states, rather than as a group of simultaneous conditions. The analysis is not that of the mental faculties in the abstract, but of the modes in which they are severally and successively brought into action, taking time as the test and exponent of their succession.

This method of enquiry forms in effect the subject of two chapters in my volume of 'Mental Physiology.' I have there shown how much of striking illustration we can bring to the acts and moods of mind by thus viewing them in their relation of sequence. The consciousness of everyone tells of this sequence as a simple fact, and it is implied, if not expressed, in all that has been written on the functions of the senses, on association, memory, and the mental emotions; but never, as far as I know, distinctly recognised as a method of enquiry. Yet if we may admit that the individual being (*das Ich* of the Germans) cannot exist in two separate states of perception, thought, feeling, or volition at the same absolute instant of time, we do in fact denote a special mode of analysis, capable of explaining many phenomena—anomalies as well as morbid conditions of mind—which resist all other interpretations.

However difficult or impossible it may be to dissever and distinguish the momentary states, which in their aggregate form our existence, still they are *sequent* moments—a measurement of mental time, we might say—were it not that consciousness, even when thus directed, can hardly take account of the rapid and incessant changes imposed upon it. There is a certain chronometry, often very exact, in the functions of organic life. We cannot thus describe the fleeting operations of mind—the *infinitesimal fluxions*, we may call them, of thought and feeling. But neither can we reason at all on these acts or states without regarding them as sequent, and ever displacing one another in that series which gives personal identity to our being. What has been so much written upon under the term of Association of Ideas might better perhaps have been described as Succession. We cannot well part with the phrase of *personal identity*, yet that of *personal continuity* might perhaps better describe the series of states forming in their aggregate the individual life of man.

In the chapters just alluded to I have given various examples of this mode of viewing the mental functions. One or two such I cite here, as illustrative of the argument in hand. An instance familiar to all is that sudden and entire absorption of consciousness by some inward thought, even when the senses are submitted to the strongest impressions from without, as from the loudest swell of a Handel chorus or the rudest noises of a London street, or when fronting the Matterhorn or the Niagara Falls. The physical action on the organs of sense is the same, but the mind is working within itself, and all perception of external objects utterly annulled for a time. But let this cause of distraction be removed, and the mind is suddenly opened to the objects of sense before it, which may themselves again be as suddenly suspended by some new and abstracting thought. Or suppose some strong agitation of the mind, from whatever cause. For the moment it displaces all perception or feeling of other things, but is itself as suddenly obliterated by the intrusion of other objects of sensation or thought, recurring in all its force when these objects are removed. Such alternations of state, repeated again and again more or less rapidly, must be familiar to everyone even commonly observant of his mental relation to the daily incidents of life. In truth the whole of mental life consists in these successive changes, so far interpreted by time that each one may be regarded as having its own identity, however momentary in duration and however linked with antecedents and consequents by what seems an inseparable continuity.

I believe, however, that more may be done *analytically* by taking time as a basis than in any other way. It requires, indeed, that faculty which few can fully or fairly exercise, of turning the mind inwards upon its own operations. Even the most stable mind cannot long maintain this reflex action upon itself without confusion and fatigue ; the difference of the power in different individuals involving various diversities of intellect and character which admit no other interpretation. But the most closely directed consciousness can only tell generally and vaguely of the rapidity with which successive states of mind press upon one another even in their most ordinary sequence.[1] As in reasoning upon the divisibility of matter we use the term of *Infinite* to cloke our want of comprehension of its ultimate analysis, so in regard to mind, the number and rapid succession of its states, whether of thought, emotion, or will, make it next to impossible to discover by consciousness the continuity of the series. Who can unravel the sequences even in the most familiar acts of life, as in the thoughts and volitions which precede and produce speech ? Who can decipher that complex and seemingly simultaneous action of mind and bodily organs which enables the musician, from notes before his eye, to execute the most difficult passages with fingers and voice at once ? Or how must we interpret the wonderful yet familiar fact of a man reading aloud, line after line, without error or stop, while his thoughts are wandering on some matter wholly alien to the book before him ?

[1] M. Comte has strangely denied the competence of consciousness as an interpreter of mental functions. This seems to me sheer paradox. I have admitted the difficulties of the appeal to the mind for a record of itself. But whether using the word *consciousness*, or any other, no doubt can exist of the reality of the *subjective knowledge* thus obtained.

These and endless like instances might seem to sanction the belief in an absolute co-existence as to time of different states or acts of mind, and especially of those in which volition is concerned. Such, indeed, is the opinion held by Sir William Hamilton, and expressed in the term of Association of Ideas. It is difficult here to rescue the truth from the verbal and other ambiguities which beset it. But I am led to believe that Sir William did not sufficiently regard the inconceivable rapidity of these sequences of mental state—a rapidity such that to all consciousness it becomes continuity—nor make due allowance for those acts become so far automatic from habit that consciousness and volition have lost all direct relation to them. His argument that it would be impossible to compare or discriminate perceptions and ideas unless they were simultaneously present to the mind, implies a deeper knowledge of all such functions than we really possess. It is in truth as difficult to conceive the mutual relations of simultaneous states of mind, as of those directly successive; and where the action of the will on the bodily organs is concerned our ignorance is equally complete.[1]

But what is this will or volition of which we all speak so fluently, but which it puzzles the most profound philosophy truly to define? We have nothing to do here with the old question of 'Necessity and Free-will'—that metaphysical and religious puzzle of all ages, the pith of which Milton has gathered up into

[1] In Aristotle's treatise Περὶ αἰσθήσεως there is a curious discussion upon the question of the possible co-existence of different sensations ἐν χρόνῳ ἀτόμῳ.

one grand line of his poem. We are now regarding simply that faculty through which the mind acts upon matter without, and especially upon that body with which it individually co-exists—a co-existence so mysterious that language applied to it is but a shelter to our ignorance. Neither into this problem need we enter here. What bears more upon our subject is the fact, well attested by experience, that actions produced at first by express volition gradually assume from repetition much of the character and force of instincts. The will initiates some act of change. The subordinate acts fulfilling the intent become in the end so automatic that consciousness is lost in their rapid and unerring sequences. We will to walk, to talk, to read, to write. In the child each particular part of these acts requires a special direction of mind, an effort of will. As life goes on, and they become habitual from repetition, the mind may be said to relegate a part of its power to the bodily organs. It puts them into action, stops or controls them, but has no separate consciousness of these multitudinous motions, rapid almost to continuity, methodised automatically, and synchronous for different organs.

These automatic acts, in their various relations to the intellect, will, and passions of man, as well as in their relations to the instincts of other and lower animals, form a part of the great network of life, which neither philosophy nor science have yet unravelled. It is on these acts, as associated with volition, that I believe mainly to depend the theory of a possible *absolute synchronism* of separate states or acts of mind.[1] But despite the difficulties of language the question on which I am writing may again be intelligibly stated. Is it not a more exact as well as simpler conception of mental phenomena to regard their connexion as one of series and succession, rather than of synchronous or co-existing functions? When the mind is in one distinct state of thought or emotion, can another and different state supervene without removal of the former? The distinction here cannot be challenged as one of method merely. But, in truth, method itself, in a research thus complex and obscure, is one of the conditions most essential to success. And, as already said, I think that which I am now suggesting to be valuable, not solely as subsidiary to others, but as itself affording results which no others can equally obtain. To use two Greek words actually applied under similar purport, I prefer the γραμμή rather than the κύκλος as a foundation for mental analysis.

In speaking just now of volition, I had chiefly in view the action of this power on or through the material organs. But also in regard to the purely mental processes, the same question presses upon us, 'What is the will?' How far by effort of mind can we govern the sequences of thought, and those great functions of

[1] Sir W. Hamilton encounters the question, before taken up by Abraham Tucker, Bonnet, and others, what number of objects the mind can embrace at once. He tried the experiment with marbles thrown on the floor, and found reason to believe that the mind could simultaneously grasp the number six. Mr. David Forbes ('Nature,' Feb. 9, 1871), by similar experiment with beans, limited the number to four or five. But this is a form of trial in which the *sense* is mainly concerned.

memory and association, through which these sequences are especially manifested?

To answer this question we might well put aside the word Will altogether, as one so variously and vaguely used, both in philosophy and common life, that it perplexes rather than clears the path of enquiry. It is hard indeed to find any simple term wherewith to express the *potentiality* of the mind over its own operations. Where even consciousness draws so shadowy a line between what is voluntary and involuntary—where association of ideas expressed by their sequence occurs so often independently of the will, or even despite it—and where the power of controlling this sequence varies so much in different minds and at different times in the same mind, we must needs feel that we are immersed in a metaphysical mist, which it is difficult either to illumine or disperse. The faculty of volition, if such we may term it, is so inextricably blended with what is automatic in the acts of memory and association, that we can draw no distinct line of disseverment, nor even mark by consciousness when volition is lost in successions of mind which it does not control, or in bodily actions which habit has rendered next to instinctive.[1]

Here again the method of enquiry, by succession in time, seems to me to go farthest in explanation of the

[1] A curious illustration of the difficulty besetting these questions is the doubt still propounded, whether we *think in words.* Several writers (Schelling and Hegel among the Germans) hold that there must be language in thought as a necessity of the mental act—an opinion not easy to reconcile with the fact that other animals *think* as well as man; but worth noticing in proof of the obscurity that clouds over the most familiar functions of mental life.

phenomena—a limited interpretation, it is true, since we really know nothing of that mysterious mechanism by which one thought engenders another, or the memories of past things are revived, sometimes after half a life has gone by without a shadow of them having crossed us. All that has been written upon the association of ideas and memory, with or without the aid of cerebral anatomy, is but a confession of this ignorance. The work of Hartley, which I can recollect as still in some repute, was a futile attempt to explain phenomena mechanically, which the better science of our own time has shown to be inapplicable.

Receding from what is impossible, let us see what may really be gained by this manner of regarding the mental states as a series successive in time. And first, as to the amount of power the mind has, or habitually exercises, in determining these successions. Such power is evidently a limited and fluctuating one. Thoughts and emotions are ever coming in upon us unbidden or despite the will; clinging to us as moments of mental existence with more or less tenacity, displaced either by mental effort or by external causes. All this is true as regards the action and changes of the mind within itself, apart from things without. I am speaking here of what are really familiar facts, but not duly noted as such, or followed to the conclusions they suggest.

Foremost among such conclusions is that of the great difference of different minds, as regards the power of *governing* these sequences of state—of initiating a series, and holding to it steadily, despite hindrances from without—and changing or suspending the succession by effort of will. No one can fail to recognise the reality of these differences. Who does not see in them the material for definition of the highest forms of intellectual power? This faculty of governing and directing the operations of mind—one of the peculiar prerogatives of man—expresses in its degree the superiority of one man to another. Let the test be applied to those whom we meet in the familiar intercourse of life. You see the mind of one man submitted to vague and incoherent associations, unable to maintain continuity of thought, or to disengage itself from any dominant idea or feeling of the moment. Contrasted with this defect is the power, just denoted, of guiding and controlling the operations which form in themselves our intellectual and moral existence—a power varying in every degree—innate for the most part in the individual, but susceptible of change from the incidents and conditions of life—necessary to the highest grades of mental excellence; but in its enfeeblement, from whatever cause, reducing man to a lower level of mental being.

It is not easy to find language for the exigencies of this enquiry. We are speaking at once of mental operations and of the power of the mind to change and control them. How are we to separate and distinguish functions thus blended in one identity of existence? The ancients in some sort did it, by their distinction of the *νοῦς* and *ψυχή*; the latter representing a higher spirituality, farther removed from the material world. Our own words, mind, soul, &c., are perhaps less definite, yet all tend to denote, however vaguely, a line dividing the more mechanical functions of the mind from that higher individuality, which is *conscious of itself in itself.* But here again we are met and entangled by the new doctrine of *unconscious cerebration*—a perplexing phrase, yet not more perplexing than the function it professes to describe. We admit, and are arguing upon, that succession of mental states which in their series form the individuality of our being; partly governed by the will, partly automatic from habit or the influence of the external senses. But this hypothesis, yet unproved, of 'unconscious cerebration' supposes intellectual operations in which consciousness has no part, but which nevertheless evolve true logical results. It is difficult enough to interpret the phenomena of sleep and dreaming. But here we are called on to recognise an *exclusion* of mind from the highest function of mind—a stretch of metaphysical paradox hard to admit, even while confessing our ignorance as to those other relations of the simply material and spiritual in our nature which no analysis can reach.

Reverting now to our especial enquiry, we find much to illustrate the value of the mode of research I have sought to indicate. Take, for instance, the undoubted fact that the operations of some men's minds are more rapid in logical sequences than those of others. Such inequality has been shown to exist in the time required for transmission to the sensorium of actions on the organs of sense, and of volitions conveyed to the motor organs. The experiments of Helmholtz and Du Bois Raymond on the *rate of trans-*

mission of nervous power come in evidence here, as also the curious facts deduced from delicate astronomical observations, showing that different observers perceive and record phenomena under appreciable average differences of time.[1] We go but little beyond their material evidence in asserting that one mind is more rapid than another in the pure operations of thought, whether governed by the will or not. Common observation here gives cogent proof, not solely of differences in the minds of others, but of diversities, well worthy of note, occurring at different times in our own. Who is not conscious to himself of moments when thoughts stream through the mind with more than wonted force and rapidity? when, to use Locke's words, 'the mind will press forwards, and there is no holding it in?' Who, on the other hand, is not conscious of times when the faculties are sluggish, when reason halts as if unable to pursue a train of thought, and the mind passes into vacant reverie, or is dominated over by some single idea from which it cannot disengage itself? Even the simple act of *reading* becomes an experiment of the differences of time in the reception of ideas in different persons. Some, as a sort of necessity, read or utter each word singly; others compass the meaning of many words by a glance. Some explanation may be given of their diversities

[1] My friend Professor Mitchell, of the Cincinnati and Albany Observatories, published a formula of *personal equation*, founded on the relative *aptitudes* of different observers as expressed by time. On this subject I would advert to a curious passage in Lucretius (ii. 262 *et seq.*), where he adverts to time as intervening between the act of the will, and the sequent effect on the bodily organs.

through that view of the phenomena of sleep which I have dwelt upon elsewhere, as the only just exponent of this great function of our nature. But *self-consciousness* is the only true interpreter of these changes of mood and state, which are ever going on in the individual mind, from causes objective or subjective, known or unknown.

I have already spoken of the difficulty of thus turning the mind inwards upon its own acts and states. A yet greater difficulty is that of *self-experiment* upon the conditions—to try, for instance, what can be done by pure effort of will in determining the objects and sequences of thought which, in their common course, are so largely governed by automatic associations of former images and memories. An act of recollection may in some sort be called an exercise of the mind upon itself. But I have sometimes in my own case made more explicit trial of this kind, making time a part and test of the experiment. Within a minute I have been able to *coerce* the mind, so to speak, into more than a dozen acts or states of thought, so incongruous that no natural association could possibly bring them into succession. In illustration I note here certain objects which, with a watch before me, I have just succeeded in compressing, *distinctly and successively*, within thirty seconds of time—the pyramids of Ghizeh; the Ornithorhynchus, Julius Cæsar, the Ottawa Falls, the rings of Saturn, the Apollo Belvedere. This is an experiment I have often made on myself, and with the same general result. It would be hard to name or describe the operation of mind by which these successive objects have been thus suddenly evoked and dismissed. There is the volition to change; but how must we define that effort by which the mind, without any principle of selection or association, can grasp so rapidly a succession of images thus incongruous, drawn seemingly at random from past thoughts and memories? I call it an *effort*, because it is felt as such, and cannot be long continued without fatigue. But it can hardly be called an *effort of will*, since this seems to do nothing more than make the mind a *tabula rasa* for the moment, to receive the new objects so strangely—I might almost say, *irrationally*—written upon it. The whole comes within those mysterious inter-relations of mental life of which we can only truly speak in confession of our ignorance.

Quitting this instance of what might be called a *play* of the mind upon itself, I may notice other cases illustrative, more or less, of that succession in time of mental acts which, as a basis of enquiry, I am seeking to suggest. I have already alluded to the great diversities in that power, by which we give connexion and order to the sequences of thought, constituting what is called Reason. It is as curious as instructive to study men's minds through their different syllogistic capacities. Locke says: 'There are some men of one syllogism, some of two syllogisms, and no more;' and he might have denoted yet more forcibly those diversities which render the processes and results of one man's reasoning absolutely unintelligible to others. It may further be observed how curiously the sequences in some minds are *dislocated*, as it were, from all common and natural connexions. The thoughts in such persons are inconsecutive and fragmentary; and the mind, working dreamily within itself, takes little heed of what comes from without, even of the responses of common conversation. Some of these cases, of which I have seen many, tend to more serious mental aberration, forming one of the several links with insanity under the multiform shapes which mental maladies assume. All these abnormal states form a large school for study, in reference to the successions and correlations of mental acts of which I have now been speaking. The idiot and the maniac interpret to us many of the conditions of the soundest and most capacious minds.[1]

How different, again, are the *modes of thinking* of the same mind at different times! I have already alluded to this; but everyone who cares to do so may collect illustrations replete with interest from his own consciousness. Take the instance of that sudden quickening and elevation of mental power which is obtained when the faculties are strongly evoked by occasion or necessity, as in public speaking, in close and cogent argument, in the repartee of wit. The case of the orator is perhaps the most striking. As he warms with his theme—'ubi res agitur, et vera dimicatio est'—thoughts, memories, images, and words crowd upon him for utterance with unwonted rapidity, and for a time his mind seems raised to a higher level of genius and power. Conversely, the faculties which

[1] When Roger North describes his brother Dr. John North as 'the most intense and passionate thinker who ever lived and was in his right mind,' he is using phrases which do not go beyond the frequent reality.

are capable of being thus quickened and invigorated by intellectual society and struggle are seen or *felt* to decline in power when brought into contact with feebler intellects and frivolous subjects of thought. Such instances are familiar to all who take even ordinary note of mental phenomena in themselves and others. The mind rises or falls from the conditions to which it is subjected.

This whole subject of its *transient states* is, in truth, a very curious one, and not, I think, adequately studied. It embraces, of course, not merely momentary changes like those just described, but those larger fluctuations which the totality of life brings before us—changes belonging to the different ages of man, the appurtenance of poetry as well as philosophy, and finely portrayed by the genius of Horace and Shakespeare. But the daily and hourly fluctuations of state are those of most import to the philosophy of mind. Rochefoucauld says, and truly, 'On est quelquefois aussi différent de soi-même que des autres.' We speak of the mind as a unit, and in the broad sense of personal identity it is so. But within this individuality lie those many and ever-changing diversities of intellect and feelings which enter into the current of each single life. Observation unceasingly tells us of the influences alike of external and internal causes in producing these transient states of mind. Hunger and satiety, heat and cold, fatigue and repose, exuberant health and the languor of disease, are the commonplace interpreters of the fact. Opium, wine, and the other narcotics and stimulants, each has its peculiar effect for a time on this the higher part of our nature. So much must be conceded to the materialist, whatever use he may make of it. Look, too, at the influence of weather on the mind, felt, indeed, more generally than is recognised. He must be a man of blunt sensibility who is not exhilarated by a sudden burst of sunshine amidst the clouds and gloom of a stormy day, or softened by the still repose of a summer evening.

These continuous changes may be said, in fact, to embody in themselves the totality of life, of which they are the active and direct expression. Occurring in those whose lot is cast in the higher places of the world, the effects of such passing moods of mind are often wide and lasting. The obscure or secret portions of history, cherished as such by learned and ingenious historians, might in many cases, I doubt not, be best construed through these erratic states of our common nature which govern monarchs, ministers, and leaders of armies, as well as lesser men. There is more of this in the philosophy of history than can ever be told.

A few remarks still remain before quitting our enquiry. I have already suggested that the term of *succession* might well be substituted for that of *association* of ideas. It is obvious that the acts or states of memory, the most mechanical of the intellectual functions, must come under the same view; and the *vagaries*, as they may well be called, of this great function are in truth best interpreted by this method of enquiry. Recollection, however (the ἀνάμνησις of Aristotle, who well draws the distinction), has a higher interest as an active faculty of mind, and one which strikingly illustrates the diversity of power in different individuals as well as in the same person at different times. I might say much on these phenomena of memory and recollection, as bearing on the subject before us; but they are too numerous and complex to be dealt with as a mere appendage to other enquiry.

Another remark, however, occurs which cannot well be detached from the general method of enquiry I am sugesting. In writing elsewhere on the phenomena of sleep and dreams I have noticed our imperfect knowledge of these functions, as concerns the changes they presumably undergo at different ages, and under different conditions of life. This remark applies not less to the processes and associations of the waking mind. We go but partially to work in analysing the acts of the adult and cultivated intellect. The observation of these needs to be supplemented by a knowledge, much more difficult to obtain, of the conditions of uneducated infancy and childhood—of the intellectual imbecilities of old age—of the deficiencies and aberrations of the idiot and lunatic—of the mind of the rustic or of the factory operative, his life a machine of manual labour. Not only the subjects of thought, but the *power*, *methods*, *and rates of thinking* are presumably as diverse in these several cases as are the conditions themselves. In most of them the materials on which the mind acts are fewer and more simple, and their combinations proportionally less complex. Admitting exceptions for certain forms of lunacy, we may presume the succession of mental states, of perceptions, acts of reason and volitions, to be generally less rapid and their changes less various in these instances; and, what tells more in the intellectual comparison, the power of the mind over its own sequent operations is feebler and less coercive. The differences may be of degree only, but they graduate between the intellect of an infant or idiot and that of a Newton or Shakespeare.

I might from my notes add something more on this interesting topic. But I have said enough, I hope, to mark it out as a special path by which to seek further ingress into the mysteries of our mental nature—a path, however, like any other having this direction, stopped at the same point by a barrier insuperable to all.

ASTRONOMY AS A SCIENCE.—THE SUN.

What I may write under this title will be but a partial glance at that progress in Astronomy, which more than ever marks this science as one of the most wonderful, but not duly appreciated, attainments of man.

I know no case in which the marvellous is so lost in the familiar as the indifference with which men gaze on the stars of heaven on a night of clear sky. Were it one star or planet only, or the multitude seen for the first time, the sight would be felt as one of wonder and awe. Such feeling is finely expressed by Pascal and Kant in noble passages of their writings. But it is lost by repetition, even to those who know the grandeur of the objects—the magnitudes, distances, and periods of time, with which astronomy as a science is concerned. We look at the full moon and on the swelling tide of a great river, ignorant or failing to feel the grandeur of that mysterious power which gives physical connexion to objects seemingly thus remote. Men and women come out of their crowded assemblies at midnight and look up to the dome of heaven and its 'patines of bright gold' with less interest than to the ceiling of the theatre or the lights of the ballroom they have just left. The great zone of the Milky Way, with its lustre of innumerable worlds, is seen without amazement; though even ancient poetry described it as the 'Via in cœlo sublimis,' the 'Iter ad alta tecta Tonantis.' One who passes from the hazy skies of our island to the splendid midnights of the Mediterranean or of tropical lands, may for a time be moved by the wonderful spectacle above him. But familiarity here also speedily deadens the impression, save to such a poet's eye as that of Lucretius, who in some of his finest lines (ii. 1025 *et seq.*) attributes the difference with which these wonders are regarded to the cause just stated.

Paley says, and rightly, that astronomy does not furnish the best argument to natural theology. The objects are too vast, and their final purpose too obscure, for a just appreciation in this sense. A single fitness to some manifest purpose in a single organ of the body affords more instant and entire conviction. Stellar astronomy in particular, as developed by the labours of the last hundred years, deals with numbers and distances so far beyond all comprehension, that common belief recoils at the very ingress to this great vision of the universe; and higher intellects can hardly pursue the facts admitted to the conclusions they involve. I have known men of strong reasoning powers, but otherwise directed, sceptical as to their reality, and needing to be told of the return of Halley's comet or Encke's at the predicted time, and of eclipses and transits exact to the minute foretold long before, or to be shown a nebulous spot in the sky resolved by the telescope into innumerable stars, before their belief could be got for the yet more profound attainments of the science. Certain of the most striking discoveries of the elder Herschel—such as the motion of the sun and its planets in space, and the results derived from his method of *gauging* the heavens—were for a time doubtfully received even by astronomers themselves.

At that period, indeed, the science had gone little beyond the confines of the solar system in any scheme of exact research. We had a partial nomenclature of stars, and a knowledge of relative brightness and position, the latter facts often expressed by whimsical analogies drawn from a distant and credulous age. The true sidereal astronomy is of recent date, and owes much of its wonderful achievements to the increased power and perfection of the instruments employed. It has now bridged over the interspace between our own and other systems of worlds, and shown by sure arguments from evidence that there is no actual gap in the series—that some at least of the forces and elements in the worlds thus remote in the universe are identical with those which give movement, order, and life to the globe we inhabit—and that we may safely affirm *unity of cause*, if not *unity of laws*, as regards the whole. In this conclusion of the *unity of creation*, and therefore of the Creative Power, we have the strongest argument which astronomy ministers to natural theology.

But there is another proof, though less direct, to be drawn from this source. Notwithstanding the ignorance of the mass of mankind of the objects and attainments of astronomy, the science itself is that which best shows the intellectual capacities of man in their most exalted application. Testifying thus to the highest conditions of mental endowment, it casts a reflex light on that creative design and power which, whatever the manner of evolution, could bring these faculties into existence and exercise.

Look simply at what this science expresses regarding man in comparison with the animals nearest to him in the scale of life. The lights of heaven, the sun, moon, and stars give images to the eyes of all these creatures, as to those of the astronomer. But to them they are images only, without note or result. To the astronomer those simple circles and points of light are the interpreters of the universe. He discovers through their places, aspects, and motions those astonishing facts as to space, time, and magnitude which figures fail to express to the thought, and the laws which, with unerring power, pervade these vast spaces and periods of time and govern all the movements and mutual relations of the worlds around us. Few men reach this high intellectual level, but man is the only being to reach it.

Astronomy is rich in examples, but one or two may suffice to show this meaning. A satellite has just been discovered of Sirius—that great globe shown to be equal in size and light to sixty of our suns, and some millions of times more distant in space. A few years ago Bessel, from a minute periodical variation in the right ascension of this star, conjectured the existence of such a satellite. It has now been seen, and with it some fainter luminous points, the possible indices of a planetary system of this great sun. But a short time before, the beam of light from Sirius (reaching the earth after a passage of years through intervening space) has been made to yield a photographic image of the star and a spectrum with lines corresponding in part with those of the sun—proving thereby the existence and identity of the chemical rays, and the presence of certain material elements in this remote part of creation, which recent discoveries have shown to be in common to the earth and the sun.

The researches now directed to this great centre of our own system similarly attest the genius and successful labours of modern astronomy. Some thirty years ago it seemed as though our knowledge of the sun had reached its highest possible attainment. Its distance from the earth, its magnitude and specific gravity, the laws by which it governs the orbital motions of the planets and comets, its own proper motion in space, the time of rotation on its axis, and the dark spots on its surface indicating this time; its influence on the ocean-tides, &c.—all these things had been either exactly or approximately determined. The light and heat of which it is the perpetual fountain, though comprehended in their origin only as emanations of force, had been the subjects of admirable analysis in their passage through space in the solar spectrum, and in their influences on matter, living or lifeless, on our own globe. Speculation on some points went further, but more exact science for a time halted here.

It was but a halt, however, and this at the threshold of what may almost be called a new science of the sun, such and so numerous have been the discoveries since made. One of these, however, is the discovery of an error. The mean distance of the sun from the earth (calculated and accepted by astronomers upon a parallax derived from two transits of Venus a century ago) has been recently revised upon new bases of observation, and the estimate reduced by 3,000,000 of miles, or about a thirtieth part. This correction may seem trifling to those ignorant of the exactness of the science. To the astronomer it is a weighty one, and the more striking because derived from the concurrence of distinct sources of evidence. The direct proofs are from astronomical observations, but one detached proof, singularly coinciding in date, deserves especial notice, as being drawn from experiments by Foucault and Fizeau on the velocity of light—some of these experiments of such admirable subtlety of device and execution that an apparatus confined to a single room sufficed to *demonstrate* the velocity of a ray, passing through 185,000 miles in a second of time! This rate of motion, less by 7,000 miles than that deduced from the occultation of Jupiter's moons, almost exactly concurs with the correction just noticed as to the distance of the sun—a coincidence satisfying the most rigid conditions of enquiry. No fact can better illustrate the prowess of modern science, in continually bringing to the discovery of a common truth phenomena and even laws seemingly distinct in the natural world.

This remark applies not less to other polar phenomena recently disclosed, and eminently to those great discoveries by aid of the lines in the spectrum, which show the existence in the media enveloping the body of the sun (photosphere, chromosphere, or by whatever name designated) of various metallic elements and gases familiar to us on the surface of the earth. The methods by which certainty has been given to this wonderful result, while they illustrate the physical relations of all that is greatest and smallest in the material world, do also strikingly express that growth of intellectual power through which man has reached a knowledge thus far beyond that of all prior ages; beyond even what might seem the destined limit of human attainment. Nor is any such limit yet obvious to us. The very negation of various terrestrial metals, shown by the absence in the solar light of the lines interpreting them, and the existence of lines in the spectrum to which we have no index in our earthly catalogue, are facts equally pregnant for the future. Even while writing this paper, with intent to illustrate by solar researches the present aspect and aims of astronomical science, these researches are in active, almost daily, progress; bringing before the eye movements and changes ever going on upon the surface of this vast central luminary—phenomena which, though of surpassing grandeur in their scale, depend upon the presence in the sun of certain material elements identical with matters ever present and active on our own globe. It is well to note here, as an index to the mutual relations of the physical sciences, that chemistry, optics, electricity, and telescopic observation are all concerned and blended in the methods to which these discoveries are due.

We see the sun, then, no longer as a simple central globe, tranquilly diffusing its influences to the planets in surrounding space, but as a vast body, undergoing continual and violent changes on its surface, and, it may be, secular changes also, of which time only can reveal the import and extent, but which, if existing, must assuredly alter some at least of the conditions of our own planet.

But the science of the sun in our own day does not stop here. Known in all ages as the source of light and heat—in later times as the centre of planetary gravitation, whatever that mysterious force may be—it has now become known, though more imperfectly, in its magnetic relations to the earth. This connexion, equally mysterious, is made almost certain by the averages of long observation, involving not only the diurnal magnetic changes included within the solar hours, but also a seeming periodical coincidence between the maxima and minima of solar spots, and the maxima and minima of magnetic inequalities on the earth. These relations, indeed, require to be attested and defined by further research, comprising as they do the theory of the magnetic force, still imperfect in its very elements, and the physical conditions of the sun's surface, not yet fully understood. But their existence is sufficiently proved to carry conjecture beyond, to the probable diffusion in more remote space and among other globes of that elemental force, call it what we will, which we know, as electricity, to be associated with all states, forms, and changes of terrestrial matter, and which we cannot suppose dormant or non-existing among other worlds, subject to the same law of gravitation, emitting the same light, and even yielding in some instances a certain evidence of the same material constitution.[1]

Recurring, however, to the sun, as one more special illustration of modern astronomy, we must look again as a part of this science to the still unexhausted wonders of the solar spectrum. This spectrum, formerly seen in its prismatic colours only, has now become the exponent of invisible rays, stretching far beyond its visible extremities; propertied as heat at one extremity, and with those specific chemical actions at the other, which have given a new and beautiful art to mankind. The undulations conveying (or forming) the three powers thus blended in a single beam have specific relations to the different forms of matter on earth, such in kind and so essential that life and organisation would cease to exist deprived of their influence. Science is every day disclosing new and unexpected relations to this effect; while the powerful prismatic spectroscopes now brought into use are analysing, still more minutely, and under varying conditions of heat and density in the gases evolving them, those spectrum lines of different elements, the relations of which have given us such unlooked for access to the matter of the sun itself.

This unceasing derivation of light and heat, and perhaps other powers, from the sun—a derivation not limited to our planet, a speck in the firmament, but

[1] Milton, in the phrases of his noble poetry, might almost be said to predicate those discoveries of our own day. In the third book of 'Paradise Lost' he speaks of the sun's *magnetic beam,* and in the same passage of the *arch-chemic sun.* A certain sort of inspiration and vaticination of the future often seems to enter into the higher poetry of each age.

ever going on in every direction of space [1]—has furnished material for other more speculative questions in solar science. How are the losses caused by these emanations compensated or repaired? Or, seeking the cloke of words, and saying that it is force and not matter which is thus expended, how is force, in itself a real existence, restored or renewed? Recent theory has sought some answer to these questions in the supposition that heat at least may be regenerated in the sun by the violent impact upon it of asteroids or nebulous matter from surrounding space. This hypothesis is at the best little more than conceivable. We have evidence, indeed, that matter, under various forms, does exist in interplanetary space, and that one or more asteroidal rings have orbital motion round the sun, coming into periodical contact with the orbit of the earth. And could it be that the sun does derive increment of matter from these or other sources, we might infer from analogy an evolution of heat from every such impact on its surface. But admitting this, see how far we yet are from any law of equivalence! How unable to strike a balance between loss and gain in these mighty interchanges! Or, again, if light and heat be simply modes of motion, as modern science ventures to define them, where are we to seek the source of reparation in the sun, not indeed of substance, but of force or propulsive power? To say that the aggregation of new matter brings with it new power of this kind, is

[1] Calculation at this point shows that the earth receives but the 2,300-millionth part of the light and heat which the sun radiates into space.

little more than an affirmation of words, betokening, not scientific facts, but conditions and conceptions which science has failed to reach.[1]

These, however, are speculative matters, contributing little to the true physical history of the sun. The solar spots, assiduously watched by such observers as Schwabe, Carrington, De La Rue, Lockyer, &c., have added much more to our actual knowledge, though still leaving it incomplete as to their nature and origin. The indication they give of rotary motions of the photosphere, varying at different distances from the sun's equator, is one curious result of very recent observation. More curious still are those delicate and beautiful observations with the spectroscope, which tell us, without aid of eclipses, the nature of the curious rose-coloured emanations from the sun's surface, hitherto so vainly speculated upon; and which in associating them with the agency of known elements (however vast the difference in degree) bring us nearer to that unity which it is the purpose of all science to attain. Much is still to be learnt regarding these gaseous solar envelopes, and the changes unceasingly going on in them. But the objects and methods of research are well defined, and the zeal given to their pursuit is a sure guarantee of success.

Time, however (supposing a sufficient duration of

[1] I find Professor Challis propounding another speculation on this matter, viz., that the sun may be the recipient of undulations from more remote stars—conveying them forwards through its own molecular mass, and itself not losing power by this continual transmission. An hypothesis of this kind tells little more than the intrinsic difficulties of the question.

the human race on earth) seems the sole means of solving that higher question, as to the proper motion of the sun itself, together with its planets, in the universe of space? Whether what the short life of our astronomy here shows but as a rectilinear motion in a given direction through this vast void be not really the segment of an orbit round some centre of gravity yet unknown? All analogy points to this conclusion, but of more direct evidence there is none.

Holding in view these various discoveries and the speculations to which they legitimately lead, no one having intellectual sensibility (a phrase I willingly adopt) can regard without some emotion this great orb of the sun, rising or setting on our earthly horizon—for these are the times when it may best be seen—or wonder that there should have been races of men who have viewed it as representing the Supreme Power of the universe. The noble lines in which Milton addresses light are a hymn to the sun itself, as the source of that wonderful element which pervades all space, ministering to the least as well as to the greatest purposes and acts of the Creative Power. In the foregoing paper I have taken the sun as representing to those who are not familiar with the subject the methods and progress of modern astronomy. Many other examples might have been taken in illustration, but none more striking than this.

LIFE ON THE EARTH.—RELATIONS OF MAN TO OTHER ANIMALS.

1868.

Modern science has been active in deciphering the succession and relation of different forms of life on the earth. The grand marvel is the existence of life itself. All questions are subordinate to this, whether they concern the innumerable forms now in being, or that long and wonderful series of extinct existences which fossil geology has disclosed.

What is Life? It has undergone a dozen definitions, some by very eminent authorities, but all liable, more or less, to objection from error, incompleteness, or obscurity. The problem has pressed upon every age, and in our own time has been brought into connexion with the latest discoveries of physical science. Nevertheless, we still need a definition which may satisfy all the essential conditions without becoming valueless from its too great generality. That given us by Aristotle, though involved in certain terms of Greek philosophy, is as good as any that have succeeded it. The well-known definition of Bichot: 'La vie est l'ensemble des fonctions qui résistent à la mort,' and that of the Encyclopédie, 'La vie est le contraire de la mort,' are too epigrammatically negative to serve to any use.[1] They omit, moreover, that which is the very essence of life, viz., that of reproducing life more or less like in kind to itself. No definition can be good which does not include the condition of an organisation capable, by sexual or other means, of such reproduction.

The definition of life has been perplexed by other ideas annexed to it. The terms 'vital principle,' 'vital energy,' 'vital force,' &c., though needed for description, and which in one sense may be admitted as realities, do not really define anything that we can construe to the understanding. We cannot assert, on proof, that life is engendered by, or engenders, any power or force special to itself. Nevertheless, in assuming, which we must do, that it transforms certain known forces so as to appropriate them to its peculiar functions, we virtually admit a special and characteristic power, call it what we will. A formal definition (which after all has very little scientific value) may exclude what is thus ambiguous to our reason, but in the present state of our knowledge the conception of life embraces it by what is next to a necessity.

Something more may be said for bringing time, as an element, into the definition sought for. Every form of life, endlessly dissimilar though these forms be, has its average period and term of existence, as well as chronometry in its various particular functions. Growth,

[1] The definition by an eminent philosopher of our own day that life is 'the continuous adjustment of internal relations to external relations,' is subject to the same charge of a generality which lessens its scientific value.

maturity, final decay, and death belong to living organisation in its every shape on earth.

In what, and how, and when did life begin on our globe? In its lowest aspects, whether animal or vegetable, we see nothing more than a few material elements, aggregated under the simplest forms, with very few organic functions; yet these so propertied as to preserve existence for a certain time—to provide for a succession of similar existences—to live and die. From these simple conditions (taking animal life as best in illustration), we find a series rising upwards by broken steps to those which are most complex and complete. In no part of this ascending scale is there any very wide gap—what seemed in many instances to be such having been partially filled up by recent discovery in the living or in the fossil world. However this series may have begun, and whether worked out by progressive derivation or evolution within itself, or by successive acts of special creative powers, equally may we affirm the unity of scheme in this vast connected scale, and the necessity of a First and Supreme Designing Cause. If the endless forms, functions, and instincts of life which we see around us be derived by progressive changes, in unmeasured time, from a few primitive types of being, such changes bespeak vital laws and energies acting on matter through, or concurrently with, the great forces of the natural world. Under any and every view of the subject, *intention* by some higher Power, however obscure to man as the interpreter, is manifest as the foundation of the whole. This is the sole standing-point to our reason, when regarding the origins, varieties, and perpetuations of animal life on the earth.

The science of life, in truth, is yet in its infancy. Modern physiology has done much in expounding the material changes by which individual life, springing from its germ, whether through ova, fission, or budding, is matured and maintained, and those further changes by which it comes to an end. But the ultimate mystery of generation is yet unresolved, and every speculation hitherto vain as to that vital function by which life is begotten from life, with resemblances and differences equally inexplicable under any known physical laws. Putting the point in a simple but cogent form —What is that power, principle, or energy—call it as you choose—which out of a single germ, or germs, or germinal matter, or protoplasm (the names signify little) invisible to the naked eye, can evolve, by gradual accretion of fresh matter, the likeness of an anterior being, even in its minute peculiarities of structure and function—which, in the human being, for instance, can reproduce, after the omission of one, two, or more generations, some marked feature of face, some organic or functional disease, or even, as races as well as families show, certain mental characters and endowments? Or what, again, is that occult principle of life in the seed which enables it, after the lapse of thirty centuries, to germinate again into the perfect plant, when the fitting conditions of light, heat, and atmosphere are supplied? The molecular theory, which serves to illustrate so many physical problems, is of no avail here, nor does science through any other path approach the solution of the mystery.

We encounter at this point the question as to 'Spontaneous Generation,' a momentous enquiry, bequeathed to us in a vague form from antiquity, and recently revived under conditions of very delicate experimental research. Can matter of any kind, under any circumstances, generate life without the presence of the ova or germs of prior life? Though the enquiry has applied itself only to the lower forms of infusoria, it is one of deep interest, whatever the solution may be—involving, as it does, in connexion with recent theories of derivation and development, the whole question as to the origin of life on the earth. The researches of M. Pasteur, admirably guarded against all contingencies of error, are in my mind next to conclusive in favour of the old dogma, 'Omne animal ab ovo.' But the opposite view sustained by Pouchet and others cannot be put aside without further enquiry. And such is now in progress, by methods which strikingly attest the exquisite exactness of modern experiment.

Nothing more startles contemplation than the *quantity* of life upon the earth. Around us, above us, below us—air, ocean, lake, river, mountain, plains, and forests—all nature teems with it; from the eagle, whale, and elephant downwards, to the monads and vibriosi of infusorial life. Recently even the bottom of the sea, at the depth of two miles, has been found laden with these forms of life, perfect in their individuality, and not inferior in type to the kindred species existing above. The enumeration of animal species, so denominated, reaches at least 200,000, and is every day augmenting. But this gives a feeble idea of those *aggregates of individual lives*, presented by single species, generally in proportion to their minuteness. All reckoning fails to reach their numbers, or those of the countless multitudes of organised existences which perish as ova or before they come to maturity. Every book on natural history abounds in these facts; yet few rightly comprehend them or feel adequately all that is wonderful in this enormous multiplicity of life, and in its renewal by reproduction, generation after generation, through successive ages of the globe. The most minute insect or mollusc has its pedigree enrolled in the great volume of life. If man could truly read these histories some of the great problems of nature might find their solution.

I may say for myself that I never enter the Natural History Galleries of the British Museum or the Zoological Gardens without a feeling of amazement mixed with awe. And this feeling is not lost, but intensified, by contemplation of details. Whence and for what purpose in creation this marvellous number and variety of beings—of forms and organs, of instincts and actions? The question cannot be evaded by reason, and is not answered, even presumptively, by science. It extends too beyond existing life (and with incalculable time added as a part of the problem) to those fossil vestiges of extinct life which now crowd upon us so numerously from every part of the earth. A single footstep pressed on one of the walks of the London Parks covers thousands of minute shells, each the habitat once of a living animal. Every railway tunnel under a chalk-hill carries us through massive rock, the workmanship in its origin of myriads of foraminifera. That city of Richmond, in Virginia, of the bloody struggle around which I have recently been a personal witness, stands upon a foundation of infusorial shells.

It is the destiny of life, whether animal or vegetable, to be everywhere the food of life. Death is the transmigration, not of *being* but of the *material of being* into new forms and modes of existence. This great natural law, which makes animal life in its every shape depend for evolution and maintenance upon life already existing, extends from man downwards to the lowest grades of the animal creation—strikingly exemplified in those parasitic creatures now so numerously catalogued as to form a distinct portion of natural science. And a notable, though inexplicable, part of this great scheme of nature is the constant and obvious provision in the animal world for the maintenance of succession even at the expense of individual life. Among the insects it is common to see the individuals propagating life perish as soon as this function is fulfilled.

Without stopping to refute Buffon's strange doctrine (supported, indeed, by one recent authority), that the *absolute quantity* of life has been, and must ever be, the same on the globe, it is well to note here how largely physical conditions, as well as human necessities and intelligence, influence its distribution over the earth. Natural history is profuse in examples to this effect, both in the animal and vegetable world. Even as regards human life we are continually admonished as to those accidents and conditions of existence, physical and social, which augment or lessen its amount on any given area of the globe. Take the single case of Ireland. The potato, naturalised as a food of the country, raised its population to the inordinate amount of eight millions. The potato disease of 1845 and the following years (the work of one of the lowest forms of parasitic life) took off nearly a quarter of this number by famine or emigration. In every grade below man in the animal kingdom life is similarly subjected to the conditions which press upon it from without, either such as are purely physical or the conflicts of different forms of animal life with one another. This is in great measure a new branch of knowledge, and it has already been rendered a prolific one. We see how not only the quantity but also the organisation and habitudes of life depend on local and ever-varying circumstances, and how far man is concerned in fixing or changing these. Much, however, yet remains to be done, as well in correcting errors of older date as in determining the laws which pertain to this part of the great problem of life on the earth.

In close connexion with this subject, and its most important correlation, comes the question regarding the relations of man to the other forms of animal creation peopling the earth. Surrounded on every side by living beings, consuming them, consciously or unconsciously, as food, and even inhaling them with every breath, this question must ever be one of deep interest to human thought and well worthy all that can be done towards its solution.

Bayle says, and justly, 'Les actions des bêtes sont un des plus profonds problèmes sur quoi notre raison peut s'exercer.' Taking the simplest view of the relations involved in this problem, we may speak of man as the head of the living creation; the latest, probably, certainly the loftiest, in that long series of existences which we follow downwards till animal life is lost in the lower organisms of the vegetable world. But this is a feeble outline of all that the question involves. Within the wonderful series just denoted lie whole volumes of facts, inviting or almost compelling research into the connexion of the human being with creatures lower in the scale of life. The careless thinker may let his reason go to rest on this admitted human supremacy. The philosopher, looking on the dog crouched at his feet, sees in him an animal with organisation variously akin to his own—with intelligence, memory, feelings, and passions of the same kind, however differing in degree and manner of use—with appetites and necessities of life similar also, though more in subordination to instinct and hereditary habits of the species. The idle spectator gazes on the anthropoid ape with mere merriment at this mockery of human form and gesture. The man of deeper thought cannot stand in face of these creatures without some feeling of awe in the contemplation of that mysterious scheme of creation which has brought them thus near to himself in the scale of animal beings.

Pascal says: 'Il est dangereux de trop faire voir à l'homme combien il est égal aux bêtes, sans lui montrer sa grandeur. Il est encore dangereux de lui trop faire voir sa grandeur sans sa bassesse.' The caution is chiefly needed for philosophers, since to the general sense of mankind familiarity disguises this great wonder of the world of life. But the science of our day, bringing fresh methods to bear upon it, has boldly encountered the problem—encountered, but not yet solved it, as far as regards that question of intention or design which lies at the bottom of the whole. The wider observation and better classification, and the study of fossil remains, aided by all the resources of comparative anatomy, have wonderfully enlarged this domain of knowledge, but in doing so have given origin, and legitimately, to new hypotheses still under active controversy. I especially allude here to that doctrine of evolution or transmutation of species by which it is sought to reduce to certain natural laws of change, selection, and succession those inter-relations which pervade the animal world from man down to the lowest zoophyte—a doctrine which has received its latest and happiest illustration from the work of Mr. Darwin on the Origin of Species.

But, apart from this larger hypothesis, other and more absolute results have been derived from the researches of our own day. It is almost needless to mention one of these, coming in refutation of a vulgar notion that the creation of the rest of the animal world is but a corollary to that of man—a ministration, as it were, to his higher being. Every part of natural history, and very especially the history disclosed to us by fossil remains, utterly annuls any such conception. Man is the highest and most wonderful member of the created series. But he is integrally a member of it. And it would not be too much to affirm, were such vague affirmation worth having, that not one-hundredth part of the animal creation, counted by species, has relation, direct or indirect, to his existence on earth.

While discarding, however, any such assumption of the *dependent relation* of other animals to man, we must admit that another relation presses more cogently upon us if we adopt the doctrine of progress in the forms of life by gradual evolution instead of by special creation. This doctrine cannot be held, as it is held by many, without including man as a unit in the scale of progression—the highest product of those laws or accidents of development by which inferior forms of being are raised to those of higher grade. We cannot stop short at the human threshold, if the argument for transmutation has carried us thus far. But this question, perfectly justifiable in itself, is one requiring separate discussion, though so closely allied to all other problems of the living world that none can be wholly dissevered from it.

From the comparative anatomy and physiology of the present day we derive a very exact knowledge of the structural and functional relations of man and other animals, traced upwards from the dawning of life in each. The enquiry rises in interest as we come to the higher orders of mammalia and those quadrumanous animals the proximity of which to man even nomenclature has been led to recognise. It is needless to cite the several resemblances of structure, and of the functions to which they serve, through all the stages of generation and growth, of decay and death. The brain, as the organic minister to the mind, is the part to which we look with deepest curiosity. Though certain structural differences have been indicated, the main and most obvious distinction between the brain of the anthropoid apes and that of man is the difference of *size and weight.* Without quoting the various facts derived from Wagner and other enquirers, it is enough to know that the cubic capacity of the largest gorilla skull yet examined is less than half that of the average human cranium. It may be that molecular differences, unseen by us, enter into and modify the cerebral functions. But the fact still remains certain that this condition of quantity in the brain plays a part very essential in the relation of members of the animal world, including man, both individually and distributed into races of men. And the conclusion is more striking as we descend in the scale of being, and find decrement of brain associated throughout with decreasing intelligence, and the substitution of those instincts which become in the end the totality of life.

We can in nowise reason upon this relation of size and weight to the cerebral powers. Here, as in all that concerns the connexion of the brain with the mental functions, we have barely reached the mere rudiments of knowledge. The same may be said of those cerebral convolutions the presence and complexity of which are so remarkable in man, and which in the higher quadrumana differ less from the human type than they do from that of the lemurs, the lowest of this order. This part of structure we can in nowise interpret, either in its presence, its absence, or the variations incident to it.

But the structural relations of the higher mammalia to man are a preface only to the deeper question regarding the functions severally attached to them. Structural likeness of organ implies likeness or identity of function. Does resemblance of brain, in its various degrees, warrant fully this interpretation? or is there some specialty here which forbids or limits the application of the rule? I confess I know of none. In whatever way the scale of animal life be arranged, there is a certain proportion found to exist between the cerebral development of the species and the presence of those faculties to which the brain ministers in man. This fact must be taken generally, as we are unable to gauge with exactness in other animals qualities and functions which are not easily described or measured even in ourselves. But in such general sense, and restricting the enquiry to the higher animals, we come upon a multitude of recognised facts, which, though escaping serious thought from their familiarity, are cogent and of deep import in the conclusions to which they lead us.

Even without serious thought, however, common language has fully recognised these facts as they every day come before us. We speak habitually of the varying *intelligence* of different animals, individuals as well as varieties and species. We speak of their *characters* and *tempers* as different, denoting thereby propensities, passions, and affections the same in kind which belong to the moral nature of man. I have already alluded to the dog, as the instance most familiar to us—the animal 'ad hominum commoditates generatus,' to take the closing words of Cicero's eulogium. But seeking more general illustration from among the higher animals, domesticated or wild, the following may be taken as a summary of the comparison with man.

Of their reasoning faculty in this relation no happier definition can be given than that of Cuvier: 'Leur intelligence exécute des opérations du même genre.' Milton says, in more guarded phrase, 'They reason not contemptibly.' The *kind* of reason, however narrow in its scope and combinations, is virtually the same. The mute syllogism of the monkey, or dog, or elephant is perfect as far as it goes, and might be translated into speech or writing. It is less easy to apply the term *reflection* to their intelligence, yet I think it cannot rightly be excluded. Locke denies to them the power of forming, '*abstract or general ideas;*' but these terms themselves have long been the subject of controversy, and are not easily admitted into proof. That they possess and largely employ the memory of objects and events is indisputable; but we have not the same proof as to that higher faculty of recollection—the *μνήμη συνθετική*—to which the mind of man owes so much of its power and attainments.[1]

Another question occurs, whether *anticipation of the future* comes within their scope of thought? In-

[1] Aristotle denies to other animals this faculty of *ἀνάμνησις*. He says, *Τὸ μνημονεύειν τῶν ἄλλων ζῴων μετέχει πολλά· τοῦ δὲ ἀναμιμνήσκεσθαι οὐδέν·* Cicero speaks of the 'mens, ratio et memoria' of the ant.

stincts are doubtless largely prospective, and the more perfectly so the lower we go down in the scale of life. But does any animal intellect, save that of man, possess this power? An old English writer speaks of 'the boon to brutes that they are nescient of evils to come.' And this may be true; yet still with admission that they have some faculty of forecasting the future, where not remote as to time, and coming in close relation and sequence to the habitual events of their existence. This forms, in fact, a part of the education of animals—a term we cannot refuse to adopt for those conditions, natural or artificial, through which their several faculties are fully evolved or modified, and in many instances even made to supersede the natural instincts of the species.

To other faculties, intellectual in kind, it is impossible not to annex the *sense of humour*, so conspicuous in very many animals, though not duly noticed in the inference it affords. The gambols, gestures, and sly artifices of monkeys well depicture what are the sports and tricks of human childhood. The dog, toying with his master or gambolling with other dogs, shows his feeling of fun as plainly as if it were put into words; and a little reflection will show how much lies beneath this single and simple fact.

The intellectual faculties, then, are alike *in kind*, while far inferior in power and capacity to those possessed even by the lower races of mankind. As physiology tells us of stages in the fœtal growth of man corresponding with what is the final type of inferior forms of life, so does the mind of the untutored child aptly represent those degrees of intelligence which are the highest attainment of the creatures nearest to us in the animal world. Some writers, as Lord Herbert of Cherbury, have held that the capacity for conceiving the existence of God forms the chief distinction between the reason of man and that of brutes. But this may rather be taken as one of many analogous cases, expressing the limit imposed on the faculties of the latter.

As respects the feelings, passions, and propensities of the animals thus near to our confines, we must regard them as essentially the same with those which denote the moral nature of man—very different, indeed, in their objects, and wanting those nicer shades of the human character in its various grades of cultivation, but still to be described only by the same terms and understood in the same sense. Without running into subtle distinctions of name or nature, it is enough to recite generally the common qualities most familiar to observation. Such are, love and hatred, emulation and jealousy, anger and revenge, boldness and fortitude, pride, and perhaps vanity, gratitude, cowardice, and cunning. These qualities are not defined by difference of species only. As in man, they characterise individuals of the same race, and are innate, more or less, in the temperament of each.

It does not concern us here to trace them downwards in the scale of animal life till they vanish in the bare instincts of existence. The main point is, that such a scale exists, culminating in man, and in its higher grades approaching to him in the kind, though not in the degree, of these various faculties. It is a marvellous approximation, deal with the matter as we will. And interpreting it, as we must needs do, through the long gradation downwards of inferior forms, living or extinct, we can come to no other conclusion than that of a great *Scheme and Design*, under which animal life is created or evolved progressively with higher powers and endowments. It does not invalidate this conclusion that we are unable to decipher the total series, or to explain the unequal or broken steps of progress. Nor is it touched by the controversy now going on between the doctrine of special successive creations and that of evolution in time from one or more primordial forms. If the former be true, the design of the Creator is expressed in the successive appearance on the earth, at intervals of unknown length, of creatures rising in the organisation of those parts which minister to intelligence—if the latter, the same designing Power must have given to certain primordial forms capacities and laws of transmutation and development, enabling them to multiply into endless varieties, and through some of these changes to attain to forms and faculties approximate to those of man. Reason or theorise as we will on this matter, we cannot but end with the belief that there is a preconceived plan, however hidden from our comprehension, in all that concerns the being and conditions of animal life, and nothing fortuitous in the position of man, at the summit of the scale so designed.

But recognising this conclusion, how entire is the blank beyond! What conjecture can we form as to the purpose of this great plan, of which man comes in as the highest exponent and present terminal of the series? How explain that long array of beings, multitudinous in number and forms, now buried in the rocks of the globe, and indicating innumerable ages of life anterior to man? Any notion of *tentative work* in creation is excluded by the character and complexity of the series, and not less by the conceptions which alone we can form of the Creator. That Power which could confer the higher faculties of existence, either by special acts or general laws of progress, must have been capable of creating the higher without the intervention of the lower grades of life. But, however we may shape the argument, the fact on which it rests is that of a scale of created beings, irregular, indeed, in parts, yet showing relation and continuity throughout, and therefore what we must regard as *unity* in the original design.

While making full confession of ignorance as to the purpose of this vast world of life around us, it must be repeated and ever kept in mind that man is an integral part of the scheme. His endowments, even as attested by those wonderful instances which form the pride of human history, are still relative in kind and degree. And if we descend in the human scale itself—detaching from the great mass of mankind the names rendered immortal by virtue, genius, learning, or art—we bring the connexion yet closer to those forms of animal life which, though below man, may well startle him by their proximity. No one can have travelled much, as I myself have done, or lived observantly among inferior races and classes of mankind, without becoming conscious of this. Poetry has told us, and truly, that gems of genius and greatness often lie hidden in silent obscurity. But we are forced to admit, looking broadly at the characters impressed by descent upon races and communities of men, that the *capacity* for achieving greatness is lessened—the faculties themselves, intellectual and moral, degraded—by adverse conditions of existence, physical or social. The sadness of this reflection is abated by the justifiable belief that under different conditions, and aided by hereditary transmission, these faculties may be extended and exalted far beyond the limits marked by our present experience. On the latter point I have commented in another of these papers. A century more will give those then living sufficient evidence on a subject of deep interest to the future history of mankind.

One question there is respecting our relation to other animals which has a specialty of its own. How much of the superiority of man depends on the wonderful faculty of speech, on which he so supremely transcends every other part of the living creation? I say *transcends*, because speech simply understood is but the communication of thought, will, or emotion by intelligible sounds; and, so defined, it is certain that very many animals, even far down in the scale, are gifted with this power, exclusively of those other senses or instincts which serve to the necessities or pleasures of their social life. If the dog could speak with his tongue, as he does with his tail, how much of keen intelligence and warm affection would he express!

But as regards human speech, 'the joint energy of our best and noblest faculties,' we cannot confine it within any such naked definition. This capacity in man, due in part to the peculiar anatomy of the vocal organs, but more, we may affirm, to cerebral organisation, assumes in its cultivation and results a far more exalted aspect. Without entering on the wide question, now actively discussed, as to the origin, structure, diffusion, and divergence of languages, it is enough to say that the faculty of speech, nurtured and perfected in its various forms, and robing itself in those written characters which spread a silent but living speech over the globe, has done more than any other endowment in giving to man his peculiar position in the animal world. Suppose for a moment the annihilation of language, spoken and written, and in place of it an intercourse by gesture or brute sounds, 'vox et præterea nihil,' and think how vast the void that would ensue, how great the degradation of man's nobility and supremacy! Those higher powers and workings of genius which have procured for some men the veneration of all ages, would have been dormant and fruitless, had this wonderful mechanism of language not come in aid. Take the very highest of these human achievements, and see how much depends on prior knowledge, gathered from the labours of generations gone by; which labours would have been lost but for this manner of transmission from age to age. Knowledge is correlative in every sense of the word. Insulate the human mind, and its supremacy is impaired or lost. We have evidence of this in those nomadic and other races where language has never got beyond a low grade, and is represented by written characters as rude as the life they depicture. Such men still keep superiority to the animals around them; but it is a feeble dominion, and maintained by means which much resemble the acts or instincts of brutes themselves. The interval is lessened which separates them from the living world below.[1]

Here, however, we must notice another specialty of structure, whether original or derived, which has largely aided in giving his superiority to man. This is the *human hand*—a member of the body well meriting the valuable volume which has been written upon it. As a subject for speculative thought it may be less impressive than the one just discussed. But pursued into details, it is pregnant with instruction as to those methods through which man obtained his earliest powers over matter, not solely in the common arts of life, but even in those sciences which have raised him so high in the scale of being.

To sum up the results of all reasoning on the subject, they amount but to this, that there is a designed plan in the totality of life on the globe, as it has been, and as it now is—that man enters as an integral part into this plan—and that progress towards higher grades

[1] There is a striking expression of William Humboldt on the human faculty of speech: 'Der Mensch ist nur Mensch durch Sprache. Um aber die Sprache zu erfinden müsste er schon Mensch seyn.' And elsewhere he describes man as 'ein singendes Geschöpf, aber den Gedanken mit den Tönen verbindend.'

The speculation regarding mutism as a step of transition between the brute sounds of the anthropoid animals and the language of man is a notion held only to fill up a gap in a theory.

of existence is one part of the great scheme we thus contemplate in outline. Our real knowledge does not go beyond; nor can we reach, even by the hardiest human conjecture, to that Supreme Purpose, past, present, and prospective, which lies at the bottom of the whole, and to which man is submitted in common with all other forms, from the highest to the lowest, of animal life.

ANIMAL INSTINCTS.

[Written in 1869.]

This is one of those subjects of enquiry in which, though furnished with facts and instances innumerable, we yet fail to reach that ultimate truth which it is the object of all philosophy to attain. No effort of reason or speculation has yet reached the core of the question.

In a chapter on 'Instincts and Habits,' in my volume of 'Mental Physiology,' I have sought to define the actual state of our knowledge on the subject; and the relation of this great problem of animal life to others blended with it—inextricably blended, we may say, since no artifice of definition can dissever that *continuity* which pervades all forms and functions of the animal world, from the highest to the lowest. When we say that nothing is done in nature *per saltum*, we are denoting a general fact, if not law, which Leibnitz was one of the first to recognise and apply in philosophy, and which every later advancement in science has tended to illustrate and confirm—none more so than the subject before us.

The following paper will be supplemental in some sort to the chapter above-mentioned. The facts must mainly be the same; but I shall seek to give them more explicit direction to those conclusions, positive or negative, which admit of being reached. A larger design would needfully embrace vegetable instincts also, from their close connexion and continuity with those of animal life, but to these I can only here cursorily refer.

The question what we are to describe as instincts first presses upon us—one not easy to answer. We can define them under their more special forms, as distinct from reason, and often even in direct conflict with it. Such definitions are familiar; based on endless instances and satisfying the mind by their seeming completeness. Yet if we approach the phenomena more closely, we find a *border-land* where reason and instinct are strangely and inextricably blended—each invading the domain of the other, and reciprocally producing changes which variously affect the functions of both. Acts, primarily of reason and volition, pass by constant repetition into habits having the compulsory force of instincts, and often even transmissible to offspring; while instincts submitted to the pressure of unwonted conditions often assume new faculties and modes of action, which if we shrink from calling them acts of reason can only be interpreted as newly-developed forms of instinct.

It is on this border-land, however, if anywhere, that we may hope to obtain some enlargement and better definition of our knowledge. Little or nothing is gained by multiplying examples of individual instincts, strange and curious though they be, and worthy of a better classification than any yet adopted. Those of the bee, the ant, the spider, the carrier-pigeon, the salmon, the beaver, the tailor and weaver birds, and endless others, might be cited; but the instances most familiar to us represent in effect the marvel of the whole, and put the common question of origin into its most cogent shape. The old instance of the beehive, quoted from one age to another, tells all that is most wonderful in these instinctive mechanisms of life, invariable through all known time, and fulfilling the most complex functions of physical and social existence with a precision which no reason or volition of these creatures could effect. 'Quel abîme aux yeux du Sage qu'une ruche d'abeilles,' says Réaumur, and says truly. What is, and whence comes, this marvellous power? What are the forces which put into action and direct the admirable mechanisms, so various for different animals, yet so invariable for each—so closely allied in many ways to the material works of man, yet manifestly connected with other active influences, to which our knowledge of matter gives no interpretation? The vigour of Newton's intellect, directed to this problem, found no other solution than that the Creator of Life is Himself the *moving power* in the innumerable forms of instinct which pervade the animal world. Such conclusion does but plunge the problem into deeper obscurity. It is in effect one shape of pantheism—the barrier at which so many efforts to reach what is unreachable come to a sudden end.

But though failing to reach the ultimate truth in this matter, there are several subordinate problems lying in the way, and affording the nearest approach to it. These problems, too, are of deep interest in themselves, and in their connexion with the whole physiology of animal life. That which first offers itself is the relation of physical structure to the existence and variations of instincts—a question closely pressed upon us by recent doctrines and researches. Are the organic forms or material apparatus to which particular instincts are attached brought into this connexion by special acts of creation? Or do changes gradually going on, from whatever cause, in the forms and organs of animals produce corresponding developments of the instincts appropriate to each? This question, which is at once seen as deeply concerned with that of the Origin of Species, goes straight to the point, and admits of no evasion. Those who hold the doctrine of transmutation of species, and their derivation in the totality from some few primitive forms, must needs acquiesce in the latter view; one sanctioned doubtless by the many cases where change in external conditions creates new habits of life, which by repetition and propagation take the character of hereditary instincts, and modify to a certain extent the bodily organisation. But the admission here is a limited one only. The doctrine in question—disputed, indeed, but powerfully advocated—involves really the dependence of instinctive action upon organisation, under the direct relation of cause and effect. In assuming the evolution of new organic forms from material causes acting on prior organisms, themselves similarly developed from antecedent structures, instincts come in only as sequent on such changes—an acquired and not an original possession.

It will be seen, then, how much of the point of the problem lies within this single question. If it can be shown that some instincts are of such kind that no material organisation alone is capable of producing them—and others such that none but a special and designed organisation could evolve the particular instinct—we quit in these cases the domain of accessible science, and can appeal only to that higher Creative Power which is in itself the great mystery of the universe.

And such examples numerously occur, seeming to compel this appeal. We cannot, with all the aids derived from comparative anatomy, the microscope, and other resources of modern science, make any actual or conceivable organisation the exponents of those social instincts of animal life which serve not solely to individual existence but to the necessities or well-being of a community—which are in numerous cases *prospective* in their action—are strictly hereditary—commence, untaught, with life itself, and terminate only with death. How, for instance, can aught we see of the bodily structure of the hive-bee explain that marvellous fabric of the honeycomb to which even mathematicians pay their homage of admiration, or the social economy of the hive? What is there in the organisation of the white ants to account for the strange and complex yet well-ordered economy of these insect communities? Where do we find the organs giving to the salmon, to the migratory birds, to the carrier-pigeon their peculiar instincts as to seasons and localities? What is there in the beaver urging this animal to employ his constructive art, though rendered useless by captivity? From what structure can come that *prevision* of the future implied in the simple building of a bird's nest? or what subtleties of the external senses can explain those selective instincts as to food common to every creature of the animal world?

Instances of this kind might be endlessly multiplied, as significant as curious. They go far to sanction that phrase of Cuvier's where he describes the instinct of animals as 'un rêve qui les poursuit toujours.' But if so, what puts into motion these wonderful dreams of instinctive life? Anatomy, even the most searching, gives no answer to this question, and all reasoning and speculation are equally mute. It is that ultimate mystery to which allusion has already been made.

While thus separating the great mass of instincts from anything we can see or conceive of mere structure, it is needful to recognise the many instances where the domestication of animals, or other less obvious external causes, have altered both the bodily conformation and habits of the species, impressing the character of instincts, in fixity and force, on the habits so transmitted from one generation to another. Such changes belong chiefly, if not exclusively, to what I have termed the *border-land*, where intelligence is closely blended with instinct; and they are most striking where domestication by man has worked upon the highest degree of natural intelligence. Our social relations with the higher apes are happily not such as to furnish much illustration. But the dog, as concerns this point, is an *instantia crucis*, expounding better than any other animal that strange blending of reason, habits, instincts, and affections through which he comes into such close alliance with man, and illustrating at the same time the various affinities by which the latter is linked to inferior grades of the animal world.

This relation of habits and instincts will at once be seen as one of consummate importance to the whole question before us. I have treated of it at some length in the chapter before alluded to, and shall here add only a few remarks in further illustration. Where the origin of instincts is the problem every illustration is of value, and not least those which converge from different points upon common truth.

The definition of habit, as a mere expression of fact, is simple enough, and it may be carried far down into the animal world. But complicated with the functions of the will, as habits are, both in their origin and progress, it becomes far more difficult to describe or decipher them. In truth, this single word of *will*, so familiar to common speech, has been prolific of doubt and dispute in every part of philosophy. Though the mind of man especially here becomes the subject of illustration, it is not easy for the consciousness so to analyse its own workings as to separate the pure act of will from the other complex machinery of our mental nature. I have dwelt elsewhere on the psychological fact, as important practically as in theory, that numerous automatic involuntary acts, mental and corporeal, have their origin in acts primarily of the will, becoming assimilated in the end, in compulsion as well as aspect, to the simpler instincts of animal existence. The life of man in its every part is replete with examples of such changes; but with this general mark appended to them, that they are least frequent and compulsory where the mental energy is the highest. The main fact here is recognised in the ἔθος and φύσις of Aristotle; in the 'Consuetudo, deinde Natura' of Quintilian, and in a thousand maxims and common-places of our own day. But physiology, as a science, defines the fact far more strictly, connecting it with all the faculties, animal, intellectual, and emotional, and making it the exponent of many strange anomalies of individual life. When we say that 'habit is a second nature,' we pithily express those permanent changes produced by continual repetition even in the most important functions, and which, thus infixed, are often transmitted from one generation to another. No law, however, can yet even approximately be applied to this hereditary transmission. It merges in that deep mystery of generation in which so many of these secrets lie hidden.

These remarks chiefly concern man, but not exclusively so. The kindred thus denoted between instincts and compulsory transmissible habits may be seen much lower down in the scale of animal life, manifestly pointing towards that ulterior question, now the subject of such keen controversy, whether all actions that we call instinctive may not be thus engendered from simpler conditions of existence, granting unlimited time and physical changes, unknown in quantity and quality, acting from without upon animal life? This, in fact, is the main question embodied in Mr. Darwin's doctrine of the Origin of Species. A negative answer to it can only be reached through the proof that there are classes of instincts which cannot belong to any visible or conceivable bodily organisation.

I have already spoken on this point, expressing my belief that there are instincts thus characterised, and not otherwise to be interpreted to our conceptions than as original in the species or genus to which the animal belongs. The lower organisms are those in which the instincts of life are simplest and most absolute. As we rise upwards the more complex structure gives greater liability to disturbance from outward causes, and in the higher animals we find the influence of intelligence and feeling and the habits generated thereby. But in all these grades of being phenomena come before us which no organisation, though deciphered by the subtlest anatomy or physiology of the vital functions, can explain. In numerous cases, indeed, specialties of structure are seen, necessary to the special instincts to which they subserve. But this falls far short of proof that structure alone has generated the instinct. The powerful muscles and other structural peculiarities of certain birds and fishes are necessary to their periodical migrations by land and sea. But the act of migration itself is the marvel—determinate as to place, time, and method—guided by no sense or reason we can define or conceive, yet fulfilling its purposes with a certitude no reason could attain. Numerous animals have special apparatus adapted to objects wholly *prospective*, such as the building of nests or other preparation for future progeny; acts often very complex in kind, distinct and uniform for the species, but in nowise explicable as a provision of reason. The sexual instincts, and those connected with food—appetencies essential to life on the earth—come under the same head, as acts not due to intelligence nor to any obvious structure. Look, again, to the beehive or the ant-hill, where the instincts regard the individual creature far less than the community—where such communities are made up of members differing in structure and functions, yet all inter-related by mutual necessities—and where the instinctive energy is chiefly manifested in making provision for the future.

These instances, a few out of many, suffice to show that there are classes and kinds of instincts which cannot be interpreted through bodily organisation, either original or induced by the habits and conditions of existence. Much, indeed, may be admitted as to the latter causes, especially where the higher degrees of intelligence become interwoven with the complex fabric of life. But there still remains the profound problem of a power acting in and through this fabric of which neither our senses nor reason can render any account. It is the same mystery as that of the generation of life from life; the same, indeed, in a sense beyond mere analogy, since the insoluble questions are alike in each case, and so clearly blended that they can scarcely even be stated apart. If our knowledge ever advances further into these mysteries (including the strictly collateral one of the origin of species), it must be by pursuing this common path. As far as I can see, there is none other open to us.

I have spoken of induced habits in man and the higher animals as often acquiring an instinctive character, and even becoming transmissible to offspring. The instincts of man, as the highest in the scale, form a very curious but difficult topic—made more difficult by the larger intelligence blended with them, and further perplexed by those innate propensities and idiosyncrasies, intellectual and moral, which give diversity to human character, and often exercise a compulsion upon it which no reason or will can take account of or resist. It is not easy by definition to dissever these propensities from instincts. But while at once the most familiar and the most inexplicable phenomena in the philosophy of mind, they will be seen to belong chiefly to individual life; and though sometimes transmitted to offspring, are not, like true instincts, subject to any common or certain law. The animals nearest to man in intelligence have, like him, individual propensities, but these more closely interwoven with the peculiar instincts of the species. As we descend in the scale these individualities gradually disappear. The instincts become more definite in kind, identical for each species, and at the lowest point limited seemingly to the simple necessities of existence and reproduction.

Other causes make it difficult to define the special instincts of man. The voluntary and involuntary functions, and those of mind and body respectively, are so variously interblended, that even consciousness fails to detect the lines of separation. To the more doubtful instances mentioned above we may add the sexual instincts, those which express emotions of mind, as laughter, weeping, sighing, &c., and perhaps also certain infantile acts occurring at the very dawn of life. But all these cases are less distinctly marked in their nature and origin; and looking at the instincts of man and other animals collectively, we reach the general conclusion that reason acting through the will, and instinct guiding and governing the acts of life apart from the will, exist in inverse ratio to each other throughout the scale of the animal creation; the latter at a certain point encroaching so entirely upon the former that life becomes a mere mechanism, however complex and wonderful the functions performed.

I say at *a certain point*; but who can denote the point at which every trace of intelligence is lost in the blind compulsion of instinct? The little community of sparrows in my London garden puts before me a daily picture of the curious intermingling of the two faculties; and even in the nests of some birds we find adaptations to altered physical conditions which in man we should deem the result of intelligence. Experiments show that even the rigid architecture of the bee-hive and the equally rigid laws which govern this insect community undergo changes, made by the bees themselves, to remedy mischiefs inflicted from without. Unless we can satisfy our reason, or rather shelter our ignorance, by some such phrase as *supplementary instincts*, we must needs admit that intelligence is at work here. Many similar cases occur of contrivances adapted to meet casual interferences with the instinctive life of the species, and they might doubtless be variously multiplied by research in this direction—that is, by direct experiments made to determine how far, and by what methods, instincts interfered with may be supplemented by the resources, call them what you will, of the animal itself. Such experiments would be as curious as instructive. They are the rather to be recommended from the paucity of other means of entering into the depths of the question. The careful observation of the instincts of hybrids, and of the mixed breeds from varieties of the same species, is one of other collateral paths of enquiry, yet only partially pursued, all in the right direction, but all stopping short of those ultimate truths upon which alone a true theory of instincts can rest.

In the paper before referred to I have spoken in some detail of the nervous system as that part of the animal organisation which, though instrumentally only, ministers most directly, it would seem, to the phenomena of instincts. The experiments which show the impairment or abolition of certain instincts by special injuries of the brain or spinal nerves, or even of the antennæ of insects, prove undoubtedly the ministration of these parts to the functions in question. They also render it probable, as do other considerations, that the excitement, direction, and catenation of instinctive acts are fulfilled directly through the nerves; and very especially through that system of ganglionic nerves, which in its functions, direct or reflex, so largely controls every part of organic life. The absence of any brain in many large classes of animals whose instincts are absolute and complete, makes it indeed necessary that we should look to these ganglia and nervous centres of the trunk as the structures coming into closest connexion with them; while to maintain this view throughout we must suppose some inscrutable form of nervous matter in the lowest types of life, where the instincts are strongly marked, though no such matter can be detected.

It will be seen what various unsolved questions beset every part of this great problem. Still the relation just denoted carries us a step forward in the enquiry, by associating the instincts which bind animal life to the outer world with those peculiar internal organisms which *instinctively* serve to the maintenance of life itself. It is one of the great prerogatives of science to advance itself through these secondary relations, even where the ultimate problem lies beyond reach.

If material organisation tells us so little on which to frame a true theory of instincts, still less can we seek this by an appeal to those powers, or *forces*, as they are termed—light, heat, electricity, &c.—which act on matter universally, and not least under its organic forms. Life, indeed, could not exist, or its functions be maintained, apart from these forces, which minister to instincts as to other vital actions. Still it is excitement and ministration only, and no solution of the mystery. Nor do we gain more by bringing the 'vital principle' to our aid, which here, as elsewhere, is a barren phrase, veiling our real ignorance.

A special work on instincts, based on larger comparative observation and on experiment, is still wanting to us. More hands than one might be required, but it is a work which would well repay in probable results any amount of labour bestowed upon it; having peculiar interest, moreover, in its connexion with the question of the origin of species, to which I have already alluded. The main problem to be solved is the relation, as to priority or causality, between the organisation and the instincts of species. To this must be added subordinately all that concerns the hereditary nature of instincts—their relation to habits and casual conditions of life, including here the divergence of species into races, and the influence upon them of reason and the will. The doctrine of transmutation or evolution, refusing to admit the special creation of new forms of animal life, can only explain the diversity of instincts by supposing changes of organism, needfully involving changes of the instinctive functions; and this not only where reason and instincts work together, but also in those cases, far more numerous, where the latter, wholly detached from intelligence, are altogether compulsory in their nature. I have already given the reasons which seem to me to make it certain that instincts cannot belong to structure only. In a matter thus obscure, where an unknown power comes into the question, it is something to obtain even such negative conclusion. If we ever reach one more positive, it will probably be on that border-land already denoted, where mental and material functions, intelligence and instincts, are found together either in co-operation or conflict.

EVIL IN THE WORLD.

All theories, ancient and modern, which seek to explain the existence of evil in the world are based mainly on one or other of the following assumptions: 1st. The existence and counteraction to good of a personal evil spirit. 2nd. The repugnancy of matter as the material of creation, or other limitation to the Creative Power. 3rd. The permission or ordination of evil, under general laws, or for purposes designed by the Creator.

And first, as to the doctrine of a *personality* of evil. Strange it is that while Christian theologians have at all times been so sedulous to shape their tenets into creeds and formularies, they should have neglected to give clear utterance on a point of such deep interest to the whole history and moral condition of man. A phraseology of belief is maintained without any open expression of it. Satan, the Devil, the Evil One, the Evil Spirit, are some of our now familiar terms, thus translated from the language of Scripture. Why are they not distinctly interpreted to us, either as metaphorical phrases or as really affirming an individual personal existence? One or other determination must be true, but which? The distinction here is far more important than three-fourths of the doctrinal questions which distract the Christian world and divide Christian Churches. Why should a matter thus momentous be put before us as it comes through the misty medium of Manichæan or other Oriental philosophy?

Are there really Scriptural texts so wholly free from allegory or metaphor as to compel belief in a Being the personal author of evil? If there are, then should the whole of our theology be remodelled, for our conceptions of God and of his relations to man are wholly altered by such belief. If there are not, then ought theology boldly to declare the negative. Nothing can be more destructive of intelligent faith than those vague terms and traditions, which obscure the truth, but which we fear either to define or discard.

Probably very few intelligent persons do really believe in a personal Satan, having power or even permission to contravene what was designed for good in the world. I have often put the question to men of deep religious thought, and have found either that it had never definitely occurred to them, or been perplexed to their minds by the phraseology of pulpits as well as of common speech. It has been said, and truly, that in England the great poem of Milton has done much towards giving personality and its attributes to Satan. I have known myself some curious instances of this unconscious derivation of opinion.

I have looked with some attention to the use of the word *Σατανᾶς* as it occurs in the New Testament, taking Griesbach's text. It must be allowed that many of these passages (some thirty-two in number) will bear, others even seem to press for, a *personal* interpretation.

But there are many others in which the word is clearly used metaphorically; and these, in my mind, furnish an index to the former, and a strong argument against such mode of interpretation. Would the word ever be used to express merely evil thought, temptation, or sin, if in other places it affirmed a personal being, the spirit and author of evil in the world? I think it nearly impossible that this should happen. The metaphor embodies itself in personality. The personality, if existing, would exclude the metaphor.

I refer below to a passage in St. Luke's Gospel which seems to me conclusive as to the point in question; and to other passages showing how doubtfully the belief in an evil spirit is justified by Scriptural authority.[1] Yet I have more than once heard the personality of the Devil preached explicitly as a doctrine of

[1] See Luke xiii. 11, where a woman is described as πνεῦμα ἔχουσα ἀσθενείας for eighteen years; and verse 16, where it is said of the same woman ταύτην δὲ ἔδησεν ὁ Σατανᾶς δέκα καὶ ὀκτὼ ἔτη.

I find Dr. Howson, in his Hulsean Lectures (1861), quoting the mention of Satan by St. Paul in Acts xxvi. 18 as a proof of his existence and power. The inference I draw from this passage is just the reverse. The Διάβολος of John viii. 44 conveys more of personality, yet taking the whole phrase of the context, it may be simply metaphorical for evil. Ought our translation to render διάβολος and δαιμόνιον, coming near together, under the same word of Devil? There is evidently a different meaning in the original, whatever it may be. The passage in Matthew xii. 24 *et seq.* strikingly illustrates the difficulty of interpreting these several terms, to which that of Beelzebub is here added. The ἡ βασιλεία of Satan, another phrase in this remarkable passage, can fairly be construed only in an allegorical sense, which sense it reflects upon the context.

The singular contradiction between 2 Samuel xxiv., and 1 Chronicles xxi., can only be explained (and this imperfectly) by supposing what is translated Satan to be a personification of evil thought or action. The passage in Job of colloquy between God and Satan is still more manifestly allegorical. The word rendered Satan, as far as I know, occurs nowhere else in the Old Testament.

religion; listening to which I have felt that the preacher was unconsciously annulling the unity and supremacy of God, and making the government of the world an act of partition and struggle. If it be said that the Devil is permitted for a time only, this is but saying that God permits evil for a time, and evil effected by other spiritual agency than his own. However difficult the subject be under any aspect, all wholesome belief is lost amid doctrines which thus, upon a few ambiguous texts, deface and degrade the attributes of God. I do not think it needful to speak in detail of those various modes of Oriental belief which distinctly recognise a good and evil spirit in the world—a duality, in fact, of Divine Being and Power. Such belief is the first grade of polytheism, and belongs to the earliest conceptions of man thus directed.

2ndly. *The Repugnance of Matter, or other Limitation of the Creative Power.* A familiar doctrine of ancient philosophy, attributing to matter a certain quality of passive resistance—*malignity*, it has been sometimes termed—something that checks or contravenes the Creative Will. Quotations, Greek and Latin, might be largely multiplied on this topic, and as copiously drawn from the Gnostic writers of the early centuries. The questions they embrace cannot be better stated than in a single passage of Seneca:—

'Quantum Deus possit? Materiem ipse sibi format, an datâ utatur? Utrum idea materiæ prius superveniat, an materia ideæ? Deus quicquid vult efficiat, an in multis rebus illum tractanda destituant, et a magno Artifice pravè formantur multa, non quia cessat ars, sed quia id in quo exerceatur sæpe inobsequens arti est?'

This passage, in touching upon the origin of matter itself, brings into view the most profound question in all philosophy—the relation of the Creator to the material of creation. The problem is as insoluble now as in the days of Seneca, and so must remain to every future age. Where neither matter nor spirit admit of other conception or definition than through the phenomena they bring before us, all hypotheses as to their primary relation are idle and fruitless. The word ἀρχή, used in the same sense as the *Beginning* of Genesis, denotes what will ever be a hidden mystery to man.

But that the defect or oppugnancy of matter is the cause of evil in the world, we may deny on this plain consideration, that what seems defect or special evil in certain parts of creation does not occur equally, or at all, in other parts, though the material worked upon, and the power working, are the same throughout. This argument applies not solely to the physical but even more to the mental and moral conditions of humanity. To every evil and imperfection there is some comparative good or perfection standing in contrast. The creative power put forth and seen in these higher and happier manifestations cannot be judged as one limited or controlled by some inevitable necessity in those other cases where our shallow reason discerns only evil or defect.

This hypothesis, as regards matter, belongs chiefly, however, to the ancient philosophy, and I dwell upon it only because I have had occasion two or three times to argue against any such limitation of the Divine Power —on one of these occasions with the most profound thinker and acute reasoner I have ever known.

3rdly. *The Permission or Ordination of Evil in the World.* Almost equivalent terms where omnipotence of the Creator is assumed. The problem of evil under this relation has been the theme of endless discussion among laymen as well as theologians, but discussion falling far short of any satisfactory conclusion. Every reasoning man has had this great question before his thought, and been forced to recoil from it, or rest on the faith that what cannot be understood here may be made clear to us hereafter.

Putting aside that theological form of the question represented by the doctrine of original sin (a doctrine which creates many more difficulties than it resolves), natural reason has been variously appealed to for an answer. In this answer moral and physical evil are both concerned, and in closer relation to each other than might at first appear. It would not be easy to recapitulate all that has been argued and written on this subject. It has been urged that without suffering there cannot be trial of fortitude and patience—that without temptation to evil there can be no virtue—that the scheme of life embraces death, and thereby the painful changes which often precede it—that much of this suffering is due to our own errors or excesses—that the world is governed by general laws, and that man, like other animals, is subject to these laws, and to the physical elements around him, throughout his existence. Arguments of this kind, if they partially content the reason, are felt still to leave an unsolved mystery behind. The phrase of Paley (due, however, to Balguy before him), that 'evil, as far as we can see, is never the subject of contrivance,' is perhaps the happiest that has been brought into the question, pointing as it does to the last of these methods of solution, viz., that governance of the world by general laws, which is everywhere so strongly denoted to our reason as part of the design of the Almighty.

To sum up all I have ever ventured myself to conclude on this dark question. I cannot give belief to a Satan, a personal spirit of evil, infringing on the unity, if not also on the power and supremacy of God. Seeing what I do of this Divine Power, not solely on the earth, but in the universe around, I cannot suppose it to be controlled by the properties of matter or other undefined physical obstacles. For what remains I can come to no other conclusion than the need of great humility, and the confession that no thought or wisdom of ours can rightly comprehend that design of the creation, into which man and the mixed good and evil of human life enter fractionally only, as parts probably of some higher scheme. I have felt an entire submission to this ignorance the best relief to those perplexities of thought which the aspects of human existence press upon everyone who thinks at all.

PERFECTIBILITY OF MAN.

Among the many questions as to the origin and destinies of man upon the earth none is of deeper import than this: what, if any, higher elevation may be attained by our species in its totality from causes, physical or moral, operating through time, with or without design, on the communities and races of mankind? The problem is a difficult one in its simplest shape. It is made more so by the ambiguities of language, as well as by imperfect knowledge of the actual characters and conditions of mankind at large over the globe. Within the walls of a well-endowed college, or amidst the luxurious refinements of a modern capital, the argument will be handled in a very different way from that suggested by a familiarity with savage or nomadic life—with the vast half-civilised races peopling, under one name or other, the whole of Asia—or even with the mass of those who tenant our great cities, or toil with their hands in our fields, factories, and mines. All these and other forms and attributes of humanity enter into the question. The very term *Civilisation* is of vague import, and difficult to apply either chronologically or geographically. What we call such has no permanence in place or time, but has burst forth at different periods in certain countries and communities, reached a certain maturity, and then been arrested or quenched. Such at least has been the history of the rise and fall of many of those ancient empires and cities which have left deepest impress upon posterity. The term, moreover, is used for what differs in kind as well as in degree. It is one of those conventional phrases which, while serving in some sort to embody the loose and floating elements of human thought, do yet often tend to obscure them.

To meet the question proposed in the title above it is needful to recur to the past history of man for interpretation of the probable future. Though I can give but a faint outline to a subject fitted for volumes, some part of this interpretation must be sought for even in the origin of our species, and its relation to the other forms of life on the earth. The question, for instance, first arises, are we to regard the different races of mankind as all primitively derived from a single stock? or are certain diversities of race such that we must look to a plural origin, to different primitive stems, in explanation of them? Much may be said, and much has been said, on both sides. I incline myself to the belief of unity of origin, and have in one of my essays urged the main arguments for this view, such as the fertile interbreeding of all races, the continuous gradations by which those farthest separate in aspect are linked together in all the physical and moral qualities of humanity, and those relations of language which, though obscure in part, have led some of our most eminent philologists to conclude that there is nothing in the elements or diverse forms of speech incompatible with the supposition of one common source on the globe.

Another enquiry under earnest discussion at the present time is yet more closely linked with the subject before us. This is, the question as to the origin of species in the animal world—whether they are severally acts of special creation, or derived by successive gradations of evolution or transmutation from one or more primordial forms of life? Under the latter view man cannot easily be excluded from the series so established; and accordingly several naturalists, English and Continental, have submitted to and vindicated this conclusion. Without absolutely accrediting the opinion, I must not deny that it suggests some speculations of interest as to the future perfectibility of man. If the higher quadrumana (for the argument starts from these) be capable, under any conditions, casual or designed, of attaining to the human attributes, why may not man—a member of the series, though supreme in the scale—be considered capable of developing, in progress of time, more exalted forms of those faculties which are now distinctive of his place in the world? On the other side, again, comes the question, if man be the latest in a long succession of special acts of creation, why may not other beings with still higher attributes be hereafter brought into existence in a similar way?

It would be fruitless to bring questions of this obscure nature into the argument before us. The former opinion has doubtless attracted most attention, in its connexion with the origin and development of animal species and varieties, and with that recognised law of progress by which *specialties* of organisation are evolved, or differentiated, to use a modern term, from more general forms. The latter hypothesis, admitting neither of proof nor disproof, can only be met by presumptions founded on the seeming stability of the actual conditions of the earth (a supposition upon which both astronomy and geology throw some doubt), and on the great elevation of man above other animals in his mental nature, justifying the belief that in him the final design of the Creator, as regards the earth, has been fulfilled.[1] Putting aside, however, these vague speculations, we recur to our main question, can the human race, as now constituted, and by its own intrinsic capacities for change and progress, raise itself to a higher level of intellectual and moral power than that now existing?

In seeking to answer this question we must once again refer to the inferior forms of life around us. The natural history of man cannot in truth be separated from theirs. One obvious fact here, and very important to the argument, is the great and often lasting change produced in many of them by domestication and human instruction. Such changes, indeed, made more for man's sake than the animals', may be only partial and doubtful improvement upon the wild races. Even in the case of dogs—an instance always foremost in illustration—the *canine republics* of some Oriental

[1] It is worthy of note that two writers, so little congruous in other ways as Locke and Bolingbroke, have each expressed the probability that created beings exist elsewhere of higher grade than man. The astronomer may find some sanction of his own for this conception.

cities give curious proof of that native sagacity which man has elsewhere so largely appropriated to his own uses or pleasures. The effect of domestication, indeed, is chiefly that of altering the physical qualities of animals and adapting them to special purposes. But their peculiar instincts also, and those faculties of intelligence and feeling which bring them nearest to man, are susceptible of changes, propagated by generation, and often becoming permanent in the race—permanent at least as far as experience goes, for in no case can we be sure that a return to the primitive conditions of the animal might not restore more or less of the original type. To a certain extent, indeed, we know that this happens, but it is equally sure that in some animals the artificial habits acquired become secondary instincts, modify the organs and functions, and perpetuate in the race the new qualities acquired.

The obvious bearing of this on the case of man is open to one important exceptional remark. He alone is submitted to no superior being on the earth capable of thus controlling or perfecting his natural instincts, of cultivating his reason, or of creating new capacities and modes of action. As far as we can venture to interpret the design under which he exists, man, as a species, is left to the self-development of the faculties with which he is gifted—faculties varying widely in degree, but alike in quality throughout mankind—acting and acted upon by the accidents of the world without—submitted equally to physical conditions and social influences—subject, further, to congenital propensities and passions in the use or abuse of which lies the exaltation or debasement of his being. We recognise these as the causes which, in their operation through ages, have dissevered mankind into races and nations, as well as into the subordinate communities and classes—civilised, semi-civilised, or savage—which cover the globe.

Recurring to the main question, a special enquiry first presents itself. We see how much has been done by a system of selection and interbreeding in variously modifying and improving the breeds of many other animals, giving new power as well as direction to their original faculties.[1] Can similar methods be applied to man with any similar result? This, with a few partial and insignificant exceptions, has never yet been attempted, and the social and sexual relations, even among the least civilised people, make it very unlikely that it should ever fairly be carried into effect. Plato, in his Republic, propounds a scheme for giving the state control and direction of marriages as a means of social advancement; and the austere laws of Sparta, by their *γραφὴ κακογαμοῦ*, and *γραφὴ ὀψιγαμοῦ*, assumed a right to the practical use of this power. But any such theories or enactments, based on the narrow scale of Greek republics, are of little present import. We might, indeed, in pure speculation suppose the experiment of grouping marriages (excluding close consan-

[1] Thoroughbred racers furnish an instance in point. The *winners* descended from Eclipse were reckoned at 334. From other famous horses a still greater number.

On this subject of *congenital propensities* we are bound to take large *numerical* views, illustrations, and averages, such as Humboldt applied to *physical geography*, and Liebig to other physical phenomena. The average amount of *insanity*, for instance, as far as it can be derived from authentic documents, &c.

guinity), so as to bring into union, through one or more generations, certain special qualities eminent in kind or degree, and including mental as well as bodily endowments. As the experiment may probably never be made, it is useless, if not impossible, to conjecture its results—whether the progeny of such conjunctions would be prodigies of excellence or of defects. I mention the latter contingency because what we call genius has for the most part a certain kindred with aberration of mind; and because we are yet ignorant of those laws of generation and hereditary affinity on which are founded family character, and on a wider scale the character of communities and races. To seek for definite results from the blending of mental qualities by inheritance would be working with untried tools or materials too fine and fugitive for experiment.

Putting aside this speculative form of our enquiry, we recur to it under that larger aspect which makes the past history of mankind the interpreter of the possible or probable future. But here, again, under this phrase of the past history of man, how vague from its complexity is all we bring into the argument! Who can define or describe this history even on a single region of the earth's surface, seeing that in every region of which we have historical record changes have been unceasingly in progress, in some cases raising man in the scale of civilisation, in others degrading him to a lower level of life? These changes and relative conditions are manifestly of supreme interest in a question where the extremes are so widely apart; where we have to compare the Hottentots and Bushmen, the

Fuegians, the Andaman Islanders and Esquimaux, &c., with the cultivated people of classical antiquity, or with the higher culture of some of the nations of our own time. Can we in changes of physical condition and other natural accidents find explanation of those vast diversities growing out of a single stock of human existence—diversities of human culture which time has brought about in the same regions and even among the same races of men?

To meet questions like these we are forced back in speculation on the grade and condition of that primitive people on the earth from which all others have their presumed descent. Here written history is a blank, traditions are wrapt in mist, and our sole reading is in those rude sepulchres of caves and tumuli which have disclosed to us the admixture of human remains with those of animals now extinct on the globe, the present congeners of which dwell in climates and countries far distant from these places of entombment. Such researches are yet in their infancy, going little beyond a few detached spots on the face of the earth. Who can conjecture the results of future discovery, especially in those regions of Asia the seats of the oldest empires, as well as of those nomadic races which poured themselves westwards to subdue and occupy what are now the most civilised parts of the world? The inference from the discoveries first denoted is that of rude tribes of men, generally of a lower anatomical type, rudely implemented, but showing in succession, on the same soil, a progress in those arts and means which serve to human subsistence. The successive ages, or what seem such, of stone, bronze, and iron implements, are the interpreters to us of this progress. It may be that these are but the memorials of insulated races, separated and degraded from a higher primitive stock. Time and wider research can alone solve this question. We are unravelling the Assyrian, Babylonian, and Persian histories by sculptured monuments and cuneiform writings, and the caves and mounds of these countries may afford us hereafter the record of still earlier times and races of men. Without venturing to affirm the result, it is probable that this path of enquiry will lead us here also only into a ruder form of humanity, and that our knowledge will never go beyond this point.

Another path, however, is open, more easy and familiar than that just denoted. Still seeking to reach the future through the past, but under less obscure conditions, the comparison at once suggests itself between the attainments of the highest civilisation of antiquity and those of the age in which we live. We cannot, indeed, carry this comparison authentically farther than to Greek and Roman antiquity. Egypt and the great Asiatic empires have left us marvellous monuments of older date; but their semi-civilisation was either arrested or degraded by time, or by the influx of more barbarous races, obliterating the advances that had been anteriorly made.

A comparison between ancients and moderns cannot, however, come within the narrow compass assumed by Sir W. Temple, Bentley, and Boyle in their angry controversy. It is difficult, indeed, to bring *moral conditions* into the question at all, seeing how large and vague is the term. But the intellectual relations may be better defined and understood; and taking this phrase in its widest sense, the comparison comes to an instant issue. It cannot be doubted that the powers as well as attainments of certain European peoples in our own age have reached a higher grade than those of any other time or people in the anterior history of the world. We may hesitate in giving precise dates to the periods of progress. Hallam has called the seventh century the *nadir* of European civilisation, while Leibnitz has noted the thirteenth as singularly barren of intellectual culture. But all doubt ceases when we come to the intellectual history of the last three centuries, and especially of the century now in progress—one marked by rapid achievements of discovery, invention, thought, and action which will designate it to all posterity. The advancement of physical science stands foremost in the picture, attested by the wonderful discoveries of our own time, and in the nature as well as number of these discoveries denoting those higher qualities of intellect to which they are due. The logic of every branch of knowledge has become more strict, the demand for truth and exactness in all results more absolute. Together with a greater perfection of methods, more profound thoughts and higher generalisations have been applied to those mysteries of the universe, the power of apprehending which, even partially, is the especial faculty and glory of man. It is impossible to read the writings of the ancient philosophers, even of those who saw farthest into these things, without recognising the changes that have progressively come over the human mind—changes not limited to the physical sciences, but extending to all other branches of human knowledge. Germs of thought and speculation which failed to ripen in the philosophy of older times have now matured into established truths. What were conjectures have become laws, and it is in the discovery of these laws that we obtain evidence of the highest capacities of man. Some sciences, indeed, such as political economy and social statistics, are almost altogether of recent creation; and seeing their importance to the welfare of mankind, they interpret well that conjoint progress of thought and action which has done so much to extend and define the civilisation of our own age.

Admitting, however, this progress and higher grade of culture in certain communities of men, we have yet to see what proportion these bear to the totality of mankind. Neither geography nor arithmetic can be brought to solve a problem thus complex. The areas of higher and lower civilisation are everywhere so crossed and intermingled that, even in the countries most familiar to us, lines and numbers fail of affording any certain demarcation. Looking largely over the globe, and especially what is called the Old World, we find some of the most populous nations seemingly arrested at a certain point of progress, and going through ages in succession without notable advancement, often with obvious decline. Ancient philosophy or poetry fondled the notion of a primitive purity, a golden age, of man, sullied and defaced in later times. But history, as we have seen, is silent or speaks only in fables of these earlier epochs of mankind. What it tells us gives no measure of time, or knowledge of what was human life, in the long antecedent void.

These considerations give more definite shape to the questions before us: How far may the advancement of a portion of mankind be carried by ulterior progress? And how may such advancement be extended over the entire earth and to all races of men? Taking the latter and wider question first, one conclusion speedily presents itself, viz., that all future progress in mental culture and civilisation of the great masses of mankind—whether defined as races, nations, or classes of men—must for the future come by diffusion from those points or centres where the torch of a brighter humanity is already kindled and ready to cast its light around. That there are many dark lines mingled in this light may well be confessed. But it is nevertheless the source whence the larger civilisation of the world must come, accelerated and assured by those recent acquisitions of power which are due to the science of our day. The steam-engine, on land and sea, has broken through all the barriers which formerly divided and dissevered nations. When we can send a message across the Atlantic in a few seconds, by an agent scarcely known two centuries ago, it may well be felt that all old reckonings of time and distance are gone by, and that the future state of the world will be subject to conditions very different from those of the past.

Such changes are rapidly going on under our eyes. They all tend, directly or indirectly, to the greater unity of mankind—to the assimilation of languages, modes of government, knowledge and arts, and the habits of personal and social life, among peoples widely separated though all prior ages. Taking fair measure of time into the account (and of the future duration of time on the earth we are as ignorant as of the past), we may securely affirm that the total aspect of human life will be altered over the globe. Important questions arise how far this assimilation of races over the globe may not, for a time at least, *lower the human scale* in some of its attributes. Look at the changes going on at this time in the ancient empires of India, China, Egypt, and Japan—at the rapid, perhaps precocious, growth of populous communities transplanted from the Old World to the prairies and forests of the Indians in North America, or to the lands of the ruder savages of Australia, both the destined centres of a new and wide civilisation. It is a revolution of centuries accomplished within the existing generation of man. The slave-trade has been happily displaced by a trade in free emigrants, seeking to find in these new regions more space and scope than the Old World can afford them. Glancing on the globe at the position and petty surface of our own island, it may well seem marvellous that this single nation (the *ultimi orbis Britanni*) should have played so dominant a part in the mighty changes now in progress. Milton speaks of 'England's precedence in teaching nations how to live.' If the phrase were true for his time, how much more is it for our own!

The conclusion we have reached, that the elevation of the species must be derived chiefly from the higher civilisations already partially attained, suggests at once the question, how may the flow from this fountain be itself rendered more abundant and pure? How may the import of the very word *Civilisation* be raised, by its being associated in the future with higher faculties of intellect and moral feeling?

The question, thus shaped, is one abounding in curious speculation and of deep interest. Admitting the capacity for higher development, which among the faculties bestowed on man are most susceptible of such elevation? Here the answer may best be, those which in degree, if not in kind, most markedly distinguish him from the brute creation. The senses of sight, hearing, and touch, which mainly connect man with the external world, are severally possessed by many other animals in greater perfection of natural sensibility, but without the capacity for that augmentation of power which human genius has given to these senses, and to that of vision more especially. The outer form, and those internal organs on which man's life depends, are probably susceptible of little farther change, from those incidents of soil, climate, food, and social condition, which have created and defined the actual communities of mankind. It is to the brain, as the instrumental minister of mind, that we must look, if admitting a material cause for the advancement of man in the scale of being. A free admission of ignorance as to all that concerns the proximate relations of matter and mind exempts us from dealing here with this long-litigated question. What physiology and comparative anatomy call upon us to believe is, that the brain, in its size and weight, in the proportion of its parts, and in other specialties of structure, does—we know not how or why—correspond with and in some sort denote the capacities of mind of which it is the instrument. Many exceptions and anomalies there are, and these wrapped in the same mystery as the normal relations of elements so entirely incongruous to our conceptions, yet so inseparable in our present existence. In this failure of all interpretation we are forced to acquiesce.

We must, therefore, not too keenly speculate on the manner and proportion in which the mind and the material organ may respectively contribute to the development of higher powers. The argument before us rests upon the assumed facts, that there are notable differences in the brain as regards volume and other structural peculiarities—that these differences have some connexion, however inexplicable, with the kind and degree of the mental endowments—and that they can be extended and perpetuated by inheritance, so as to characterise not only individuals but whole races of mankind. The different forms and capacity of the skull in different races have been carefully examined, and they accord well with the relations just denoted.[1] Human design has had little or nothing to do with these results. But in their existence itself we have the proof of an aptitude for change which, even apart from

[1] It is the view of Herbert Spencer (in contradistinction to the doctrine of Kant, regarding innate perceptions or ideas), that the constitution of our minds is wholly derived from experience—not individual experience solely, but the accumulated experience of our ancestors *transmitted to us hereditarily.*

any direct purpose or intervention, may issue hereafter in higher degrees of mental attainment—in greater vigour of the faculties generally, as well as of those special qualities and those felicities of genius which in every age seem to have carried some men beyond the sphere of their common humanity. The occurrence of the latter instances, though they come in strong contrast to the mediocrity or abasement characterising the mass of mankind, gives proof of capacities belonging to the species as such, from which we may augur, under new conditions, its future and more general elevation.

In pursuing the argument, however, we must not analyse too minutely those various faculties of perception, intellect, feeling, and will, to which we give unity under the name of Mind; nor those innate individual propensities (*aberrent* they may often be called) on which the phrenologists dwell in evidence of their doctrine, and which, whencesoever derived, are elements both in the highest elevation and greatest abasement of man. Here, more especially, we encounter those mysterious problems regarding generation and inheritance which are of such deep concernment in this as in other questions now under active discussion. Science is still working outside these problems. If it should ever go deeper into them, the question as to the future perfectibility of man might gather some special evidence or presumption from this source. As it is we must be content in coming to a general conclusion on the general grounds already denoted.

These reasons, however short of absolute proof, are fully sufficient to convince my own mind of a futurity to man on earth more exalted than his present condition here. Inequalities, vast and various, there must ever be, from the necessities of human existence, but the grade of the species may be raised. Admission being made of the capacity for change, and this without any known limit of amount, the argument recurs for illustration to the comparison of what *is* with what *has been*, and the inference from this as to the possible or probable future. It is a subject fitter for a volume than a loose essay. I will merely remark here, that had there been any prior type of civilisation higher than that of Greece and Rome, it must inevitably have left its marks behind. We may take this grade of mental culture, then, though deficient in some arts and inventions which even China and India had attained, as the highest of the ancient world. But, however remarkable in many ways, it had not vigour enough to perpetuate itself, when brought into conflict with abuses from within and barbarian pressure from without. A long series of dark centuries intervened between this era and that of modern civilisation, during which period Christianity itself, in its creeds, acts, and usages, was degraded to a level little above that of the feudal barbarism co-existing with it.

Such degradation as that of the Dark Ages in Europe can never occur again. The present areas of high civilisation, though still limited in extent, and defaced by many dark shades, are not exposed to the dangers just denoted. They cannot again be overrun by ruder races from without; and any internal changes, especially in countries where the present maximum of elevation has not yet been reached, are much more likely to result in ulterior progress than in decay. Add to this the wonderful powers, won by man from nature, for rapid diffusion over the globe of the attainments hitherto limited to certain detached regions only, and we may fairly rest in the conclusion that the human race has a higher destiny before it than the perpetuation of its present estate.

I must admit, however, that the argument thus far regards chiefly the intellectual advancement of man, and the means serving to this great end. His moral and social progress in the future is a matter of at least equal concern—a topic closely allied, indeed, to the former, but rendered still more difficult of discussion by the ambiguities of language and the more complex evidence with which we have to deal in comparing the moral condition of ancient periods and countries with that of the world in our own time. To what common formula or phraseology can we reduce elements so diverse and so difficult of interpretation, even where most familiar to us? There is, indeed, a certain community of character in mankind, derived from a common nature, and from those necessities of life which press alike upon all. But this is overlaid by so many specialties, physical, local, and accidental, that we can seldom compass any complete or certain conclusions. Take even Rome as an instance. From history, poetry, and satire we know its social condition under the early Emperors better than that of any other ancient city. Yet how vague our comparison, in a moral sense, of the mass of this population with that of a modern capital! And, if reaching any plausible conclusion as to cities, how little does this tell us of the multitudes peopling the empires and kingdoms to which these cities belong! Such comparisons, applied either to different ages or to different countries and races of men, rest much on ill-defined words and phrases, and afford little assurance of truth. The vocabulary of the most abstruse physical science is simple compared with that of moral and social philosophy.

Allowing, however, for all these ambiguities, we cannot doubt the well-proved fact that the moral and social character of a people, taking these terms in their highest and clearest sense, may be greatly and lastingly elevated by the concurrent influence of good laws and government, of religion and education truthfully and wisely administered. While in every case the actual attainment is far below theoretic perfection, the existence of such attainment becomes a pledge for progress beyond. Even taste, 'that delicate and aerial faculty which can scarcely endure the chains of a definition,' may well be supposed capable, if not of higher powers, yet certainly of so much larger diffusion as to give fresh life and refinement to those moral conditions with which it is always closely associated.

History furnishes no such pregnant example of the change in question as that already referred to, viz., the contrast between the last three centuries, during which Western Europe has ripened into its actual civilisation, and the thousand years directly preceding them. Many single stars are seen through this long gloom of ages

—men such as Alfred, Bede, Anselm, Abelard, Roger Bacon, Aquinas, Dante, and Wickliffe—who rose above their time in moral and intellectual power. But the dark picture of so many centuries is little illumined by these flitting lights. Its true colouring is that of barbarian inroads on a tottering and vicious Empire—of feudal tyrannies—of ecclesiastical superstitions or frauds—of the selfish austerities or more secret evils of the monastic life—of persecution in its worst shapes—and of a general ignorance and credulity offering itself an easy prey to these incumbent evils. The fictions of an age of chivalry and of mediæval learning have passed away, and we can happily bring these thousand years of darkness into strong contrast with the social as well as intellectual state since attained. I willingly employ the word Humanity, in its largest sense, to denote that which has been the subject and substance of the change which has thus supervened. And one chief mark or test of this change among civilised nations is the more zealous effort, *on principle*, to reform old errors and abuses by annulling or mitigating the laws, customs, and creeds in which they have come down to us. There is cause for some pride in affirming that England furnishes the fairest example of efforts thus directed to the abolition of old abuses and towards a higher future.

The actual moral evils in the world are such, however, and so many, that time must be taken largely into our calculations of this future. Some of these evils can hardly be detached from the necessities of existence, as they affect the bulk of mankind; but there are others which happier ages may mitigate, if they cannot altogether annul. Of these war stands first and foremost—an anomaly it might well be called, were it not that the pages of all history are sullied with its records, from the earliest time down to our own day, among the most civilised and religious as well as most savage races of men. When and how is this blemish upon humanity to be effaced? Our actual civilisation, as we see, has failed to effect it. Is there any higher grade attainable by man which may meet this great requirement? I would fain believe that there is such—to be reached through the progress of the moral and intellectual faculties, and itself furnishing the best test and happiest result of this progress. Ages may pass beforehand, but it is hardly credible that the time should not come when this dark stain will be removed from the history of mankind.

INFINITY—ETERNITY—THE UNTHINKABLE.

THREE words of great import in every sense, and having a common relation to the most profound objects of human thought! It is a German poet who somewhere prays to be saved from the harassing notion of Infinity, and not without cause for the wish, since the fact or idea expressed by this single word marks the barrier before which reason recoils in awe and despair. Whether space, time, or number be concerned, an argument trenching on this attribute of infinity is at once arrested, and no subtlety of words or thought can carry it farther. The phraseology of common speech, and even of grave doctrine, does indeed often employ the word, but in some cases mischievously, and never with any reality to the understanding.

It is one of the tests of true philosophy to know when this barrier of the Infinite has been reached. Between the *infinitely great* and the *infinitely small*—the celestial distances and magnitudes, and the atoms and atomical actions of matter—we stand on a middle ground, closed at each end, yet spacious enough for the largest intellect and genius to work in. Then again as to time. The moment of *present being* lies between the *infinite past* and the *infinite future*—equidistant from both in the sole sense we can give to what has no conceivable limit behind or before us. Eternity, indeed, has become almost exclusively a theological term, to which few can, or dare, attach its full meaning. It is a word of solemn sound, but barren to the understanding—'a negative idea clothed with a positive name.'

Numbers, in expressing the quantities and relations of space, motion, and time, as well as the atomic constitution of matter, carry us far into the depths where thought finally loses itself in the infinite. However startling, and to many incredible, the arrays of figures through which science now expounds the great phenomena of nature, these are really the methods which distinguish and protect truth from ignorant and idle speculation. What can be translated into and checked by arithmetic is generally a sound conclusion, whatever the amount of numbers concerned. Such figures, indeed, sometimes carry certainty so far beyond the reach of conception that the term Infinite seems justifiably applied to what is in reality but a step towards it. The mathematician, through his peculiar method of interrogating nature, attains some results which no observation or experiment can reach, and often touches on those terminal points where an Infinite in the series stops all progress beyond. Those ultimate ratios, which Berkeley calls 'the ghosts of departed quantities,' approach the depths of the infinite, but halt on the brink.

The controversies as to motion in the abstract—a dispute stretching from the age of Zeno and Aristotle to that of Newton and Boyle—and the kindred question regarding force, similarly unconditional, well illustrate these subtle methods of seeking ingress into the innermost secrets of nature. With the ancient philosophers all this was a sort of intellectual disportment. In our day the progress of more exact science, both by experiment and observation, has brought us into direct contact with these problems, and very especially with that which regards the origin and nature of force—of that invisible but momentous power or powers on which depend alike the great motions of the universe and the most minute atomic or molecular actions of matter itself. But here, again, human thought has hitherto been baffled in its struggle with the inscrutable; and where not ending with a *reductio ad absurdum* has been compelled to halt upon subordinate laws, and terms provisional only, to express the unknown that lies beyond.

The word *Unthinkable* has been well applied of late to denote some of the objects and speculations of which I have been speaking. Another phrase, familiar from recent controversy, shows the fashion of language still employed to veil our ignorance. This is the *Unconditioned Absolute*, a cumbrous conjunction of words, whether theologically or otherwise applied, and expressing no truth which a simpler phrase might not have conveyed.[1] To go thus back to the scholastic

[1] Sir W. Hamilton has sought to give the character of a 'law of mind' to these relations of the intellect with the *conceivable* or *conditioned*, and the *inconceivable* or *unconditioned*. The *infinite* and *absolute* come under the latter head as *unthinkable* to our reason. Admitting the distinction, it adds but little to what we knew before.

ages for the phraseology as well as substance of an argument, is a poor homage to the ampler and more exact knowledge of our own time. Lofty though the aspirations of physical science now are, they more readily recognise and acquiesce in the limitations imposed upon them, than do those metaphysical theories, German or English, which end but in a labyrinth of words.

Yet when thus speaking of the practical limits of human knowledge—of those points in every science where the infinite and unthinkable come in—we must not deny the existence of ulterior truths—*felt* to be such, though not comprehensible by reason. There is more than mere paradox in the saying of a French philosopher: 'Là, où finit le raisonnement, commence la véritable certitude;' and Pascal lucidly, as always, illustrates the impotence of reason to reach a truth which must nevertheless be such.[1] What we feel as wholly beyond the scope of thought does not lose its reality by being so. Taking an instance just alluded to, we can affirm that God *is*, though we know not *how* or *what* He is. This ignorance, in fact, is denoted by the very terms we use to express our adoration of the Supreme Being. The words Infinite, Immortal, Immense, Invisible, Incorporeal, Absolute, &c., do not assert what *is*, but what *is not*. I have just turned up

[1] Pascal says that we neither conceive a line divided by an infinite number of bisections, nor a section that cannot be divided; but though these contraries are both inconceivable, one of them must necessarily be true.

in Photius a series of epithets similarly applied—τὸ ἀσώματον, τὸ ἀόρατον, τὸ ἁπλοῦν, τὸ ἀσχημάτιστον, &c. It is what Mr. Mill somewhere calls 'a fasciculus of negations,' but negations commonly understood in a positive sense.

NATURAL THEOLOGY.

All natural reason and feeling, and all controversies regarding the Deity, however disguised by words, involve two distinct views, viz., that which regards him as everywhere and at all times present, and acting in all events; and secondly, that which regards him as *personally* or *undividedly* apart from those great laws of universal nature which he primarily designed and rendered active by his power.

But here, as in many other matters beyond our senses and reason, what are apparent opposites closely approach each other.[1] The Deity, present and acting throughout all nature, becomes in effect the *general law*. The general law, regarded in the sense of a fixed and perpetual operation, usurps the place of the Creator. The approximation here expresses the difficulty, ever found, of escaping some form of pantheism, when seeking to scale this high problem by reason alone. Scrutinise severally the orthodox terms of Omniscience, Omnipresence, and Omnipotence, and you feel yourself brought to the edge of the abyss denoted by this single word. Oriental philosophy, and that of the classical ages, came upon pantheism by the

[1] 'Les extrémités se touchent, et se réunissent à force de s'être éloignées, et se retrouvent en Dieu et en Dieu seulement.'—Pascal.

same paths of thought which had led Spinoza, Goethe, and others of later time to the same general issue; any seeming variations being due either to ambiguities of language or to the mental temperament of the enquirer. When, for instance, we take up Goethe's writings we find him pressing on to his pantheistic conclusion with a power and poetry of language which entangle his reason, and almost disguise his conclusions from himself. Even Newton, in a paragraph of his own handwriting which I have seen, gives expression to what must be declared a pantheistic view of the nature of the Deity; though elsewhere solicitous to avoid a conclusion which Cudworth not inaptly terms 'the deifying the nature of things,' and which, by whatever path arrived at, leaves the mind in an impenetrable labyrinth of its own creation.

I do not know any attainment of natural theology in our own time, either by abstract reasoning or inductive evidence, which has not been in some way preceded and prefaced by those who have thought or written in ages gone by. Dryden asks, in his 'Religio Laici'—

> Canst thou by reason more of Godhead know
> Than Plutarch, Seneca, or Cicero?

And but for the limitation of verse he might have added the great names of Plato and Aristotle; and among Roman writers those especially of Lucretius and Pliny, who in one way or other exhaust every conception which human reason can apply to the Divinity above it. We have various references to the same theme as handled by the earliest Greek philosophers, the *οἱ πρόσθεν ἡμῶν* of whom Plato speaks, as recognising a supreme *Νοῦς καὶ Φρόνησις* governing throughout the universe. The same belief, as is well known, has been handed down, under more vague or distorted forms, from the remote antiquity of all the great Oriental races. The Egyptians, though like other astrolaters locating their Supreme Power in the sun, yet held that this embodiment was assumed by his own volition. Among the savage races over the earth the same conception exists of a Supreme Being, however rudely material the expression given to it.

We might expect all this to be so. Apart from all revelation, the general conception of a Deity, however modified in details, springs from sources common to every race of men in every age, viz., the need, as it may well be termed, of conceiving some Intelligence and Power distinct from and above our own; and the proofs from design or adaptation throughout the world that to this Intelligent Power belongs the work of creation and the maintenance of things made. If these conceptions are ever annulled it must be by the artifices of metaphysical language, and not by any realities of thought.

Without dwelling on Warburton's opinion (a very doubtful one), that the greater Elusinian Mysteries taught expressly the unity of God, or quoting from Cudworth's vast body of authorities on the subject, it is enough to say generally of the great Greek and Latin writers that they rarely use other than the singular number when speaking explicitly of the existence and attributes of Divine Power. Polytheism is cast aside in such cases almost without comment or remorse. In notes I have made of the more striking passages bearing on this point I find few exceptions to the remark. Aristotle's expression of unity is especially simple and distinct—*Εἷς δὲ ὢν, πολυώνυμος ἔστι*; and as far as I recollect he hardly ever speaks of the heathen deities by name. Seneca, whose power of deep thought has been somewhat hidden under affectations of his style, expresses the same idea. Even where the plural is used in such discussions the tendency is often to a singular meaning, or the two forms are indifferently mixed, as in the 'Timæus' of Plato, who makes his *Ζεὺς* almost synonymous with cause or mind.[1] The dramatists and poets, for obvious reasons of art, speak more as polytheists, yet we read in Pindar of the mysterious *τις*, supreme in the government of the world; and Æschylus shadows forth the conception of a higher being than the Zeus who chained Prometheus to the rock. The Homeric Zeus has itself formed the theme of a learned work in Germany.[2] But, as regards the polytheism of the ancients, it must ever be kept in mind that it comes to us mainly through the medium of poetry, which filled up and coloured the wandering traditions of different races of men, giving them an embodiment which the philosophy even of that time refused to recognise.

Rarely, if ever, do we find the sentiment of real

[1] I fear it must be said that the most learned commentaries on Plato (and no heathen author has been so sedulously scrutinised for his meanings) have failed to decipher his entire opinions on this subject. Take passages in the Νόμοι in proof of the difficulty.

[2] That of Dr. Matter.

veneration addressed to the deities of the ancient mythology, though such feeling is often expressed towards the one Supreme Being. The ancient moralists, including those of the Stoic school, when they bring human virtue into connexion with the Divine Power, almost always do so under the conception of unity. The writings of Plutarch, of Epictetus and Marcus Aurelius may be quoted in proof of this.

In all forms of polytheism, indeed, it seems probable that the earliest view of the nature and attributes of the Deity was the simplest. This might well be expected, seeing that the tendency of growing but still imperfect civilisation must ever be to aggregate new objects of veneration, of fear, love, or desire to those of older date. Polytheism, especially where keeping its hold on more civilised peoples, strangely brings before us these incongruous vagaries of human folly—witness the Romans, who ended by bestowing divine honours upon even the most profligate of their emperors.

Various passages, however, in Seneca and Pliny show well the different nature of the questions which the wiser men of that age propounded to themselves, and their close affinity to the problems which have ever since perplexed and agitated human thought. The pantheism of these passages is essentially the same as that of Spinoza and the more recent German writers, through language, ever ready with its disguises, may lend a different aspect to the doctrine.

While touching thus far on the opinions of the ancient philosophers, it is impossible not to feel that the controversies and creeds of the early Christian Churches have led to a more obscure and unsettled conception of the Deity than we find in some of these great heathen writers. The old and vehement disputes concerning the nature of the Trinity, though now for a time sunk into silence amidst other controversies, were yet still rife in my younger days, and but two centuries ago called for the interposition of the sovereign to arrest the angry argument of two of our most eminent divines.

The metaphysical or *à priori* proof of a Deity, variously attempted at successive times, is felt more as an exercise of logic than a conclusion of the reason. The speculations of Proclus and the neo-Platonists in the nature of the Supreme Being, repeated in modern phrase by Hegel and others of his school, leave the question in the obscurity from which they profess to withdraw it.[1] The schoolmen of the dark ages bestowed their logical subtleties on the subject without solving any of its difficulties. Archbishop Anselm is perhaps the one who has left the deepest mark of his genius upon it. The axiom in his Prologium, that the idea of God in the mind of man is in itself an irrefragable proof of his existence, descended in succession to Descartes and Leibnitz, and has given foundation to the belief of many men of lesser note in the world. The labours of Dr. S. Clark on this subject are well-nigh forgotten.

[1] There is more wisdom, because more candid confession of ignorance, in the words of St. Augustine: 'Veriùs cogitatur Deus quàm dicitur, verius *est* quam cogitatur.' Sir I. Newton's expression, 'Non est æternitas, sed æternus et infinitus; non est duratio et spatium, sed durat et adest,' escapes pantheism by giving personality.

But after all no reference to ancient opinions, nor any mere abstract propositions, can satisfy that craving of the mind for greater certainty which this question begets. The only safe and solid foundation of natural theology is happily the simplest and easiest of attainment; that is, a conviction of the personality or individuality of the Deity, and of *design* in the creation. These are the points (in themselves inseparably allied) of highest concernment to man. What we seek for is the proof of an individual being, who has designed what we see in the world around us, and carried these designs into effect, either by specific acts of creation or by the mediate action of powers and laws directed to their end. The 'natura naturans' of certain authors satisfies no conception, intellectual or moral. The phrase of Natural Law is a barren one, unless annexed to the idea of a legislator; and to bring in the word Nature as fulfilling this idea is but a recoil of language upon itself. In reasoning on the personal unity of God, as attested and represented by the unity of creation, we gain, it is true, no comprehension of his nature or mode of existence. The *absolute unconditioned* and other such phrases are words and not meanings, and bring at most only negative conclusions to the mind. But the *individuality* of God—and I think this a better term than *personality*—can be comprehended as a subject of thought. And when this conviction is gained through the evidences of design, as contrasted with chance—for this is the real point in question—it furnishes the nearest approach which simple reason can make to this great mystery of the universe.

Duly apprehending, then, these conditions of the problem, we come finally to such evidences as the true, if not sole, basis of natural theology—the argument of every age and race of mankind. Will to design and power to execute are the conceptions which belong to the natural belief in God, under every form which religion has assumed. For religion, however distorted by human formularies, can only rightly be defined as the relation of man to his Creator, under the actual conditions of this life and the contingencies of a future. Sir J. Herschel uses the term of a *Personal Will*, and in many parts of his admirable writings dwells upon the conception of such *personal will* as concerned in all the great works of nature. Through the admission of a system of secondary laws we may keep this conception asunder from that pantheism in which, as we see, so many hypotheses have merged.

Arguments and proofs of design spun out through volumes (as in the 'Bridgewater Treatises') are of less practical value than a few cogent cases, ready at hand, certain in conclusion, and easily understood. It is a common fault in this, as in other like questions, to seek to strengthen proof by multiplying instances, without regard to their relative weight. The force of the impression is thereby lessened, and the thought led to wander from that which is more certain to that which is less so. I think it is Swift who says: 'An idle reason weakens the weight of good ones given before.' Let a man have in hand two or three well-assured instances, such as no doubt can disturb, and he is prepared at every moment to renew and fortify the convictions he has once attained.

Of the various forms this argument from design has assumed I still think that of Paley the best, from the lucid manner in which he makes his illustrations serve to establish the personality of the Creator and his unity in creation. He happily expresses in a few words the conclusion attained: 'I desire no greater certainty in reasoning than that by which chance is excluded from the present disposition of the material world.'

There are those of the present day who deprecate the looking after *final causes*, and bring the epithet of Lord Bacon to justify their distrust. I myself could wish the phrase changed for one more simply suggesting intention or design. But, be the wording what it may, the meaning is one which cannot be discarded. The idea involved has often been ignorantly or presumptuously applied, but this does not annul its reality as a great elementary truth attainable by our reason. And it may be added in this instance that one case well proved becomes the interpreter and proof of a thousand.

Seeking for the best example of such *instantiæ crucis* as I have suggested for use, the eye at once offers itself—familiar as an illustration, yet not to be despised on that account, nor because it needs some understanding of this wonderful organ, well described as 'equal in force to many volumes of theology.' The perfect adaptation of a most complex structure to the not less complex properties of light is so complete in its proof of *design to form and power to execute*, that to dispute the conclusion is to give up the office of reason. Or, limit the case to the passage of light through the crystalline lens only, and to the effect of its singular structure in rectifying vision, and the argument even gains in force by its simplicity. Some have sought to impugn the perfectness of the organ; but even had they not been answered by Brewster and Helmholtz, the conclusion would not have lost its validity.

Were we able to interpret equally the delicate and complex parts of the internal ear, the evidence of design here would doubtless be no less cogent. In truth, the four little bones of the tympanum, ignorant though we are of the specialties of their use, do yet in their peculiarities of position and connexion as clearly denote design, and design fulfilled, as if the purpose of each was written out distinctly before us. Chance could not have placed them there. In these instances, indeed, as more distinctly in many others, we may notice certain approximations in series from lower grades of life, and in the case of the eye certain incidental variations which seem to be transmissible by inheritance. But still these things, carefully attested, cannot annul the conclusion, founded explicitly upon adaptation of structure to the complex laws of light and sound, that these organs are fashioned by design, and are not the result of casual conformation or of any selective power inherent in the creatures thus endowed. Whether the expression be illogical or not, I would cite the eye as an instance where all reason merges at once in a certain and inevitable conclusion.

The whole physiology of animal life abounds in such instances (especially the *specific secretions* of *special organs*) fitted to be thus used. But what I here seek to press is the storing up of a few the most instant and certain in conclusion. The various ills and turmoils of life, as well as the vagaries of human thought, require that the convictions so obtained should be often and easily renewed. No form of religion but must gain by that natural theology which can be brought home to the acts and duties of daily life. Laborious treatises, if read, are speedily forgotten. We want instances which no argument can disturb or gainsay; and a few such become the interpreters of a multitude of others more obscure to our limited view.

In the foregoing pages I have treated of natural theology chiefly as regards the existence and individuality of a Supreme Being, the designer and potentially the author of the works of creation we see around us. Of the moral attributes of the Deity, as they have been somewhat presumptuously called, I do not speak here, thinking on various accounts that this topic, when ventured upon at all, comes better apart from and in sequel to the other. One remark only I would make, having relation to both, viz., that the argument for design from organic structure is in nowise vitiated by defects in such structures arising from accident or natural decay. These must be held as parts of a larger scheme, which our imperfect conception of the intents and methods of creation prevents us from approaching even by the boldest natural hypothesis.

MATERIALISM AS A QUESTION OF SCIENCE AND PHILOSOPHY.

WHAT more can be said on this question than has heretofore been said? The arguments of the materialist are essentially the same, whencesoever derived or however worded. Their truth can never be proved, nor absolutely disproved—in other words, they cannot logically be disproved, because they are incapable of proof. You may refine *ad infinitum* upon material structure and the forces affecting it, and indicate new relations of these to the functions and faculties of mind, without advancing one step to the real solution of the problem. The old questions still start up: What more do we know of matter than of spirit? May not the qualities, so-called, of matter have their reality in mental consciousness only? That such questions have been asked and vindicated is the best proof that human reason is unable to encounter them in this ultimate form.

Still it is well to simplify the reasonings which thus end in a confession of ignorance. They have been so far entangled in the fluctuating language of different ages and schools, that some care is needed to keep the argument and conclusion fairly in sight. Even now new terms come in quick succession to perplex the questions which two or three centuries ago Descartes, Stahl, and Leibnitz took up in their own phraseology in succession to that of more ancient philosophers.[1]

The materialist argues, and justly as to fact, that the mind and its functions grow together with the growth and structural changes of the body, from infancy up to maturity—that old age brings on, though less definitely as to time, the decay of both—that in all stages of life the phenomena of sleep and dreams, of idiocy and insanity, of delirium and drunkenness, of apoplexy and fainting, and the other various forms and accidents of cerebral disorder—all show a direct and indispensable relation of the brain and nervous system to the intellectual and moral states of the man.[2] Of the fact that no material change can occur in the nervous organisation without some corresponding change in the mental functions, the proofs are endlessly furnished by the daily experience of life. Birth, dating even from the fœtal state—death, at whatsoever age occurring—these seeming termini of our being are intelligible to us only as parts of a present necessary co-existence and relation of body and mind. By no effort or artifice of thought can we dissociate these portions of our common nature, so as to feel or conceive what we call Mind singly in itself.

The materialist finds a certain aid to his argument in the strange differences of individual minds. The phrenologist may be wrong or ridiculous in his denotation of these specialties of character, intellectual or

[1] Germany furnishes the most explicitly avowed materialists of our day, in Virchow, Vogt, and Moleschott.

[2] A few lines of Lucretius, in his third book, put clearly all that belongs to this argument.

moral. He may and does err in looking to the outside of the cranium as the sure interpreter of the mental faculties and feelings lying underneath. But the fact remains untouched that there are wonderful innate diversities in all that constitutes the mental being of man—diversities in the kind and degree of intellect—diversities in the perfection of the senses, in memory, in the elements of taste, imagination, and genius—diversities not less strongly marked in those propensities and passions which define our moral nature. These differences are found in the highest mental qualities as well as in the lowest and basest. They are strikingly shown in the faculties which seem to involve a certain *mechanism* of action, as memory, the mathematical or numerical faculty, and those connected with the fine arts, music, painting, &c. As in the case of bodily resemblances, these mental idiosyncrasies are often traceable to hereditary causes; but where not obviously so, still they are innate.

The question, however, remains unanswered: Are these differences due to different cerebral organisation? Or is this organisation but the instrument to express and put into action the diversities in a part of our being to which no material epithet or description can apply?

And this brings another physiological fact into the argument, viz., the greater development of the brain in man than in any other animal, and the proportion found generally to exist between the size, weight, and complexity of this organ and the perfection of intelligence and other mental endowments. That such relations do exist, however imperfectly defined in their details, is well attested by observation. It is hard in such a case to accept *quantity* as a measure of *quality*, yet we must needs do so under certain conditions. That there are *tracts* or local portions of the brain, with which the convolutions are perhaps most intimately concerned, having special connexion with different faculties of the mind, can scarcely be denied, looking to the various physiological evidence for this fact. Even the faculty of speech, on the evidence derived from its morbid changes, has lately been submitted to this interpretation. But admitting to a certain extent such localisation, we still are not beyond the threshold of the question, whence come and in what consist the endowments of thought and feeling as we see them in many animals, and supremely in man? The question, then, however it be shaped, again forces itself forward: Do the facts which show that unceasing changes of mind are produced by material causes acting through material organs prove that such organisation is *in itself* capable of *generating* those wonderful functions of perception, thought, feeling, and volition which in their totality constitute the mind of man?

The answer to this question I think to be that no such proof is possible, and that presumption is wholly against it. That we cannot give other explanation of the phenomena is no argument, in a case where reason and consciousness are equally unable to lend any aid. Nothing that the most minute anatomy or physiology have taught us can bridge over that chasm—*hiatus infranchissable*, Cuvier well calls it—which separates what alone we know of the properties of matter from the functions we individually know and feel as the qualities of mind. Refine upon material atoms—the *μεγέθη ἀδιαίρετα*—as you will, no step is gained in advance. Bring in that organic agent, Protoplasm, which some modern physiologists regard as the basis of all living organisation (a compound itself of the four great elements already known in connexion with the phenomena of life), and we still get no farther. The structure of the brain, however keenly scrutinised in its medullary and cineritious substance, its convolutions and commissures, and the intimate texture and distribution of its fibres and cells, discloses nothing of the real mystery. Chemistry, though subtle enough to detect a minute proportion of phosphorus in all cerebral matter, embodied in a curious crystallisable compound, *protogen*, of which again another compound, *neurine*, is supposed to be the base, has done more to perplex than enlighten by these discoveries. Nor need this failure cause surprise, seeing how imperfect is our knowledge even of the most conspicuous parts of the structure of the brain; of its *doubleness* as an organ, of the functions of the cerebellum, &c. To memory, the most mechanical perhaps of the mental acts, we can assign no seat or texture in the brain. We see no organisation for this vast storehouse of the past—no secret place for memories latent for half a life—no material links serving to associate them together, nor any physical cause for their decay or obliteration in old age. There has been a good deal of speculation of late founded on the cerebral cellular structure, and schemes have been devised assuming to explain the phenomena of memory and association by these cellular connexions. But such hypotheses are utterly without proof, and do not really carry us farther than the hypothetical vibrations and vibratiuncles of Hartley's school. It is better to avow ignorance than thus to screen it. And if we cannot connect this faculty with structure, far less can we conceive such connexion in the case of those higher faculties of intellect and feeling to which memory itself is but a minister.

Minute anatomy, as well as physiological experiments, have afforded more certain results as to the functions associated with the medulla oblongata, medulla spinalis, and the nervous ganglia. But these are parts either appertaining to organic life or instrumental only to the mental faculties. And here, as in regard to the brain, we are wholly without knowledge as to the nature of that wonderful endowment of *nervous matter*, medullary or cineritious, aggregated or granular, enabling it to fulfil such vast and various purposes throughout every grade and form of animal life.

This view of the *incommensurability*, as it has been called, of matter and mind, of body and soul, has been held by the philosophers of every age; always embarrassed, indeed, by terms vaguely defined, such as the νοῦς, ψυχή, and πνεῦμα of the Greek schools, and the equivalent ambiguities of our own and other languages.[1]

[1] The distinction between the νοῦς and ψυχή, so strongly marked in the 'Timæus' of Plato, is denoted even in the old Latin dramatist Attius: 'Sapimus animo, fruimur animâ.'

But the questions in hand are mainly the same, and the difference in dealing with them is chiefly that created by the severer methods of inductive enquiry. Abstract definitions of the soul and of matter are now submitted to tests which go far to exclude them from the pale of science. Aristotle's expression, that 'the soul may be better said to contain the body than the body the soul,' defines nothing real save the impossibility of reaching the truth by that faculty of reason, the nature of which is a main part of the problem to be solved. A happier phrase, and somewhat nearer to the point, is that of Spinoza: 'Body is not terminated by thinking, nor thinking by body.' Quotations on this subject might, indeed, be endlessly multiplied from the classical writers —from the later Platonists, from the mediæval schools, and from the philosophy of our own time. But in their totality they prove nothing more than the absence of any conception congruous and common to the two elements concerned in the question, and the fruitless toil of language to redeem this incapacity of thought. I have spoken of the little that has been done by scientific discovery to furnish links between mind and matter. In one sense, indeed, they may seem to be farther dissociated by those attainments of physical science which especially mark the mental capacity of man. The genius and intellectual power which have penetrated so deeply into the secrets of nature—measuring the distance of the stars and the velocity of light—predicting from the minute perturbations of one planet the existence and place of another yet unknown—detecting the presence of known terrestrial elements in the photosphere of the sun and even of the fixed stars —making electric wires, with a speed that mocks calculation, the medium of human intercourse across the widest oceans—these capacities, thus developed and exalted in their objects, point at some spirituality of nature which mere matter, in our understanding of it, can never reach. That we are unable to comprehend this nature, and its complex relations to the material world, is but one of the many similar confessions we are compelled to make when seeking to interpret the mysteries around us.

DIFFERENCES OF RELIGIOUS BELIEF.

In reasoning on this matter, whether as regards sects or individuals, few advert sufficiently to an element of distinction which must ever exist, and ever divide men, whatever creeds they may be born under or brought up in. This is the diversity of natural temperament, physical, intellectual, and moral—a diversity which the common experience of life is ever bringing before us. We see one man of hard, unflinching, sceptical logic, another vague and imaginative in his reason—one with cold affections, another warm or passionate in his feelings—one with keen and artistic senses, another dull and unimpressionable—one with buoyant physical powers, another feeble and sickly in frame. You may bring these several men under the same religous creed or denomination, but virtually, they are of different religious belief, if this word *belief* has any substantial meaning at all.

And what is true as to individuals is true also, though more generally, as to the conditions under which sects and churches are formed. Certain temperaments tend to coalesce in certain modes of belief or outward worship; the founders of which religious bodies are usually men strongly marked by corresponding individualities of character. Luther, Calvin, Loyola, Knox, George Fox, Wesley, &c. are a few among the many instances in point.

The recent movement in the Anglican Church, seeking to restore that clerical supremacy and ceremonial for which Laud was ready to imperil both Church and State, well illustrates what I have just stated. This movement, apart from mere curiosity or love of change, has segregated to itself a class of temperaments, of both sexes, prone to all innovations exciting or soothing the senses; and prone, as experience has shown, to press yet farther in the same direction. Calvinism also has its specialties of thought and feeling, though the moods of character are perhaps less strongly marked. But even these incongruities of temperament have certain links which bring them near together in the complex network of human existence.

Going back to the Apostolic age, we find an individuality of religious thought and feeling, severally, in Peter, Paul, John, and James, attested alike by their alleged writings and the actions recorded of them. In the contemporary Jewish history, again, we discern, through their several tenets and usages, a similar disparity of mind in the sects of the Pharisees, Sadducees, and Essenes—differences existing in Jewish communities even to the present day. And applying this view more broadly to the various races and religions of different ages of the world, we find the same result of sects and superstitions based on the diversities of human temperament. The more tolerant polytheism of Greece and Rome yields least in illustration. But all the religions of the East (including the

Mahometan and the Parsee remnant of the religion of Zoroaster), and the Catholicism of mediæval and all later times, exhibit these diverse colourings of human character, not in individuals merely, but in those divisions and hostile sects which every religion is prone to engender within itself. In every age and country, under one shape or other, we find the same innate diversities of temperament which lead to this result—the enthusiastic and credulous, the philosophical and sceptical, the formal and ceremonial, the austere and ascetic. Names multiply and are ever changing, but the essential character of human nature continues the same, however disguised in outward lineaments. Religious distinctions, indeed, are often mere matter of inheritance from one generation to another, in nations as well as in families. But causes are at work beyond this; and the gorgeous ceremonials of the Roman Church, in contrast to the austere worship of Puritans and Quakers, represents a distinction deeply graven in the map of human life.

When Cardinal Retz described his own temperament as 'le moins ecclésiastique que fût dans l'univers,' he well denoted his peculiar idiosyncrasy. When Sir Isaac Newton, a man of very different stamp, said to Leclerc, 'In disputable passages of Scripture I love to take up with that which I can best understand,' he aptly depictures the love of fact and truth deeply innate in his own mind. Such diversities, among lesser men than these, are matter of the most common observation, though not always duly estimated in their bearings upon life, and especially in the connexion they establish between natural temperament and the religious attachments of the man. Professional experience, especially during the last twenty years, has strikingly illustrated this to my own knowledge, and often by cases forming in themselves a little romance of struggles between native temperament and the conditions of life pressing harshly upon it. History and biography abound in curious and painful examples to the same effect.

In discussing the subject of religious belief it must ever be kept in mind how vague and changeable in meaning this word *belief* is; a phantom without substance to the world at large; and even with those who bring thought and feeling to the subject, only to be interpreted by the individual character of each. This may seem a harsh judgment on a word of popular and needful use, but it will be justified to anyone who cares to examine its actual application in the case before us.[1]

Admitting these various premises, one conclusion to be drawn from them is, that all creeds, to form truly and effectively a basis and bond of religious unity, should be large and lenient in their scope, simple and humble in their phraseology. It is a hard thing, and worse than useless, to subject the consciences of men now living to the dogmas of Councils assembled in dark ages, and dishonouring even those ages by their bigoted and violent conflicts. Hilary, living and acting himself amidst Councils and creeds,

[1] Neander, in his treatise 'Das eine und mannigfaltige des Christlichen Lebens,' dwells much on the adaptations of Christianity to the idiosyncrasies of men.

strikingly depictures the hatreds and follies in which they originated. We may well join with Milton's remonstrance against 'crowding free consciences and Christian liberties into canons and precepts of men.' It is another question whether Churches, as such, can be held together without some formularies as a rule and test of unity. But this question should never be handled save under recollection of the changes time is continually working in the world, and especially in our own day. It is fitting that forms of subscription, the imposition of other ages, should be removed or lightened by reason, rather than forcibly annulled by reason's revolt.

SCEPTICISM AND CREDULITY.

BENTLEY says, 'Commend me to an argument that, like a flail, there's no defence against it.' But such arguments are rarely to be found, even in physical science, far less in that moral and metaphysical world in which it is a part of our destiny to live and exercise thought.

In another of these papers I allude to the various and vast disparity of the reasoning power in different minds—a fact, like many others, too familiar to be seen in all its import. There is a logic, or want of logic, peculiar to every mind. The perception of truth, and the mode of arriving at conclusions upon evidence, are curiously different in different men. Some men are the ready slaves of dogmas, vague hypotheses, or frauds upon the senses under the garb of science. Others carry the shield of scepticism ever before them, sometimes so closely as to exclude all sight of what is beyond. The moral and intellectual temperament are both concerned in this diversity, which shows itself in religion, politics, art, literature, and every matter of social life.

Not merely individuals but races and ages of men exhibit such dissimilarities. When Biot says, speaking of the time of Galileo, 'à cette époque la doute n'était pas inventée,' he is asserting what is a general truth as regards both the ancient and the scholastic philosophy. The subjective methods of thought (to use a German neology) dominated in these ages over the objective. Truth was sought for not by experimental proof, but by abstract reasoning and logical formularies. In our days, owing mainly to the methods and successes of physical science, the demand for proof is ever becoming more absolute in all departments of human enquiry, and an enlarged scepticism in this sense is lawful and well justified by its results.

Questions, however, there are and will ever remain in which the highest attainment of human reason can be that of presumption only, and such questions are those which best try the minds of different men in their dealings with doubt. Our lot is cast among things certain and things uncertain or unknown; the latter more numerous where the senses fail us and thought is occupied with objects unseen, or with those invisible powers that cause the things we see. Here the approach to truth is often through tortuous paths, along which none but clear and strong intellects can find their way, or rightly discover where this way is closed by obstacles which human reason cannot surmount. Those so gifted are alone able, while well defining the objects sought for, to shun the many pitfalls which the *placita philosophorum*, the seduction of hypothesis, and the shiftings and artifices of language put in their path. The right balancing of presumptive evidence is the highest form of natural logic. The reception and right use of the results so obtained is the highest function of human reason.

Recognising physical science as that portion of our knowledge which has done most to quicken and define all that relates to the evidence of truth, it may be well to remark that as the circle of such knowledge enlarges the circle of doubt enlarges also. A single new fact discovered may beget ten questions unseen before, and equally requiring solution. Science abounds in such instances. What Newton terms 'the ocean of undiscovered truth' spreads out more widely before us as we advance upon it—darkness, or faint gleams of light only, upon its horizon. Some men stand doubtingly on the shore, or embark with a spirit too timid for discovery; others adventure suddenly and rashly on this unknown sea; a few, by some happy intuition or accident, find what may be called a 'North-West Passage' to the truth sought for; but it is usually reached only by assiduous labour, and the fortunate conjunction of zeal with a rational scepticism.

Natural temperament, in fact, is the ruling power in the intellectual as in the moral world; and its diversities in different men can alone expound the anomalies we every day see in the antagonistic habits of scepticism and credulity. Those of credulity are doubtless the more remarkable in our age, as in every antecedent time, and form a curious chapter in the mental history of man—a chapter saddening in some of its aspects, but in others relieved by its kindred with that poetic faculty appertaining to man alone. Credulity changes its forms and objects in each successive age, but as a mental quality it is ever the same, and ever preyed upon by similar arts and impostures. In our own age the grim romance of the ghost-story has been succeeded by the coarser follies of spirit-rapping, table-turning, &c., all fastening upon that particular temperament among mankind which is ever ready to accept belief without weighing the evidence for it—even more ready, it might seem, where the things propounded are most incredible. The sense implied in the phrase, 'Credo quia impossibile est,' must not be confined to doctrinal divinity alone.

The sobriety and hard logic of the sceptical temperament come in natural correction of the feebleness or intemperance of credulity; and in some sort indeed they are mutually corrective, and knowledge gains from the conflict. For scepticism itself is sometimes largely in excess, and becomes a hindrance to minds otherwise powerful in seeking for truth. Dr. Wollaston, whom I well knew, was a striking instance of this. With high intellectual powers, with leisure and other appliances at command, he shut himself out from great discoveries at a period fertile of such by a morbid demand for certainty at every step of progress. The story connected with his discovery of palladium is well known. His was a mind that would never give to probabilities or hypotheses their due weight in scientific enquiry. The record we have of D'Alembert, in his life and writings, furnishes another striking example of this sceptical temperament. Devoted to mathematical proof, he could discern nothing of truth or reality, beyond or outside, unless through demonstration so obtained. He seems to have ignored the fact that *probability* is, after all, the great and necessary guide in every part of human life. The scepticism of Bayle was of a different kind; but there was fitness in the epithet he applied to himself of *νεφεληγερέτα Ζεύς*, from his habit of gathering doubts around every topic he touched.

Other instances might be quoted, but as regards the question of excess they still leave the balance large on the side of credulity. No one can better affirm this than the physician of long and various experience. In my volume of 'Medical Notes and Reflections,' first published twenty-six years ago, there is a chapter on 'Medical Evidence,' in which, while admitting the inherent difficulties of the subject, I found occasion to comment on the curious credulity of the world in all that regards the nature and treatment of disease, and the injurious reflex action which this often exercises upon the minds of physicians themselves. Though I had much reason to be satisfied with the success of this work, I heard from several quarters the remark upon it that I raised more questions than I solved. And the comment was a just one. Mental temperament on my own part had doubtless some influence in this; but the cause was chiefly to be found in the actual state of medical knowledge, still far below the conditions of an exact science, its evidences singularly complex in kind, and fettered by numerous prejudices and antiquated precepts, a hindrance to truth and the source of error and various evils in practice.

The sceptical temperament as applied to religion is a topic by itself, yet seen here also under the same antagonism to credulity as in other less momentous concerns of human life. The diversity of human creeds as regards Revelation, and the utter inability of human reason to comprehend the great mysteries of creation and the Creator save under the simple aspects of design and power, may well explain the common direction of the sceptical mind to these points. But that mind must be shallow in reason which refuses belief to all it cannot understand, and rejects the notion of God and Providential design, because it cannot measure the greatness of the universe, or interpret the seeming anomalies and evils affecting the little world on which man has his being. The scepticism of the atheist, strictly so called, halts at its first step; and his theory, if he has one, can only be expressed in terms as difficult to comprehend as are the facts which he seeks to subvert.

INSANITY.

The many definitions of Insanity are the best proof of the little of practical value which has been gained from the attempt. If broad in principle, they are lost in particular applications. If resting on individualities, these are so numerous that definitions can neither compass nor connect them. There are as many varieties of insanity as of human character, as many forms and degrees of disordered mind as of the intellectual and moral qualities in their sane state. The transitions from sanity to insanity, and the changes incident to the latter, are endlessly varied, yet even here we can generally recognise that law of continuity which so largely prevails in the world around us.[1]

The medical man who comes into a witness-box with a formal definition of madness is generally tortured into contradictions or doubts. In some legal cases of this kind, beset with grave difficulties, it might be better if the medical examination could be taken out of open court. A clever barrister, however ignorant himself, may readily put questions perplexing to the most upright and experienced physician. The

[1] A recent classification of the forms of insanity, by Ludesdorf of Vienna, into aberrations by exaltation, by depression, and from weakness, may be considered among the best, simply because the least definite in details.

subject is one so beset with metaphysical and verbal subtleties, that it is hard to find firm ground to stand upon; and the only suggestion which can be offered is that of eschewing all formal definitions, and connecting the question of sanity or insanity in each particular case, as far as possible, with some specific practical test.

But, deal with the matter as we will, the difficulties are great, and explain, if they do not vindicate, the frequent contradictions noted in medical evidence upon insanity. The intellectual character of the witness himself becomes an element in the question. Aberrations of mind—such especially as arise from excess or deficiency of natural faculties and feelings—are differently seen and construed by different men, according to their own temperament and several capacities for observation. My experience furnishes me with many examples to this effect.

One of the best as well as simplest tests of insanity is the *inversion* of some distinct habit of feeling or action, strikingly marked in the previous character of the individual; the more sudden and complete this *inversion*, the stronger the evidence of unsound mind. Such proof can only occasionally be had, since insanity shows itself more frequently as an excess or distortion of some wonted habit or feeling. But enquiry should always be directed to this point.

A question which in one form or other has hung over any theory of insanity is its relation to the cerebral organisation. One opinion attributes all deviations from what we call *reason* to changes in the brain—the *cerveau malade*; and others, as Leuret, recently, place the disorder in the spiritual intelligence itself. This is virtually the old question of materialism put into a more special form. The phenomena of dreaming, delirium, and drunkenness, as well as the moods of insanity itself, and their tendency to become hereditary, are brought in sanction of the former view. Its frequent occurrence in the most marked forms, without detection of the slightest organic disease of the brain, furnishes argument for the latter, but an argument ever subject to the exception that disease may really exist in textures to which neither eye nor microscope give us access.

The relation of dreaming to insanity has been dwelt upon from the time of Cicero downwards. The distinction lies in this, that dreams are for the most part an incongruous mimicry, while the senses are closed, of waking sensations, thoughts, and events—incongruous as to time, place, and connexion; madness is a persistent adherence (not corrected by the outward senses, though these are awake) of images, thoughts, or feelings, devoid of what may be called reality, and begetting actions equally incongruous. As a definition this is as incomplete as others, but it serves to distinguish between the wandering and transient dream, made up of fitful memories, when the senses are more or less closed, and the fixed delusions of insanity, often contradicting the evidence of the senses, and all the acts and impulses of antecedent life.

I have visited lunatic asylums in most parts of Europe, and many in America, without any abatement of the profound and painful interest belonging to such inspections. The statistics of insanity, deal with them as we may, are a mournful and mysterious page in the moral history of man. I fear it must be admitted that what we call *civilisation*, especially that of crowded communities, tends to aggravate this condition of human suffering, and from causes readily understood. Enquiry, expressly made, has everywhere told me the same tale, that religion, love, anxieties of business, and intemperance are chief among the direct causes of insanity in the world. Add to these hereditary tendency, whencesover originally derived, and we see but too well how these mental maladies have embodied themselves in the social state of man, even under the highest intellectual cultivation.

HISTORY.

Gibbon describes History as 'little more than the register of the crimes, follies, and vices of mankind,' and recording, as he does, the history of twelve dark centuries, he might well arrive at this conclusion. But its truth is not limited to any particular period or portion of the inhabited world. Take a century from any recorded time, of any country or race of men—from the Egyptian, Jewish, Assyrian, Greek or Roman history, from the dark ages, middle ages, or the last 100 years of our own age—it is everywhere the same continuous relation of wars, of national or personal struggles for territory or political power. Sydney Smith, with his wonted force of familiar illustration, calculates that since the Peace of Utrecht thirty-five minutes out of every hour have been passed in war. I have myself made a rude reckoning on the subject, drawn from the printed pages both of ancient and modern history—from the Greek, Latin, and Byzantine historians, as well as those of England, France, Italy, and Germany, in later times. The result is somewhat varied by the temper and style of the particular historian; but taking an average of the whole, it shows that *two-thirds* of the world's written history during 2,500 years, under every form of government, religion, and civilisation, is a narrative of warfare, or its inevitable adjuncts—the *μάχαι μυριόνεκροι* of all nations of men. The gates of Janus, at Rome, were closed but three times during 700 years. The accounts we have of savage life, even in the smallest and most remote isles of the ocean, all tell the same tale of strife and bloodshed.

Look, again, at the large proportion of European history of which courts, sovereigns, ministers, political intrigues and diplomacy make up the engrossing or sole material. It is true that the record here is of those whose acts and fortunes have had largest influence on the world. But what a mass of mankind is left unnoticed and unknown beneath the stage on which these higher actors play their parts in the world's drama![1] They have led armies and migrations of men from region to region; have founded or destroyed empires; have framed governments and laws, and abolished them; have attained eminence either by virtue or by crime. Yet underneath all these things lies the history of nine-tenths of the human race—untold, or told only by casual and scanty notices. Generations of this multitude successively pass away without leaving a mark behind. As an old writer says, 'The greater part of the world must be content to be as though it had never been.'

Even in the countries fondly called civilised how often are we surprised and shocked by casually *disen-*

[1] Goethe comments justly on this partial colouring of history:—

> 'Was hier den Geist der Zeiten heisst,
> Das ist im Grund der Herren eignen Geist,
> In dem die Zeiten sich bespiegeln.'

tombing a part of the community coming closely to savage life in their ignorance, habits, and vices—these characters veiled over, but not extinguished by proximity to higher grades of cultivation. Which is the nation so far advanced as not to furnish examples of these strange contiguous diversities—the inevitable result of crowded population, and of that 'labour to live' which is the necessary lot of so large a part of mankind? The Mob of every age and country—a unity in itself—tells the tale of that vast substratum of human life of which civilisation, when it exists at all, is but the surface and the colouring. Take the approximate number of 1,000 millions as peopling the earth. Give to civilised life its just definition and demarcation, and see how small is the proportion of this mass of human existence which can be brought under the title! A numerical estimate must needs be very vague in this case, yet we can scarcely err in rating it at less than a fiftieth part of the whole. All that lies outside this narrow limit is little regarded by the ordinary historian, even where materials exist for his use.

Macaulay, in one of the first paragraphs of his great work, strongly points out the baldness and imperfection of history, thus confined to the affairs of courts and camps. His third chapter well exemplifies what he himself could do in correction of this common deficiency. Gibbon held the same views; but his History embraced too long a time and too wide a space for its fair application. The historians of our own day, forestalled as to larger themes, work much upon detached periods of time, and with greater profusion of details.

The demand now made for minuteness in these details has a sort of parity with the requisitions of modern science as regards chemical analysis. Still, what we gain from this minute research is generally little more than an amplified narrative of war, diplomacy, and court or party intrigue; witness the volumes of Mr. Froude, on the reign of Elizabeth (now lying before me), fed with papers from that great depôt at Simancas which has furnished so much towards the history of the sixteenth century. Curiosity has of late been variously pampered by documents drawn from secret and unexpected sources. There is a certain danger belonging to these in the undue importance they often assume to the historian who himself discovers and uses them. There are few writers who can wholly resist this seduction.

In some relations to these tendencies of the historians of our day comes the fashion—sometimes justified, oftener not so—of upsetting old opinions as to persons and historical events. Two-thirds of the early Roman have been swept away by the merciless criticism of Niebuhr, Lewes, and Mommsen, without due regard to the fact that a simple town could not have become the germ of an empire without some such course of events as those which stand recorded to us. A spirit of paradox has gone much farther as regards the character of historical personages. The crimes of Roman emperors have had their apologists, and Richard III. and Henry VIII. have been held up as martyrs to faulty interpretation of their acts. All history is open to correction, but it ought to be sedulously guarded against these paradoxes and personal partialities.

One formula of history, not wholly new, indeed, nor without its recommendations, has recently become common in this country. It is, in fact, history carried on by a series of biographies of persons who have successively filled some eminent place in public affairs, archbishops, chancellors, chief justices, &c. Such scheme of narrative, impartially conducted, has the advantage always derived from continuity in the main object, while collaterally including the various relations of each such series to the other elements of national government. There is danger, doubtless, lest this method be carried too far, and lead to unimportant biographies written by inferior hands. The saying of Sir Thomas Browne, 'There goes a great deal of conscience to the writing of a history,' applies especially to cases where biography forms the substratum of what is written. But it has fitting application also to historians at large. Honesty of general purpose and honesty in details are not less essential than the faculty of judgment as to the evidence of facts. Cicero denotes as the *prima lex* of history, 'ne quid falsa dicere audeat, ne quid veri non audeat.'

To recur to history in its more general sense. When we speak of the history of the world, how few consider the wide gaps in this great story—the vast periods of time shrouded in impenetrable darkness! These periods are not solely such as come before all certain record, but those also which often interpose and blend themselves with recognised history. A single century may be rich in its record of men and events in a country where succeeding centuries have passed away leaving little or no mark behind. Omitting the earlier marvel of the Homeric poems, less than two centuries comprised all the grandeur of Grecian intellect. The art of Gibbon has compressed into a single sentence—one that must have been music to his own ear—the almost contemporaneous names of all the greatest philosophers, poets, statesmen, and orators of Athens. The political life of this wonderful city at the same period has been ably pictured to us in the great work of Mr. Grote. But there is some reason for thinking with Sallust that the Athenian history has gained undue prominence from the great names and elegant writers by whom it has been transmitted to other countries and ages.[1] And in any case how small a spot is Greece in the map of the peopled world, and how short this illustrious period compared with the twenty centuries following of servitude and decay!

There are few persons, indeed, who rightly appreciate the element of time in its relation to historical events. Historians themselves, either from necessity or neglect, have contributed much to this defective view. Recurring to Gibbon for an example, we find him including in a single chapter between 500 and 600 years of Byzantine history following the death of Heraclius. The wonderful art of the writer gives it the aspect of continuous history, yet how small the insight obtained into the real condition of this empire and of the whole Roman world during a period as

[1] When two scholars eminent as are Mr. Grote and Professor Jowett differ so far in their understanding of the familiar term of Sophists, we may well appreciate the difficulties of a right comprehension.

long as that from Edward I. to our own time! In our Scriptures the single Book of Judges gives the history of the Jews for upwards of three centuries; while of the forty years passed by the same people in the Desert, under conditions difficult to be understood, thirty-eight years are recorded in a few verses only. Such distances are numerous, as are also those strange gaps, either utterly void or filled with fables alone, which sometimes occur between two periods of authentic history. In the early British history, for example, 'an age of fable completely separates two ages of truth.' So also in that of Germany. However it may be with the laborious and learned readers of that country, how little do we in England know of its history succeeding the disruption of the Roman Empire and the era of Charlemagne, while the wars of the Guelfs and Ghibellines, in Italy, are the meagre but chief exponents to us of the great Teutonic people at a period still later. Or, recurring once more to the Jewish history, how little is familiarly known of that long period between the later records of the Old Testament and those of the New, though during that period there grew out of the wars of the Maccabees and other events those sects and usages of the Jewish people—notably of the Pharisees and Sadducees—which form such important elements in the Gospel narratives.

To gain something like a just estimate of historical time it has been my frequent practice to take some well-known period—say, one, two, or three centuries of recent English history—and place them in relation to the same length of time in the history of other ages in other countries; as, for instance, to bring together the three centuries of undisturbed Roman power in Britain, and the equal period from the accession of Elizabeth to the present day. This method, simple as it is, suffices to correct many erroneous impressions, and to explain various seeming anomalies in the history of mankind. History can never be rightly studied without the aid of these comparisons or parallelisms of time.

After all, we must be content to take this word History as a general term, denoting insulated and imperfect records of portions of mankind, in certain countries and during certain periods—lost, moreover, in utter darkness when seeking to go backwards to the first presence of man on the earth. The fossil history of lower forms of animal life, at periods far anterior in the depth of time, is better known to us than are the first ages of the human race. The question as to the antiquity of man has, indeed, passed from the historian to the geologist, whose researches, though not attaining actual numerical results, do yet indicate relative dates, and a point of time more remote than any other record or tradition we possess.

Mr. Buckle in his recent works has sought to give to history the character of a science. His project was too ambitious, and came to an end even before the scaffolding of the edifice was completed. The conditions of a science are in truth wholly wanting; while as a branch of positive philosophy, in the system of M. Comte, the claim of history is little better assured. But regarded simply as a portion of human knowledge, it doubtless admits of being enlarged and vivified by being made a more complete portraiture of the millions ruled, as well as of the ruling few, who leave their impress on each successive age.

In relation to this latter point much may be looked for in England from those multitudinous State records which, entombed hitherto in various dusty repositories, have recently been collected, catalogued, and rendered easy of access by the judicious energy of the present Master of the Rolls. Though devoted largely to the objects I have named as the main material of all history, they collaterally afford much illustration of the social state of the country at different periods. For the period in which we are now living, enriched even to incumbrance by the productions of the press, the future historian of England will find his chief embarrassment in the multiplicity of materials before him. His office will be, not so much to seek for facts as to sift and condense them—a remark applying to all future European history, as well as to that of the new world in the West.

SHAKESPEARE.

Everyone who rightly cherishes and studies Shakespeare becomes more or less a commentator upon him. So vast is his variety that among the creations of his genius every man may find some counterpart to himself and his own moods of mind. Every taste and temper is met and satisfied with something that is done better than it was ever done before or since.

I put down here a few scattered comments; none perhaps new, but some of them not occurring to my recollection elsewhere.

Every good English writer knows the efficiency of monosyllables. Shakespeare manifestly appreciated their force and value. Frequent instances occur of three or four lines wholly thus composed. In one passage ('Richard II.,' act iv. scene 1) seven lines come consecutively with only one dissyllabic word.

I have often tried, but never could discover any principle determining Shakespeare in his use of rhymed verses, and admixture of them with prose, save in those cases where a rhyme at the close of a scene or long speech is brought in to give force and point to the conclusion. In other cases it would seem simply as if he indulged in that careless abandonment to his genius so peculiar to the man—one rhyme, even as a mere play upon words, carrying him on to others.

The same question, and perhaps the same conclusion, may be applied to those frequent changes from prose to verse and verse to prose, even in the same scene and with the same persons on the stage, which, though often connected with the relative dignity of the persons and subjects handled, yet in many other cases can be referred only to that free and copious licence which he ever gave to the inspiration or even whim of the moment. He may be said—and it can equally be said of none other—to have written without fear of criticism and without eagerness for fame.

Almost it may be cited as a proof of his genius that he could afford to be so inveterate a player with the sound and double sense of words. Dr. Johnson, to give pith to one of his own phrases, describes the love of Shakespeare for a quibble as 'the fatal Cleopatra for which he lost the world, and was content to lose it.' The world he did not lose, but he carried so far this current foible of the age as to show that it was a fashion of speech in which his mind revelled. He delights, too, in spinning out a sort of verbal logic, of which the long speech of Pandulph, in 'King John' (act iii. scene 1), is a striking example. Words flowed upon him so exuberantly that they became playthings in his hands.

In Sheridan's play the slipslop blunders of Mrs. Malaprop, like her name, are felt to be got up by the art of the writer. The wit of Shakespeare in this way has the higher art of concealing art. Every blunder of Dogberry, Elbow, Launcelot, &c. has an appropriate drollery of its own, apart from mere play upon words; something difficult to define, but which is felt to be 'exquisite fooling.'

No single instance of Shakespeare's power is more striking than the two scenes in which Portia and Lady Percy, Brutus and Hotspur, are presented in such marvellous contrast, under circumstances exactly alike even to the turbid dreams telling of conspiracies at hand. Let the two scenes be read simply with reference to this contrast, and the power will be seen of that genius which could mould into forms of speech, so exquisitely appropriate to each, diversities of character thus strongly marked. Compare the solemn tenderness of Portia's appeal to her husband with the playful but as tender vivacity of Lady Percy. Put into contrast that touching speech of Brutus, won to the disclosure of his secret—

> You are my true and honourable wife,
> As dear to me as are those ruddy drops
> That visit my sad heart—

with the manner in which Percy intercepts and throws aside his wife's lighter appeal. The sequel of the latter scene none but Shakespeare could have written.

Two other things occur to me in the plays just named, one of which I have not seen noticed, the other not satisfactorily explained. Falstaff, brimming over with wit and fun for those who could understand him, or for his own entertainment when alone, drops the mood altogether when Shallow and Silence are his sole company. His jokes on the recruits are for his own enjoyment. He reserves the inanities of Justice

Shallow for the future laughter of the Prince and Poins. An inferior artist to Shakespeare would not have exercised this nice discrimination.

What I have never heard well explained in the play of 'Julius Cæsar' is the direct denial by Brutus to Messala, the messenger from Rome, of his having heard anything of Portia, when immediately before, in excuse for his angry mood, he had related to Cassius the fact and manner of her death. It is hardly possible to ascribe this to inadvertence. But what, then, is the explanation of it?

Gray says of Shakespeare, 'He had, I believe, several souls to his own share;' and Coleridge somewhere calls him *μυριανοῦς*. The phrase is a happy one, for there is nothing more wonderful than his superiority to all others in so many and such diverse kinds of excellence.

One of the very few wagers I ever laid was with Lord Nugent (a consummate Shakespearian scholar) upon his assertion that there was not a single passage in Shakespeare commending, directly or indirectly, the *moral qualities* of the dog. I thought this so unlikely that I took the wager, a year being freely given for its settlement. Though aided by others, I could find no such passage or phrase, and I paid the money, marvelling that such should be the issue of the wager.

Of the conjectures as to Shakespeare's religious opinions none that I have seen are very satisfactory. They have chiefly regarded the question of his leaning to the Romish or the Reformed Church. He lived in times disturbed and heated by this great change. He knew also something of the sects growing up underneath the Reformed Church, and his writings show that he was intimately versed in the history and phraseology of the Bible. That he has touched so slightly on any topic of religious doctrine or controversy, while making his characters the utterance of such deep thought on all other human affairs, goes far to prove his intended avoidance of the subject. If the passage in his will be taken into evidence, it seems to express the belief of a Protestant Christian.

Are we to grieve, or not, that so little is known of the life of Shakespeare? As in the case of Homer, is there not something which feeds the fancy in the mystery surrounding him? Yet we might well desire to know what were the characters of childhood and youth in such a man? when, and in what way, his genius broke forth? under what impulse and methods he composed those works which have given him immortality? The Sonnets have been diligently searched for his personal history, but they have rather thickened than dispelled the cloud which hangs over it. Except the signature to his will we have not a word of his writing. He indicates his own individuality less than any of those whom we reckon the great writers of the world; certainly than any of later ages. The few passages alluding to him by contemporary writers serve little more than to whet curiosity. His portraits are of doubtful reality; and, whether willing or not, we must submit to the belief that what we know of Shakespeare is all that will ever be known.

The veneration for Shakespeare has certainly much augmented within my own memory—a testimony in itself to the growing culture of the age. Putting aside theatrical representation, there is a deeper and more critical study of all that he has written, great labour given to the corrections of the text, a higher appreciation of his various powers, and eagerness after every fact that can illustrate in any way the individuality of the man. For something of all this we are ourselves indebted to German writers, Goëthe, Schlegel, Tieck, &c., some of whom have pushed their critical analysis beyond any probable conceptions of Shakespeare himself. I recollect dining with Augustus Schlegel, at Sir J. Mackintosh's, some forty years ago, when he spoke insultingly of the ignorance in England of our greatest author, adding that Englishmen must come to Germany to study him aright. The excellence of his own translation of Shakespeare gave a certain sort of authority to this comment.

INFLUENCE OF WORDS AND NAMES.

Many maxims and trite sayings are current on this subject, and justly so. But such maxims, even if remembered, will never annul this influence on the minds of men. Words have been wittily called 'the counters of wise men, and the money of fools.' Few, however, are wise and strong enough to see and put aside all counterfeit coin, and to resist the tyranny which daily and hourly use inflicts upon them. Hobbes well says, 'It is a great ability in a man, out of the words and contexture of language, to deliver himself from equivocation.' It is, in truth, one of the best tests of a sound mind to be able to do so.

I speak of words and names here simply as such, since in numerous cases it is a single word or name which governs a question to the reason of man. Abstract philosophy, religion, literature and art, social usages, and even the sterner physical sciences, teem with examples. Luther says of St. Paul's style that his words are 'living creatures.' So, in fact, are innumerable words which enter into common speech, and even into the inmost recesses of thought, impelling, controlling, or distorting, despite all reason to the contrary.

It would be amusing as well as instructive to catalogue the dominant words which, in different languages, meet us at the threshold of all learning. Many of these are the bequest of ancient philosophy—some necessary as aids to thought and speech, some obstructive for want of due definition, others insusceptible of definition altogether; many altered in meaning by time and human changes, some the growth of common use, others the petted offspring of particular schools. Psychology, under its various titles, is that part of science in which the dominion of words is largest and most uncontrolled. When we speak of the soul, the mind, the spiritual nature—of sensation, perception, ideas, feelings, volitions, conceptions, &c., these terms serve their purpose, it may be, as well as any others would do, yet they are all apt to become what Berkeley has called 'scholastic shadows,' vaguely understood and vaguely applied.[1] It is, indeed, very especially in metaphysical enquiries that words become the bladders upon which ancient errors and crude conceptions are floated down the stream of time. No writer has expressed this more strongly than Goethe; yet he himself, while following the philosophy of Spinoza and Leibnitz, was enslaved by the language of his own poetical temperament. Every physician knows that in diseases hitherto found incurable the number of remedies professing to cure is always the greatest: so in the more inscrutable problems of life and mind,

[1] A recent struggle between Mr. Mill and Dean Mansel over the body of Sir W. Hamilton's philosophy somewhat recalls the language and methods of the scholastic age.

language is ever enlarging its vocabulary without coming nearer to what is an intelligible reality.

The same thing happens even in physical science, the domains of which, though rapidly spreading, are yet on every side circumscribed by lines which mark the limits of human thought. It is in approaching these confines that we are most beset by the entanglements of language. The words 'substance,' 'elements,' 'atoms,' 'force,' 'momentum,' 'inertia,' 'affinity,' 'correlation,' 'potential or latent energy,' &c. all express great natural facts, yet all are open more or less to doubtful use and misconception. Despite this exactness, indeed, the physical sciences often halt upon particular phrases, which seem to record final truths, but which further research compels us to discard.

It is curious to note the effect on the mind of words and phrases coming to us in another language, the translation of those familiar to us in our own. This I have often felt in passing from our version of the New Testament to the Greek text, the antique English of the translation often superadding a certain meaning of its own. Or, to take slighter instances: who can read the titles of Shakespeare's comedies in their German translation without a whimsical feeling of novelty, or acquiesce at once in the name of Schwazerd for the pious and gentle Melanchthon; or in that of Arouet for the witty and profligate Voltaire? The wonted names are deeply rooted in the mind, and it is difficult or even harassing to dislodge them thence.

The influence of words deriving charm and weight from their mere antiquity, the 'verba a vetustate repetita,' is well known; and it was so in the classical ages as it is now. On the other hand, we have to encounter constantly the seductions of new words, sometimes necessary to the progress of knowledge, but often giving only a new facing to old facts and opinions. All that Quintilian says on these topics is excellent.

The theology of the Christian Church in its darker ages is heavily chargeable with invention of new words —the creation of doctrinal controversy—and is generally ponderous in proportion to the obscurity of the matter. This remark occurs to me fresh from reading the Epistles of the Patriarch Photius, whose mastery of Greek (well attested by Porson's double labour on his Lexicon) revelled in the construction of compound words—a luxury to his intellect, as well as a necessity of the topics he is handling. Bacon speaks of 'the ill-starred alliance between the old philosophy and the new faith.' This alliance required and invented a language of its own, which has been too largely transmitted by inheritance to our own creeds and controversies.

SUBJECTIVE FUNCTIONS OF THE EYE.

THE word *subjective* thus used was given by Purkinge (a physicist whom I knew at Breslau) to a class of phenomena meriting more attention than they have received—difficult of study, it is true, from their complex and transient nature, and their diversity in different persons. Science has well taught us the modes under which light reaches the retina and optic nerve. But here we lose the traces of it as a physical agent, both as regards the visual perception conveyed to the mind and those reflex lights and images of which we can hardly define the seat, but which emerge from within the eye, and are the subjects of distinct perception by the mind.

These spectra vary greatly, and, under different bodily conditions, in the same person. They require to produce them the exclusion, more or less complete, of outward vision; and pressure upon the eye, either by closure of the lid or some stronger compression from without. I regret not to have made more note of their forms and changes in my own case. But there are two forms which have drawn so strongly upon my attention for some time past, for the last year especially, that I think them worthy of notice among these curious phenomena.

The first—rare and transient indeed compared with the other—is the appearance to the closed eye of several lines, four, five, or six, of printed type, not exactly of the same length, nor exactly parallel, with divisions as of separate words—seeming as if easy to be read, yet mocking, by speedy confusion or disappearance, the attempt to read them. This spectrum rarely lasts more than thirty or forty seconds. In some cases I can connect it, from the configuration of the image, with the recent act of reading; but at other times it occurs after the eyes have been long closed in sleep or otherwise. I do not recollect to have noticed this appearance until within the last year or two.

The second phenomenon is also one of recent observation, though, as there is required an act of will or attention to be conscious of it, the physical condition implied may have existed before without such consciousness. When in the first approach of sleep, the eyes being closed, I direct attention to the organ of vision, a luminous spectrum of whitish green light appears, as if coming laterally upon the eye, about the size of a common watch-glass, and nearly circular in its outline, but indented in its circumference by five or six conical notches, and intersected in its area by a sort of network of dark lines, presenting occasionally somewhat of a regular configuration, but none that can be defined as constant. This luminous circle is visible as such for two or three seconds; it then contracts itself equably from the circumference inwards, till nothing is left but a central bright nucleus. At the moment when this nucleus has shrunk to a mere point the luminous circle breaks out suddenly again, of the same size and aspect; and the spectral series is repeated precisely in the same order and time as before, four or five such series occurring within a minute. Gradually the phenomena become feebler; and I have generally found that after a certain time, perhaps half-an-hour, they wholly disappear. I have never known them recur after the first period of sleep.

The particular posture in bed does not alter the appearances. And I may further add that they occur equally in any locality, on sea as on land.[1]

I have used here the phrase of '*directing attention to the organ*,' and I revert to this, inasmuch as it expresses, thus applied, a great physical fact not sufficiently recognised, viz., the power the mind has of momentarily attaching its perception or consciousness to particular portions of the body, and ever with some change of feeling or function thereby produced in the part. In a chapter of my 'Mental Physiology' I have dealt expressly with this subject; but I could add much more upon it were this chapter to be written again.

[1] In a lecture delivered at Leeds some years ago, Sir J. Herschel describes various analogous ocular spectra occurring to himself 'under forms of symmetry and geometrical regularity'—some of them circular and singularly like those I have described above. I do not recollect, however, that he denotes their intermission and recurrence in exact similarity of interval and aspects.

MAN AND NATURE.[1]

[Contributed to the 'Edinburgh Review' in 1864.]

Of the two works which we place at the head of this article, the first is of largest pretension, both in title and extent, and is that to which we seek chiefly to direct the attention of our readers. The second is a small volume comprising the substance of a course of Lectures on Climate, delivered at Torquay, by Dr. Daubeny, the Oxford Professor of Botany. The topic is one having such close connexion with the objects of the larger work of Mr. Marsh, that we willingly bring the volumes together, as mutually illustrative. That of Dr. Daubeny, though much more limited in design and details, is characterised by the various learning and industry which are found in the former writings of this zealous naturalist; and we shall have occasion now and then to refer to it in its bearing on the subject before us.

The author of the larger volume is an American gentleman who has held, and still holds, we believe, a high diplomatic position in the service of the United

[1] Art. VI.—1. *Man and Nature; or, Physical Geography, as Modified by Human Action.* By George P. Marsh. London: 1864.

2. *Climate: an Inquiry into the Causes of its Differences, and into its Influence on Vegetable Life; comprising the Substance of Four Lectures delivered before the Natural History Society, Torquay, in February* 1863. By Charles Daubeny, M.D., F.R.S.

States; and has further distinguished himself by a valuable work on the 'Origin and Early History of the English Language.' We always hail with satisfaction any addition to the science or literature of the world coming from our Transatlantic brethren. Whatever the issue or effects of the bloody struggle now in progress in America—a problem which time alone can fully solve—we shall still stand in closer relationship to this remarkable people than to any other nation of the earth. The terms of 'common origin,' 'common language,' and 'common literature' have become the hackneyed phraseology of public meetings and after-dinner speeches, but they nevertheless denote facts which are destined to be of deep interest in the future history of the world. The vast territory and population, united but four years ago under a single Government, can never, we believe, recover the unity they have lost. Had none of the causes of this war existed, we doubt whether the American Constitution, or indeed any constitution, could have sustained the enormous pressure upon its powers which twenty years more of growing population and diverging local interests would have engendered. But whether two nations, or half-a-dozen nations, emerge out of the present crisis, one future event will be the same—the great North American continent, prolific in all that pertains to the growth of man, will nurture a population large as that of total Europe, educated generally into a higher grade of civil and religious liberty, speaking one language, and perpetuating through this language the many glories of our early and later literature.

The Federals of the present day will not look to this futurity for America save through the restoration of the Union. We, on the other hand, strongly incline to see it in a division of territorial governments on that great continent. We believe that time, with its many accidents, and especially the feebleness of the central Government, would inevitably bring about future disruption, even were it not to occur as the result of the present war, of which the Slavery question has been the motive with many, with some the pretext. That which is inevitable (and thus many wise Americans both of the present and past generation have regarded it) is often best encountered before time has so entangled the question as to render any safe solution impossible.

This topic may seem alien to the volume before us, and yet it is not so. In treating of 'Physical Geography as Modified by Human Action,' Mr. Marsh derives numerous illustrations from the continent of his own birth; and reasonably as well as naturally so, since North America is that portion of the globe where the most rapid changes have been effected by human prowess, and where man still finds the largest scope for the growth of population and power. We may perhaps think that a slower progress would have been more salutary; but human impulses ride over all theories and maxims, and Europe has hurried forth to people the prairies, and glut the rising cities with races having very slight kindred with the primitive settlers of the country. This mixed people, however, has its destiny in the future history of the world. Without looking for those Utopian commonwealths which have never existed but in the brains of philosophers and philanthropists, we see enough, even in the sad experience of this war, to show how great is the energy and expansive activity of the race; how much they are certain yet to accomplish in moulding nature to their purposes, and changing the aspects of the great continent they inhabit. America and Australia are the two fields in which the intelligence and inventions of our own age find their widest application. The ordinary growth of centuries is here compressed into two or three generations, and the surface of the earth submitted to changes which have no parallel in the earlier history of nations.

In looking at the subject of Mr. Marsh's volume, as expounded by its title, we find something like an antithesis to the scheme of that larger work of Mr. Buckle which was brought to an end by his premature death. In two former articles of this Review we dealt fully, and we believe fairly, with the theory propounded and the arguments proffered in this remarkable work. Seeking to maintain his thesis that history may be raised, approximately at least, to the character of one of the exact sciences, Mr. Buckle founded his main argument on the assumption that man is a mere agent, pliant if not passive, under the physical laws and external influences which surround him on earth. He brought to the illustration of this doctrine a vast array of learning, familiar or unfamiliar, exact or inexact—a task easy in some respects, since amidst the enormous number of events and relations crowded into the circle of human life on the globe, there may readily be found such as will serve to vindicate any paradox whatsoever. That propounded by Mr. Buckle has been adopted, in terms even less qualified, by writers of later date. The government of the world has been described as accomplished by immutable laws; and the social conditions, changes, and progress of man represented as not less controlled by these laws than his bodily conformation and growth. In the articles just referred to we showed the various errors as to fact which have been used in support of this theory, and the one-sided character of the argument throughout. We have reason to believe that Mr. Buckle himself, in the progress of his work, grew distrustful of his own earlier views, and saw that in seeking to make a science out of the history of mankind he had no solid foundation or materials for so vast a superstructure. The building tottered under his hands while he was yet at work upon it.

The tendency of Mr. Buckle's work was to assert the supremacy of the material conditions of existence over human history and the mind of man; that of Mr. Marsh is to assert the supremacy of the mind of man over the material elements of the globe. The theme taken up by him, while regarding the relations of Man to the natural world from an opposite point of view, is more limited in its pretensions, and descriptive rather than theoretical in kind. It has further the merit of being well-defined in its general objects. The questions put before us are for the most part simple and precise. What has man done, what may man still do, with purpose or without purpose, to change for better or worse the physical conditions of the earth upon which his lot has been cast? But while thus giving our own definition of the subject, it is fair to let Mr. Marsh himself speak of the design he has had in view:—

> The object of the present volume is: to indicate the character and, approximately, the extent of the changes produced by human action in the physical conditions of the globe we inhabit; to point out the dangers of imprudence and the necessity of caution in all operations which, on a large scale, interfere with the spontaneous arrangements of the organic or the inorganic world; to suggest the possibility and the importance of the restoration of disturbed harmonies and the material improvement of waste and exhausted regions; and incidentally to illustrate the doctrine that man is, both in kind and degree, a power of a higher order than any other of the forms of animated life, which, like him, are nourished at the table of bounteous nature.

The scheme thus indicated will be seen to embrace within itself a vast variety of particular objects, and many questions not yet settled by experience. It is connected in every part with the physical sciences, as well as with the intellectual and social conditions of man, and has for its business to expound the reciprocities of action between the two. Some of the questions it involves are those which press closely upon our very existence; while others concern those higher grades of civilisation which have so marvellously subjected the forces of nature to the higher energies of man.

The design, then, of Mr. Marsh's work, though it might have been more happily expressed, is one of practical interest and value. We would willingly speak favourably of its fulfilment; but this cannot be done without some qualification. We have no fault to find with his style, which is generally clear and sometimes eloquent. We have much also to commend of zeal and industry in the collection of facts, and of entire honesty in his manner of using them—a high merit, whatever be the matter under discussion. But what we find reason to regret is, that having appropriated a worthy subject, and one of comparative novelty, he should have deprived his work of much of its value by the inartistic way in which he has put his materials together, rendering it thereby equally difficult to read and to remember them. There is what we may best describe as a want of *backbone* to the volume. Some part of this default may probably be due to the detached and fragmentary manner in which his information has been collected—something also to the fact that Mr. Marsh has obviously an imperfect knowledge of the physical sciences, and is wanting, therefore, in that exactness of method and strictness of induction which are now required on all subjects coming into association with them. His proofs are often trivial from their limited locality, and not always duly balanced as to authority and value; and he frequently omits such as might well have superseded those upon which he dwells for the support of his argument.

We have further to complain of deficiency as regards the mere technicalities of book-making. The volume is prefaced by a copious list of works consulted by our author, attesting in this his zeal and industry;

but we find no table of contents, nor any sufficient indication of the scheme followed in the body of the work. The want of these usual aids is a serious impediment to the reader, and may have contributed in part to that fragmentary character of the work to which we have alluded. The heading of the chapters is copious; but these are broken again into numerous short paragraphs, with a separate heading to each—a plan leading to frequent repetition and a want of continuity in the whole.

We can hardly note it as a fault, but it is a peculiarity in Mr. Marsh's work, that he has thrown fully half of its substance into the form of notes. Many of these notes are references to authorities, but many others are reflections of the author himself, and often of such value as to merit more diligent perusal than the text which suggests them. Numerous illustrations, as we have already stated, are drawn from the American continent, the largest exponent of the growing dominion of man on the surface of the globe. Mr. Marsh shows himself a keen commentator on the habits and peculiarities of his countrymen, and very candid in his avowal of what he thinks might be amended. In one passage, with a note annexed to it (p. 328), he speaks strongly of the *instability* of American life, and closes his comments with something very like an aspiration after change in the American method of conveying land by inheritance:—

All human institutions, associate arrangements, and modes of life have their characteristic imperfections. The natural, perhaps the necessary defect of ours, is their instability, their want of fixedness, not in form only, but even in spirit. The face of physical nature in the United States shares this incessant fluctuation, and the landscape is as variable as the habits of the population. It is time for some abatement in the restless love of change which characterises us, and makes us rather a nomade than a sedentary people. . . . It is rare that a middle-aged American dies in the house where he was born, or an old man even in that which he has built; and this is scarcely less true of the rural districts, where every man owns his habitation, than of the city, where the majority live in hired houses. This life of incessant flitting is unfavourable for the execution of permanent improvements of every sort, and especially of those which, like the forest, are slow in repaying the capital expended on them. It requires a very generous spirit in a landholder to plant a wood or a farm he expects to sell, or which he knows will pass out of the hands of his descendants at his death.

The general comments we have made on Mr. Marsh's work will show that it is one difficult to analyse in detail. We may better serve our readers by bringing before them our own more succinct view of the great questions it touches upon, and the conclusions which have been reached, or are yet before us for attainment. To superficial enquirers it may seem a matter of simple and easy evidence to denote the changes and conditions of the earth's surface which are due to human agency. But this is far from being the case. Many collateral questions and issues enter into the problem, and the objects of enquiry are so many and so complex that it is often exceedingly difficult to disengage the truth. If any preliminary proof of this were needed, it might be found in the consideration that man has a double faculty allotted to him on the earth—he creates and he destroys. We have to deal with what he *does*, and what he *undoes*, in the world of nature around him. And the modes of action in each case are often so indirect, and so little guided by reason or intention—so closely blended, moreover, with the operations of Nature herself—that our conclusions are constantly at fault, even on points of greatest practical interest. The judgments of one generation are contradicted by the more matured and larger experiences of the next.

In the summary view we are about to offer the form of history must be almost wholly discarded. We can give no initial date to the enquiry; we know not at what time, chronologically speaking, man first appeared on the earth. We are ignorant, or only scantily informed, as to the state of the earth when human existence first dawned upon it. The 'Αρχή, that mysterious term, translatable into every language, because common to all human thought, is in this particular case, as in so many others, far beyond the scope of human research. We have heard and read much lately on this question of the antiquity of man on the globe. Putting aside that theory of our own time, which solves it by assuming his gradual derivation from mammalia lower in the scale of animal life, we yet have not facts sufficient to furnish any more certain answer, as far as time is concerned. The recent discoveries of human implements and bones in caverns and elsewhere, associated with the remains of animal species now extinct, have disclosed a comparative antiquity of man (possibly also a lower grade of humanity) far greater than we derive from any written record of his history. But we can bring no numbers with which to specify this earlier date ; and while facts are every day multiplying upon us, much is yet needed for that thorough confirmation which science requires. The whole enquiry, though it has gained a sort of specialty for the moment, merges in that larger subject which has received the cumbrous name of Palæontology—a part of knowledge, we must add, however it be named, which forms one of the most wonderful exploits of human intelligence as directed to the natural history of the globe.

Nor can we do much more than vaguely speculate on the state of the earth's surface when Man appeared upon it. Geology is the only school to which we can go for information here. This science, aided by zoology and botany, has made the marvellous disclosures, to which we have just alluded, of those successive stages through which, during ages beyond all estimate, the visible crust of our globe has passed before assuming its present state and aspect. We have successive faunas and floras thus opened out to our inspection, numerous almost as those of the actual world—detached in parts by time and intervening catastrophes, yet linked together as a whole in the manifest scheme of creation. Whether the changes in them from one period to another belong to separate acts of creative power, or to evolutions and transmutations of species ever going on but hidden from us in certain steps of their progress, is the question which has started into active litigation among the naturalists of our day. We are not concerned with it here otherwise than as regards a fact recognised under any view, viz., that there has been a general progress, as time went on, towards higher organisation and capacities of existence. Taking the animal kingdom as our example, we find the series variously broken, and the inferior and simpler forms of earlier date continuing to coexist with the later and higher. But the *tendency* in the series is ever upwards; bringing its higher members, as regards bodily structure, into close contact with Man, the highest in the scale. His earliest existence is contemporaneous with some animal species now extinct, but which had near affinity to species still present on the earth. Others have become extinct even within the time of human record. Nevertheless, for our argument it may fairly be assumed that the aspect of animal life, coeval with the first appearance of Man, did not greatly differ, in forms at least, from that we now see around us.

Of the numbers, however, and distribution of these animal forms over the then existing lands and waters of the globe we are less able to speak with assurance. It may be considered probable that the animals since domesticated for human purposes were proportionally less numerous during the infancy of Man than those which are either useless to him, or with which it is his lot to struggle under the ruder conditions of life. But any conjecture beyond this would be bald speculation, unsupported by facts. The remark applies equally to the vegetable covering of the earth at the period in question. The discoveries made in fossil botany have led to its classification into four or five successive floras, corresponding in some sort with the kindred series of animal life; but more distinctly marked by the characters which changes of climate have impressed upon these wonderful records of ages gone by. The peculiar and profuse vegetation, the gigantic ferns and lycopodiaceæ of the coal formation, belong to a climate hotter than that to which their products now so abundantly minister light and heat. In the fossil flora of the tertiary strata we find ourselves more closely approaching to that of our own time, in the proportions as well as in the families and species of the vegetable world. Though forced to admit a long interval of time and change, including the so-called glacial period, between the newest of the Pleiocene strata and the human epoch, we have reason to believe that this approach to existing vegetation still went on, and that the earliest of our race found the earth clothed with trees and herbs not greatly differing in kind from those which now cover its surface. It is probable, from various considerations, that the forests of this period were very widely extended, and that the Coniferæ especially formed a large proportion of this forest growth. We may remark, as worthy of note here, that in the peat-mosses of Denmark (which show in succession downwards the vestiges of the Iron, Bronze, and Stone Ages of human implements, and thence inferentially the succession of different races of men) the lower or Stone stratum abounds in trunks of the pine and fir only; while those of the oak are largely found in the Bronze period, and of the beech (now the predominant tree of the country) in the Iron.

While speculating on the climate and conditions of the earth's surface at the time most nearly coeval with the advent of Man, we are bound to admit the difficulty of the problem which the glacial period brings before us. Our eminent geologist, Sir C. Lyell, has bestowed all his ability and zeal in seeking to decipher the probable causes of this great catastrophe—the interposition, between two periods of higher temperature, of a long period of such cold as to cover much of our Northern hemisphere (and proofs to the same effect have lately come to us from the Southern) with glaciers, the magnitude of which is very feebly pictured by those we now look upon in the Alps and Greenland seas. He has sought to connect this enquiry with his larger researches into changes of climate as affected by altered proportions of land and sea in different geological eras. But the line of discovery here has not yet fairly touched the ground. The astronomical relations of our planet give no aid towards a solution. Its internal condition, as a molten mass crusted over, and losing heat, as we presume it to have been lost through prior ages by radiation into space, while plausibly explaining some phenomena, leaves others in the same darkness as before. The total question, including its relation to the human race, is one that science has not hitherto solved, but to which many avenues are open, and a crowd of naturalists pressing forwards upon them.

We have thus far been but upon the threshold of the subject which forms the material of Mr. Marsh's volume. Yet these preliminary views are necessary to the completeness of the picture, and to a right comprehension of the influences which this new element of human life has had on the physical conditions of the earth's surface. To the animal instincts which before had rule in the world we now find added the higher faculty of intelligent design—of mental superinduced on bodily force. This is the subject with which we are here more directly concerned. We are called upon to indicate the extent, or what may better perhaps be termed the limits, of Man's power over the conditions of the natural world around him; and then to show what he has already done, or may attain hereafter, in effect of this power. We desire the more to mark clearly the several points of the argument, since the want of such method is the defect which will be most felt by the readers of the volume before us.

First, then, what is the extent, and what are the limits, of human power over the earth we inhabit? The simplest division of this large question is that which regards the influence of Man, severally, upon the *inorganic elements* around him, and upon matter *organised* into animal and vegetable life. There is close inter-relation between these objects, as will at once be obvious; but, for the sake of clearness, they may better be regarded separately; and in such division the relation of Man to inorganic existence, whether of matter or force, is that which comes first into view. His influence, as the head of the living creation, on other forms and attributes of life, will be best considered in sequel to the former.

The atmosphere, the waters, and the superficial crust of the earth, are the portions of the material inorganic world with which we are connected by reciprocal relations essential to our very existence. No illustrations are needed in proof of this general fact. But beyond it lies another, equally certain though more obscure to our conception, viz., the existence of certain forces, or active powers of nature—light, heat, electricity, gravitation, &c.—which we cannot define as material, though they are known to us only in connexion with matter, and through their several actions upon it. These so-called forces (for we have at present no fitter name for them), while governing and constraining in various ways the power and action of Man, are in other and endless ways submitted to his intelligence, and become the instruments with which he works in the material world. The relations of matter to force, as well as the correlation of different forms of force, and the connexion of all with organisation and vitality, are the problems most strenuously pursued by the philosophers of our own day. Experimental truths and metaphysical uncertainties come here into close contact, and too often engender shallow devices of language to shelter imperfect knowledge. But the search after truth by experiment and strict induction is now the rule of all science; and words are used by wise men but as counters, to be put aside or changed when they have fulfilled their temporary purposes.

We are carrying this general view far beyond the horizon which our author has been content to take as his boundary. But we feel that by thus enlarging its scope we give to the subject a higher purpose as a part of the history of mankind; and bring it into such connexion with the physical sciences as to increase the likelihood of practical usefulness hereafter. We may remark further, that many of the physical relations just adverted to, complex though they are, may be reduced to simpler and more familiar terms for the objects of our argument. The single word, Climate, for instance, expresses one of the most important relations of man to the natural world around him—a relation which concerns human existence in its every part. But this word, Climate, taken in its largest sense, comprehends within itself all those elements and attributes of matter and force, the mutual influences and actions of which produce the phenomena so familiar to us under this single expression. Earth, water, and air—as they are acted upon by heat and light, and more obscurely by electricity, the chemical and cohesive forces, gravitation and the axial rotation of the globe—furnish the material for all those complex conditions of seasons, land and ocean winds, tides, currents, rains, thunderstorms and hurricanes, snow and ice, amidst which we live, and which we are ever seeking (civilised and savage man alike) to mould into what may best conduce to the well-being of life. Even seen through its more homely details of habitation, clothing, and food, there is something great in this unceasing toil and struggle with the elements around. But the contest becomes of higher kind when man takes these very elements into his service, and gains fresh dominion over the earth through their aid. Seeing how various and vast are the forces acting, and the materials acted upon—the latter diffused over the globe, the former not limited to our narrow sphere, but, some of them at least, energetic throughout all sidereal space—we may well find much of grandeur in this appropriation to human purposes of powers above human comprehension. The instincts of inferior animals act through these powers, but without consciousness of them, and with no ability to control or direct them by intelligence.

We must not, however, carry too far this assumption of superiority. We are seeking now to define what Man can do in modifying the physical conditions of the earth; and Climate comes in among the first points in question. Its intimate relation to all other objects of physical science has just been noticed; and the term Meteorology expresses that independent branch of science designed to embrace these relations. The name is one inherited from antiquity—partially and ignorantly applied in its origin; now, like many other cognate terms, amplified in its meaning, to satisfy the exigencies of growing knowledge and a higher philosophy. But meteorology is yet far from taking rank among the exact sciences. Notwithstanding all that has been done of late years, and the better definition of the objects sought for, it is still in comparative infancy as a branch of human knowledge. We can but partially and doubtfully explain the events it records. The power of predicting them is limited to certain periodical phenomena; and to those more local sequences and averages which we are wont to note without being able to interpret them. As respects, indeed, the climate of particular countries and places, all common notions are singularly vague, and common phraseology still more so. Tables of observation are perpetually correcting the errors of ignorance, and of that *fashion* in belief which mixes itself, more or less, in all matters of worldly concernment.

Professor Dove, of Berlin, justly described by Dr. Daubeny as the highest authority in meteorology, has collected many most valuable results in reference to the phenomena of Climate; and has well indicated by his own methods the manner of research best fitted to extend the science and render it more exact. That much will yet be done in fulfilment of these objects, we regard as certain. The very complexity of the physical relations concerned in the enquiry, while greatly enhancing its difficulties, does at the same time give more various access to the truths sought for.

Meanwhile, the admission we are obliged to make of our imperfect understanding of these phenomena, so vast in scale and so complex in action, is virtually an admission that Man can do but little to control them by any exercise of his own powers. Such at least is the case as regards all the greater elements concerned. He cannot alter the course, or arrest the energy, of those great atmospheric and ocean currents which sweep around the globe—beneficent, or even necessary, in their general influence, destructive only in their excess. He cannot change the total amount of light and heat derived from the sun, though he can vary in different ways its local distribution. He has no power, save indirectly and in limited localities, over that great and never-ceasing circuit of the waters of the globe which is carried on by evaporation and by rains. Though he has subjected the wonderful element of electricity to wonderful uses, yet has he little or no control over it in the wide compass of those atmospheric and other changes in which it bears a part so large, yet even now so little understood. The same remark applies to the magnetic force as a mode of electric action; pervading, we have reason to believe, the whole solar system, and concerned probably in many more terrestrial phenomena than have yet been assigned to this cause. Over gravitation, a force chiefly strong in its concentration and by its fixed and unceasing action over all matter, Man may seem to have acquired more control; but it is in every case gained by the expenditure of some other energy, mechanical or chemical, brought into momentary conflict with this great motive-power of the universe.

Such, briefly expressed, are the limits to human power, in its relation to the elements, which in their combination form the various climates of the earth. It would require a volume, and one more ample and complete than that now before us, to denote the ways through which, directly or indirectly, man has sought to extend these limits, and to gain a higher mastery over the inorganic as well as the living world. Matter and force being ever the same in absolute amount (a modern doctrine repeating more explicitly one of ancient date), his ability consists in setting in action those changes and translations of which matter and forces are susceptible, to fulfil purposes necessary or beneficial to his own existence. The *μίξις καὶ διαλλάξις μιγέντων* expresses briefly what is his dealing with a large class of objects in the natural world. We shall touch upon some of these points hereafter; but meanwhile must speak somewhat further of the influence he has found means to exercise over local climate—a matter of deep concernment to the existence and well-being of mankind.

We say *local climate*, because it is only in special localities, and not generally over the globe, that this influence can be brought into action. And it is well worthy of note that the great agent in any such change belongs to the living world, and to the domain of vegetable life—one that Man can mould to his uses both by propagation and destruction, yet hitherto only with vague knowledge in what these uses consist. It is the forest which thus actively ministers to the climatic conditions of the earth; which, extirpated by the axe or restored by planting, changes both the face of nature and the distribution and destinies of human life. This simple name of Forest will hardly bring to the casual reader a conception of all that it implies; of the vast extent of the earth's surface thus covered in every zone, to the very confines of the arctic circle; of the various aspects and qualities of this great forest mantle, and of its relation to all the moving elements of the natural world. It is impossible to estimate, even by loose approximation, the actual extent of surface so occupied. We have given reasons for believing that the earth was largely covered with wood at the time when Man first became its denizen. And though in our own day we find in tropical countries vast regions almost treeless, the balance is fully struck on other continents by those wide tracts of close and continuous forests into which no lumberer's axe has ever penetrated. Even in Europe, where intelligence and industry have been most active in seeking fresh space for human existence, we may affirm that one-half the total area is covered with woods, either widely continuous, as in Russia, Sweden, Norway, and Poland; or broken into detached forests, as in Germany, Turkey, and France; or into smaller patches of timber, as in our own island.

A considerable part of Mr. Marsh's volume is occupied with this topic—one most natural and reasonable to an American writer. On the North American continent the vast regions east of the Mississippi, stretching northwards through Canada into the boundless solitudes of the Hudson's Bay Territory, are still covered with forests which set at defiance all common measurements of space. The devastation of a pine-forest by fire will often give to the traveller a more vivid perception of extent than whole days of passage through them. We ourselves have seen, in the wide regions of the Upper Ottowa, an area of nearly sixty miles in length and ten or fifteen miles in width, which had been thus devastated by a single fire carried by an impetuous wind over this long line of destruction. Such a wilderness of gaunt perpendicular trunks, naked of all branches and blackly charred, shows the depth and density of a forest under an aspect never to be forgotten.

America, in fact, is the country of the world where the most vigorous struggle has existed—and, despite war, is still going on—between a new and energetic people and the native covering of the soil. The forest here must be extirpated or thinned, to make room for a more profitable vegetation; and a striking feature in American landscape, even in the older States, is the crop of corn growing luxuriantly amidst the stumps of ancient trees. But while this destruction of the native woods of the country is yet in active progress, some prospective alarm has arisen lest it should be carried too far. And as this question involves very directly the influences which forests have upon the climate and physical conditions of a country, we will quote part of a long passage from Mr. Marsh, who is himself a strenuous supporter of forest claims over the globe, and in more than one place presses strongly his complaints against mankind at large, as the habitual destroyers of what Nature has done to enrich and beautify its surface:—

With the disappearance of the forest all is changed. At one season the earth parts with its warmth by radiation to an open sky, and receives at another an immoderate heat from the unobstructed rays of the sun. Hence the climate becomes excessive, and the soil is alternately parched by the fervors of summer and seared by the rigors of winter. Bleak winds sweep unresisted over its surface, drift away the snow that sheltered it from the frost, and dry up its scanty moisture. The precipitation becomes as irregular as the temperature; the melting snows and vernal rains, no longer absorbed by a loose and bibulous vegetable mould, rush over the frozen surface, and pour down the valleys seawards, instead of filling a retentive bed of absorbent earth, and storing up moisture to feed perennial springs. The soil is bared of its covering of leaves, deprived of the fibrous rootlets which held it together, dried and pulverised by sun and wind, and at last exhausted by new combinations. . . . The rivulets, wanting their former regularity of supply, and deprived of the protecting shade of woods, are heated, evaporated, and reduced in their summer currents, but swollen to raging torrents in autumn and spring. . . . The washing of the soil from the mountains leaves bare ridges of sterile rock; and the rich organic mould which covered them, now swept down into the damp low grounds, promotes a luxuriance of aquatic vegetables that breeds fever and more insidious forms of mortal disease by its decay.[1]

Such, somewhat abridged, is the theme of our American Evelyn; in style rather florid and ambitious, yet doubtless containing much that is true and of practical value. He recurs to this topic in every part of the volume, and fortifies his position by various authorities, ancient and modern.[2] Here, nevertheless, we must bring in the old claim of *audi alteram partem*, as essential to truth. Mr. Marsh bestows his zeal on one side of the case, and generalises too much upon it, without duly regarding those many exceptions which Nature is ever suggesting or forcing upon us. He seems to forget in his large conclusions that to preserve the native forest is in many countries to narrow the space allotted by Providence to the growth and maintenance

[1] To these various effects of forest vegetation our author might perhaps have added its influence on the electrical relations of the atmosphere and earth—an influence greater, we believe, than is usually supposed. But though certain as fact, the particular conditions it involves are still so little known that their omission may reasonably be justified.

[2] One of the most recent and valuable works on this subject seems to be that of Hohenstein (1860), entitled 'Der Wald.' Our old English writer, Harrison, has a curiously quaint chapter on the woods and marshes of England, complaining much of the decay of the former; and other ancient English authorities might be quoted to the same effect.

of mankind. Finding 'tongues in trees,' he allows them to speak somewhat too loudly on their own behalf, and to suppress the claims of those cereal crops and pastures which the industry of man is seeking in so many places to substitute for them.

In truth, this relation of forests to climates and other conditions of the earth in which human interests are involved is a matter hardly to be reached by general maxims. To gain anything like fair practical results it must be made a question of countries and localities —of the extent and relative proportion of surface thus occupied—of the character of the forests themselves—of the character of the country at large, whether mountainous or level, near to the sea or distant from it—of the nature of the rocks and soil on its surface—and of those various incidents of local climate which belong to other natural causes. The practical question is one widely different as applied to the forests of Scandinavia, and to those woods of the Apennines, in Southern Italy, the extirpation of which has doubtless contributed, with other causes, to defertilise and depopulate the valleys of that region—very different, also, as applied to the interminable forests of Upper Canada or New Brunswick, and to the residual masses of wood in New York and Pennsylvania. We may add, as further example, that timber growing on hills or steep acclivities, and that of plains, whether marshy or arid, can never be brought in illustration of any equal or similar influence on the physical conditions of a country. Every region has its particular aptitudes, and a single theory can in no sense be applied to all.

We may, however, fairly join our author in affirming that vegetation, under the form of woods, is necessary, more or less, to the well-being of every country; and that many regions, once fertile, have become otherwise by the loss or curtailment of this magnificent provision of Nature for their covering. And as a practical corollary to these facts we may speak with assurance of the power Man has of gaining or restoring lands, thus barren from nature or human improvidence, by planting fresh forests where none now exist. With due attention to soil, climate, and other local circumstances, he may rejoice in the conviction that he is thus providing for the good of his posterity, if not for his own: 'Serit arbores, quæ alteri sæculo prosint.' This remark especially applies to the tracts of arid sand so numerous over the globe, even in close contiguity to high cultivation, as the Landes of France, the Dunes and Steppes of other European countries. A covering of well-selected woods, or even of such plants as the bent-grass, would in time give to these sterile sands a new and happier soil; and this attained, the axe might come in to make over to the agriculturist a part of the surface thus freshly provided for his labours. Experiments to this effect we believe to be now in progress in several countries, and they will doubtless be extended hereafter.[1]

[1] At the recent meeting of the British Association we understand that a communication has been made regarding an extensive region in the Orange River territory of South Africa, bearing marks of having been formerly well wooded, but now utterly treeless and barren. The progress of colonisation northwards may make it expedient to remedy this by fresh planting; and such we believe to be the suggestion of the gentleman, Mr. Fox Wilson, who has presented this memoir.

We have dwelt on this subject at some length, from the prominence Mr. Marsh has given to it in his volume. We now come to other points illustrative of the dominion which Man exercises on the earth—illustrations more definite and intelligible than the complex conditions of climate, and the doubtful question how far, and in what way, these are modified by the forest vegetation which Man can create or destroy. Most of these illustrations belong to the age in which we are now living. All need to be brought into relation with it. The last century—the last fifty years more especially—has established a new era of human power; in which, by aid of fresh elements subjected to command, and fresh impulse given to those of older use, more has been done to subjugate the earth and ocean to human purposes than in the total period forming the prior history of mankind.

We must begin by carrying our readers for a few minutes below the surface—to those wonderful works of mining genius and industry upon which England, beyond all other countries on the globe, relies for her prosperity and greatness. In mines as they are now worked we have an admirable example of dominion gained over the natural world by the pure force of human intelligence. In the profound depth and extent of many of them, in the magnitude and perfection of the machinery employed, and in the methods by which air is given to the mine and water removed from it, we find every element of grandeur and successful energy. It is not possible here to go into details; and yet, seeing how little these things are known or estimated, we cannot forbear saying a few words about the mines of England more especially, as those which exemplify on the largest scale all others of the world besides. Our pecuniary interests are deeply involved in this branch of industry, scientific education has fairly advanced among us, and travelling is almost superfluously easy from one end of the island to the other. Yet how few have knowledge of, or care to inspect, these great subterranean and submarine workings, which bring the hidden wealth of our country to the surface to vivify us with light and heat, to furnish material and machinery for our manufactures, and motive power for every part of the globe! When we say that this indifference is strange, we use the lightest term that can well be applied to it.

According to our present knowledge, Great Britain contains within its scanty area a greater variety and abundance of minerals serving to the uses of man than any other equal space in the world. We do not profess to number the metals we now possess, since modern science, by disclosing the metallic bases of the earths and alkalis, and making known four new metals through the wonderful medium of the spectrum analysis, has swelled the list of these bodies—elementary as we still must call them—to a formidable length. But of those metals and minerals which are worked by mines on a scale commensurate with their value to mankind—iron, copper, lead, tin, zinc, coal, rock-salt, &c.—we possess an abundance really marvellous in its concentration on this small island. We do not mention gold or silver; though it may perhaps surprise many of our readers to learn that gold has been found in more than thirty counties of Great Britain and Ireland; and that by improved metallurgical processes more than 600,000 ounces of silver are annually obtained from the working of our numerous lead-mines.[1]

We must speak but cursorily, and in round numbers, of the economical value of our greater mines. The official return of their total value, as derived from those of every kind in working last year, gives no less a sum than 36,000,000*l.*—a cogent proof, drawn from a single small island, of the mastery Man has obtained over the mineral world that lies below his feet. Coal, that astonishing product of an ancient vegetable creation, comes at the head of the estimate. From an area of about 6,000 square miles of coal-fields in Great Britain, and from mines not fewer than 3,000 in number, we at this time draw nearly 90 millions of tons annually, for our own uses and those of the world at large—a consumption increasing every year, as men multiply, and steam and other appliances of heat become more necessary to do their service on land and sea. The question has of late been often and urgently asked, how long can our English coal-fields suffice for this vast and augmenting drain upon them? Calculation has been actively applied to answer it, but not quite satisfactorily, inasmuch as the estimates have varied from 400 or 500 to nearly 1,000 years.[2] We

[1] The quartz lodes now worked for gold near Dolgelly, in Wales, have produced in some years as much as 5,000 oz. of this metal. Certain veins here have yielded 12 or 14 oz. from a ton of ore.

[2] We may refer here to a valuable memoir by Mr. Edward Hull on

the more willingly accept the latter number, as it comes to us justified by the very recent invention of a machine for cutting coal in the mine, which not only executes its work far more speedily and savingly than the human arm, but, what is of far greater moment, gives working access to some of those beds of coal, less than three feet in thickness, which have hitherto been put out of calculation, as incapable of yielding any profit. As these thinner beds generally occupy areas commensurate with the thicker, the great practical value of such inventions will be readily understood.[1] Concurrently with new methods for economising heat, and possibly with the power of working at still greater depths under the magnesian limestone, they promise to retard greatly the arrival of that time—certain, however, in the end to come—when the coal-beds of England will be known only as a part of its past history. It is as useless to speculate on the effects of this destitution as on the general condition of mankind at the time when it shall arrive.

Still holding to England for illustration, we pass by a natural step from coal to iron—that wonderful metal, found now as an element in the photosphere of

the coal resources of Great Britain, published in the 'Quarterly Journal of Science' for January last. Mr. Hull adopts the larger estimate noted above, and justifies it by the statistics of each separate coal-field.

[1] These coal-cutting machines, with some variations of form, have now, we believe, been profitably applied in two collieries for more than a year. Either steam or condensed air may be used for the engine. In the former case especially it is coal working directly for its own destruction.

We have not spoken above of the three great North American coal-fields, rivalling European kingdoms in extent, as these vast deposits have yet been only very partially broken in upon by the hand of man.

the sun, if not in other more distant stars; and on our own earth subserving to the purposes and power of Man more largely than any other. The chief function of gold and silver is to represent the value of human commodities in exchange. The great function of iron is as an instrument to create these commodities, and to facilitate and perfect their use. But it would be mere declamation to expatiate here on the value of this metal to mankind. Our business is only to state briefly what England has done, and is yet doing, in raising iron ores from beneath her soil, and giving them by her furnaces and forges those several forms of commercial value which are every day becoming more various and more perfect in adaptation. A short statement, given in round numbers, will best show the progress of this great branch of national industry. In 1740, about 17,000 tons of iron were produced in England, from 60 furnaces. In 1808, about 200,000 tons; in 1820, about 400,000; in 1827, 690,000 tons, from 284 furnaces. In 1848, nearly two millions of tons, of which more than a quarter were derived from South Wales. The increase has continued, with only transient interruptions, to the present time, when we believe we may safely rate the amount at more than four and a half million tons of annual produce, to supply our own and the demands of the world—an amount, translated into money, of from ten to twelve millions sterling. Had we space for statistics we might speak of the great extent of the older iron-fields in South Wales, Staffordshire, Yorkshire, and Scotland; and of the several recent discoveries of iron ore in

Lincolnshire, Somersetshire, Northamptonshire, &c., which enlarge the area of future labours. Or we might dwell upon those happy inventions of the hot-blast, the Bessemer process, the artifices for economising heat (four-fifths of which were wasted in the old processes), and the various methods now used for giving higher value and stability to the qualities of this metal for the service of mankind.

We must touch still more shortly on the other metallic treasures of England—the mines of copper, lead, tin, &c.—important though they all are to our national welfare. The last of these three, however, merits a few words of separate notice. Tin is a metal comparatively rare on the globe; and in Europe is found in working quantity only in Cornwall, Saxony, and Bohemia; our English county being far the richest in its produce. The annual average of the metal obtained here approaches 8,000 tons; or about 1,200,000*l.* of marketable value; a quantity that does not seem likely to be increased. The history of tin has a certain mystery about it, connected as it is with the story of the Phœnician voyages to these remote coasts; and with the large use of bronze, of which tin is an ingredient, not merely in the arts of Greece and Rome, but also in the implements of races of an earlier and ruder time, to whom we can give no name or date, save through these implements of their use. Whence or how did these rude denizens of the Bronze Age, whether in the Cimbric peninsula, in the lacustrine villages of Switzerland, or elsewhere, obtain this metal, so rare and valuable even in our own time? We know that it was transported in certain quantity from Britain to Italy, across Gaul, by horse-carriage; but there is no memorial left of these earlier people to show that they had the means either to work mines or to transport to such distances the material gained. The best solution is that afforded by the analogy of tin to gold. The former metal, like gold, is found not only in veins with a quartz matrix, but also as a surface deposit under the form known as *stream-tin*, the outward interpreter of the wealth below. This probably furnished the metal to earlier ages; existing then in larger quantity than now and easily obtained; but, like gold, exhaustible in the end as a superficial deposit. As in the case of gold, too, it is uncertain to what depth the tin-ores may be found, even in the primitive veins, which give earliest date to this valuable metal.[1]

Of our copper and lead mines we do not further speak than by stating that they produce an aggregate revenue approaching to 2,500,000*l.* annually. Our rock-salt mines deserve some notice, not from their beauty, in which they are far inferior to the mines of Wielitzka and Salzburg, but from their large annual produce, in different forms, of nearly a million tons of salt; and, further, because we have here an illustration of that human activity which is ever discovering fresh material for human uses. Rock-salt has hitherto been explored and worked in Cheshire only. Within the last year a very deep boring for other purposes has disclosed a bed of this most valuable substance in Northumber-

[1] The ancient mining implements found in Cornwall add to the probability that the old workings for tin there were chiefly superficial.

land, affirmed on good authority to be more than 100 feet in thickness. This mineral treasure will not long be suffered to lie dormant. Depth is no obstacle, for the mining genius of our own day has struggled and succeeded wherever the object was worthy of the effort.

We might here, had we room for it, say much more of these wonderful penetrations into the earth, for the acquisition of that which is so valuable underneath. It would probably be far below the truth to affirm that the increased power and perfection of machines, and notably of the steam-engine, have quadrupled the mining power of England since the beginning of the century. In the Hartz Mountains and Tyrol two or three particular copper mines had been already carried to a depth exceeding 2,000 feet; but the workings, carried on chiefly by water-power, were found to be unproductive, even with Government aid. Our machinery, involving an amount of steam-power unknown before, has since distanced all other competition in this branch of industry. The mines of this country, freed from the ingress of water by the constant labour of these vast engines, so perfect as to be almost noiseless in their working, have now reached nearly the same great depth; and even in some cases been carried far underneath the sea, giving access to veins of ore wholly unapproachable but for these powerful aids to human hands. The case is the same with the great coal mines of England. Not merely are the workings more perfect in every part of their economy, but by virtue of the machinery in present use they have been carried to greater depths than heretofore; following now in many places the beds of coal as they dip under the magnesian limestone, and in some instances rivalling the Cornish mines in their extension under the sea.

The working of the English coal mines is wonderful, not only in the depths reached, but in the vast extent of many of them, and the admirable provisions made for their ventilation. In some of the Northumberland collieries—these being earliest in date, as well as most extensive—the ventilating blast of air forced down one shaft is made to circulate through thirty or forty miles of subterranean workings before emerging again at another. Well might we wish that a better security could thus, or otherwise, be given against those explosions of fire-damp which every year, from casualty or carelessness, offer such fearful records of calamity!

The deepest coal mine worked in Great Britain is that of Duckinfield, in Cheshire, reaching 2,050 feet, or more than a third of a mile, in its perpendicular depth.[1] But possibly the nearest approach to the centre of the earth—if we may thus speak of a fractional part hardly exceeding $\frac{1}{12000}$ of the actual distance—is that of a coal mine close to the sea at Wearmouth, descending, we believe, about 1,800 feet below the sea-level. This depth is recorded not only by the great barometric pressure, but by the increasing tem-

[1] This extraordinary shaft, 12½ feet in diameter, was completed in 1858, after a labour of ten years. It reaches a bed of excellent coal, nearly five feet in thickness.

perature in coming nearer the central heat of the globe. Here, indeed, we must note one of the most serious obstacles to farther penetration downwards. It is now well known, from observations in mines and artesian wells, that the increase of heat below what may be called the stationary line of temperature is at the rate of 1° of Fahrenheit for every 60 or 65 feet of increasing depth. In several deep copper and coal mines the average heat of the lowest workings reaches 80° to 85°; and one instance, in the Poldice Mine, is noted by Mr. Fox, an eminent authority on this subject, where the thermometer rose to nearly 100°, a temperature incompatible with any form of profitable or even possible human labour.

It may seem a small matter to speculate upon, and yet when speaking of changes effected on the earth by human action we cannot discard the effects of forty or fifty million tons of coal burnt every year upon the English soil on which we are living. It is the translation, from *within* the earth to *without*, of this enormous amount of carbonaceous matter, with its various chemical adjuncts. Though not well able to say how all this is disposed of in its various later combinations, we may at least affirm that a substance like carbon, so large a constituent of life in all its forms, and having such endless relations to other chemical elements, cannot be wholly inert in the addition it thus makes to the surface without. This is one of the cases where eventual effects may differ from, and go beyond, those more directly obvious to the eye.

Such is a mere outline of the changes, taking our own country as the example, which man, as a miner, is bringing about on the earth. A still stronger impress of genius and power is that which is presented by the great railways which now so largely traverse its surface; and by the tunnels, embankments, viaducts, and bridges which contribute to this vast scheme of human intercommunication. Though a generation has scarcely passed by since these works were begun, they are already so familiar to us, that we lose the full sense of their grandeur, and of all they denote of progress in the condition of mankind. Yet how strange the alteration, even to the eye, in the aspect of a country traversed and intersected by these lines of iron-road—vacant and still at one moment, a minute afterwards giving passage to a train, rushing along at the rate of thirty, forty, or fifty miles in the hour, laden with human beings and the commodities of the world. We know no spectacle more striking—appalling we might almost call it—than that of an express train thus sweeping by in its course. Accustomed as we are to see traction performed by animal labour, there is a peculiar strangeness in witnessing this wonderful trick done without any agent obvious to the eye. We know that the power is in the locomotive, but the *mode* of action is unseen, and to most people unknown.

It would be needless to dwell on those statistical facts relating to railroads, in England and elsewhere, which are every year pressed upon us in larger figures and more ample details—the amount of capital invested, the length of roads made, the number of miles run, the number of passengers and tonnage of goods conveyed, and the gross and net profits of the whole. But we may well look for a moment at some of those astonishing works to which we have alluded, as created by this change in the locomotion of the world—works in which man has attained a higher mastery over nature than even the boldest imagination ever before suggested. Take bridges as an example. In our own boyhood we were shown the iron arch over the Wear, at Sunderland, as one of the wonders of England—a structure which the modern tourist would hardly halt to look upon. The suspension bridge over the Menai came next; a bold and beautiful work, but adapted only to the old system of mail-coach roads. With the invention of the railway and steam locomotion came the tubular bridge over the same strait, a work of less beauty, but more wonderful in its dimensions, and in the new and singular principle of construction due to Mr. Fairbairn, of which it was the first example. Its success emboldened Mr. Stephenson to undertake that far greater work, the tubular bridge of Montreal, little less than two miles in length, and stretching across the wide waters of the St. Lawrence, hardly yet calmed from their rush down the rapids of Lachine. As a monument of grand engineering this bridge is not likely to be surpassed—the less likely as its benefit to the shareholders is far from being commensurate to the cost. Another triumph of human power on the same river is the suspension railway bridge of Niagara, scarcely two miles below the Great Falls, where the St. Lawrence, rushing impetuously, rather than flowing, through a deep ravine, is spanned over in mid-air by this bridge, uniting the dominions of Canada and the United States. In another and distant region of England's power, the East Indian railways show some works of this kind (as the great bridge across the Jumna) almost rivalling those of the Western World.

Look further at those admirable constructions, both in Europe and America, by which the railroad is carried across mountain chains, climbing tortuously their steep acclivities, or forced by tunnels through the rock. In the Copiapo Railway of Chili, the locomotive carries its train 4,070 feet above the sea. In the several railroads which cross the Alleghany Mountains the summit-levels are from 2,000 to 3,000 feet. The new Empire of Brazil boasts a work of similar kind, just completed. In the section, now open, of the St. Ander railroad, in Spain, an elevation is reached of 2,524 feet. The Sömmering Pass, between Vienna and Gratz, carries the traveller 3,000 feet above the sea. Tunnels from two to three miles in length are familiar to us in England and elsewhere. That which is now in progress under Mont Cenis has for its object and ambition to win a passage into Italy without crossing the Alps. To the modern engineer the phrase of the poet—

Opposuit natura Alpemque nivemque —

comes as an incentive rather than an admonition. It is probable that this object will eventually be accomplished. But is it worth the accomplishment? We, as old Italian travellers, think not. We can hardly desire, indeed, to fall back upon the time when carriages were taken to pieces for a passage over these mountains. But, on the other hand, we do not desire to exchange the grandeur of a great Alpine pass, and those glories of the first view of Italy which gave exultation to Hannibal and his army, for the sullen darkness of a tunnel, distinguishable in nothing but its wearisome length from those of our English midland counties. The engineer gains a lasting fame from his work. The traveller gains a few hours of time upon his journey, and emerges into Italy through a hole in a rock!

It may seem ungracious, as well as irrational, to throw even a shade of doubt on the advantages which railways have rendered to mankind. The magnitude of the benefits derived from this great conquest over time and space in the natural world is too obvious to be seriously impugned. Commerce, manufactures, and agriculture gain universally by the change effected; and the social relations of mankind are enlarged at least, and perhaps improved. But we must admit some few qualifications to this high estimate. Even the traveller does not gain his good without alloy. We quit our homes to see and learn—to gain fresh health and enjoyment—often, it must be owned, to follow fashion or relieve *ennui.* For all these objects the railway affords facilities before unknown, but almost too great for the worthiest purposes of travel. European tourists, now in number *legion*, are hurried from place to place with unwholesome and unprofitable speed—the slaves of trains and time-tables, and imbued with more vivid recollections of stations and crowded hotels than of countries traversed and cities passed through. In many persons, it must be added, a habit of restless hurry and love of change is thus engendered, injurious in other ways to the well-being of life. These, however, we admit to be exceptional evils, and name them only as such. We are bound to be thankful for inventions of human genius which can carry us in a short day from metropolitan streets and offices to mountains, lakes, and waterfalls; which bring Mont Blanc and Rome within a month's holiday; and enable the scientific traveller to reach the scene of his labours with less exhaustion of the various appliances of research.

The electric telegraph, that close associate and guardian of the railway, has not made such marked changes on the outer face of the earth, but may, nevertheless, be mentioned here, as the most marvellous example of the dominion Man has gained over one of the great elements of nature—an element, moreover, scarcely known as such one hundred and fifty years ago. The power we exercise over heat and light, over chemical and mechanical forces, is limited in space. The electric current—or what, in default of better knowledge, we denominate such—is made to career, with speed hardly translatable into numbers, over continents and underneath seas, performing the behests of man in social life, in commerce, in peace, and in war. It is the very element of lightning—the *vis flammea cœli*—converted into a messenger, or even, by more recent inventions, into a *disciplined writer* of human thought and language. We might bring in some qualifications here also as to the utility of this new agent of human intercourse, but our space prevents us saying more of what must doubtless be counted the most wonderful discovery of our own time.

Canals, though of high antiquity as an invention for transport, have been in great measure superseded by railways. Yet there are two works of this kind—one in contemplation, the other partially effected—which derive interest from their magnitude, and from their connexion with the new dominion which steam has given to man over the oceans of the globe. If the Atlantic be ever united to the Pacific, and the Mediterranean to the Red Sea and Indian Ocean, by ship-canals, all will be done that can be done to give speed and certainty to the great circuits of intercourse round the globe. We offer no present opinion on the much-disputed matter of the Suez Canal. Even if successful as a navigable passage across the Isthmus, there yet remains the question of profitable return—one embracing too many contingencies to be settled by anticipation. A few years will determine both these points now standing at issue.

We have thus spoken of the influence of Man on earth as a miner, mechanician, and engineer. But we cannot quit this topic of his relations to the material world, and the forces which rule or reside in it, without speaking of him also as the chemist of the living creation—and this in the largest sense which modern science has given to a word so small in its original meaning. He does not, indeed, as such, change the outward aspects of the earth, or govern the natural phenomena to which its surface is subjected. Here, as we have elsewhere explained in speaking of climate, the great chemistry of nature comes into play. Nor has he yet gone far below the surface into the chemistry of life—that mystery of organisation by which vitality is given, and its acts and instincts are carried on. But though there is yet much beyond his reach, chemistry in the hands of Man is one of the highest labours of the human intellect. It becomes the interpreter of nature and natural laws—a science through the resources of which he not only analyses the endless existing forms of matter, but under the guidance of laws almost as well-defined as those which govern the planetary motions, creates numerous new and energetic compounds, which, as far as we know, have no prototype elsewhere in creation. This progress of Man in the great province of scientific chemistry is indeed of very recent date, and we can yet hardly discern all its issues. But enough has already been done to show how much of future power will be gained from this source over the material elements around him. No field of discovery can be more fruitful in prospect, enlarged as it is by connexions, ever becoming closer, with all other departments of physical science.

We have hitherto, in prosecution of our subject, been chiefly occupied with the outline of what Man has effected by his action on the inanimate world. An outline it may well be called, for how impossible to describe those complex connexions which exist between human life and the forces to which this life is subjected!

We have now to speak of the relations of Man to the living world by which he is surrounded. This topic, vast in itself, admits of being treated either as a matter of profound philosophy, or as one of close practical concern to mankind—in this resembling many other questions which modern science places before us. The speculative part is that which regards the intention of the Creator, in bringing Man into this close conjunction with other forms of life, endless in number, infinite in variety. This question, hardly to be answered by any philosophy, touches us more nearly when limited to the animal creation only. We have already alluded to the controversies now going on as to the origin of species, or more generally of the different types of animal life; and as to the true nature of that ascending scale in which Man holds the highest place. And connected with these controversies comes in the great problem of animal life existing under forms of wonderful variety, and during periods of time vast beyond all estimate, before human life was blended in the series, and seemingly without any reference to this consummation.

The most general expression of the connexion of which we are speaking is that drawn from the law common to all parts of the animal creation; viz., life maintaining itself upon life—one form of organisation ministering to the existence of another. This is the link that binds together species counted by hundreds of thousands, and individualities of being which no numbers can approach. To this law, by the physical necessities of his nature, Man is equally subjected with the inferior creatures which surround him. While ruling in the animal world, he is at the same time dependent upon it—not for food and clothing only, for labour and for transport, but in a thousand other ways for the necessities, conveniences, and luxuries of life. It is needless to illustrate by details a matter so familiar, yet seldom perhaps understood to its full extent. Taking singly the objects which are around us in our own homes, we find few that have not been the product of living nature before being fashioned to human purposes. The original organisation is sometimes preserved, often changed by art; but still it is the dependence of Man upon organised existence without. Civilised life is mainly contrasted with savage, in the larger and more skilful appropriation of all that the living world offers to our use.

This large ministration of other parts of the creation to Man gives us no proof whatever that they were created in sole reference to him. It is impossible to regard the multitudinous forms of life—animal and vegetable, fossil or existing—which by no inference can be brought into connexion with the human being, without the conviction that some other great purposes have been intended and fulfilled in this wide and diversified creation. We cannot reach, or even approach, these purposes by our reason; but this inability in no wise impairs the force of the conclusion. Whether the production of life in its various forms and successions has been by operation of more general laws, or by special and repeated acts of creation, equally is there manifest and wonderful design in the whole; and design of which Man cannot be the single object, even if he be the final termination of the series.

The modes through which Man exercises his power over the animal and vegetable life of the earth we may briefly denote as being either by culture and augmentation, or by extirpation, or by transference of species from one region to another. Many examples of these modes of action will at once be obvious. But there are others not equally familiar, though very important to the well-being of mankind; and connected with that phenomenon of high interest in the economy of the globe, viz., the local apportionment of genera and species, and even of certain types of life, to particular portions of its surface. Without speaking of the many curious and inexplicable cases of limitation of species to a single spot, we may cite a few general facts in illustration, such as that of the Cactaceæ being peculiar to the New World, the heaths to the Old; that no rose has been found in the Southern hemisphere, no oak tree or wild apple in the vast regions of Siberia from the Tobol to the Amour; that the salmon, existing around the globe in certain latitudes of our hemisphere, is nowhere found in the Southern, &c. This singular distribution of the forms of life (original we may call it, as far as Man's existence is concerned) has furnished problems of equal and similar interest to the zoologist and botanist, with a further appeal to the geologist in seeking for their solution. But long before speculation had been directed to these local diversities or provinces of life on the earth, practical changes were already in operation, in the transference from one region to another, not merely of the products of animal and vegetable growth, but in many cases of the animals and plants producing them. We shall speedily notice some of the more striking examples of this; saying a few words meanwhile on the other modes in which Man exercises influence on the amount and physical characters of the living world around him.

We have already, indeed, following our author's propositions, spoken of this influence as applied to the forests of different continents and countries; and need not recur to this topic further than by noting how much has been done, and may yet be done, by multiplying particular trees and plants, in special soils and for special objects. The forest trees, on the large scale, are left to shift for themselves; but the mulberry, the olive, the vine, the orange, the cacao, and many others, require and receive more of human culture and selection to aid their increase and ameliorate their produce. The same may be said generally of all fruits and esculent vegetables. We find in Gerard's 'Herbal' (1596) the names of several plants now not seen in our English fields or gardens. Those which remain are multiplied and their varieties selected for culture in proportion to their value; while of plants that are useless or noxious the extirpation is carried on as far as nature permits it, and most largely in countries well peopled and advanced in civilisation.

As with the vegetable so with the animal world. Man can rarely extirpate a species, though natural causes sometimes do so; and on a vast scale, if we take prior ages and fossil species into account. But he can often succeed in greatly reducing the number, or removing altogether from a particular region those which are injurious to him. Bears, wolves, and wild boars have all been extirpated in England by direct destruction. The bear ranged our forests in the time of the first Norman kings. The wolf and the wild boar were known in Great Britain at a much later date. The crane, the bustard, the bittern have disappeared from our Eastern counties, but more in effect of advancing cultivation than of any direct agency of Man. Such changes or extirpations are, of course, less frequent in countries thinly peopled and in the rear of civilisation; yet instances of the kind, and seemingly of recent date, have occurred in New Zealand and other islands of the great Southern Ocean.

The tropical forests, jungles, and plains will probably long retain their carnivora and pachydermatous species; which nevertheless, and despite the uses derived from some of them, are diminishing in number, and will probably in the end disappear under the encroachments of Man, and the more certain and deadly weapons he now employs. Whether species, either animal or vegetable, can ever become extinct by mere lapse of time, and changes producing default in the propagating power, is a deeper question, which cannot be answered upon any knowledge we now possess.

The power of Man to augment the amount of animal life in such species as are necessary or convenient to him, is too familiar to need much illustration. There is, of course, a limit which nature in every different country imposes on this power, either by climate, soil, or other causes affecting the supply of food. But the history of our domestic breeds, and of agriculture as connected with them, shows how far human influence extends in making one part of nature subservient to another, and all minister to Man's wants or pleasures. The effects of selection, guided by reason and experience, in the breeding of animals, are even more striking than as applied to the vegetable kingdom. We here obtain qualities and aptitudes for use, not only far exceeding, but often very different from, those which belong to the primitive stock. The natural instincts of animals are moulded into new modes of action; and in the case of those most largely endowed with intelligence and moral affections (and, however we may define these faculties, who can doubt their presence in the dog, the elephant, the horse, and many other animals?) human intelligence is still more curiously occupied in bringing them into action and adaptation. We may remark, in passing, on the singular anomaly that the animal nearest akin to the human being in structure and faculties should be amongst those most alien to him in every matter of mutual relation and dependence. Whatever explanation we may give of it, we have the fact before us that the anthropoid apes, and the quadrumana generally, are more detached from Man in the conditions of life than many far more remote from him in the scale of being. Remove them from our menageries and street-organs, and these creatures, the strange mimics of humanity, would scarcely be known to the civilised world save by the narrative of the tropical traveller, and by the place they occupy in the classification of the zoologist. But this place is so defined as ever to render them objects of deep interest, and of curious though not pleasant speculation to our reason.

The most remarkable examples of numerical increase in species occur in those new countries to which Man has transported the animals valuable to him for domestic uses. In the vast regions west of the Alleghanies, in the Pampas of South America, and in the new world of Australia, the multiplication of these animals—of the horse, cattle, sheep, and swine—has been on a scale more than commensurate with that of human population. Revelling in their wide and unfenced domains, severally more spacious than European kingdoms, and breeding there with unwonted rapidity, some of these animals have even relapsed into the wild state, and become again the prey of the hunter. Everywhere they not merely aid the growth of population on the spot, but yield large material for export to the very countries from which their own races were derived.

And this leads us to speak of that power, which Man has so extensively used, of making one region of the globe minister to another, not solely through the products of animal and vegetable life, but by local exchange of the animals and plants producing them. This forms an extraordinary chapter in the natural history of the earth, and one that deserves to be more carefully read than it is. We must note, however, in the outset, that this transport and exchange is not due to Man alone, but, in the case of plants more especially, has been brought about by animals far below him in the scale of being; which, unconsciously and sometimes injuriously to themselves, have carried the seeds and germs of life from one region to another. What they have done by the mere instincts or accidents of existence human intelligence has effected with special interests and larger power. The record of such exchanges would in itself fill a volume. We can notice only a few of the more striking instances.

The most remarkable, doubtless, is that which has taken place between the continents of the Old World and those across the Atlantic, which, though peopled before, and by some semi-civilised races, yet came to us as the discovery and conquest of a new world. The balance of exchange here, as might be expected, has been signally in favour of the latter. Even those four articles—cotton, sugar, rice, and coffee—the export of which from America forms so large a part of the commerce of the globe, are all derived from plants originally carried thither by Europeans, and readily propagated, where such diversity and extent of virgin land was offered to their growth. To these more tropical plants must be added the different varieties of cereal grain, hemp, flax, clover, and other herbage, now as thoroughly acclimatised in America as in Europe. We have to set down something, however, to the other side of the account. Of vegetable products America has given to the Old World the potato, tobacco, and maize, besides several others of lesser value. Looking singly to that remarkable root, the potato, how great has been its influence, as an article of food, in multiplying largely in certain countries the amount of human life! Ireland is now paying back to America, under the form of emigrants, some part of that excess of population due to the exuberant culture of the potato on Irish soil. Tobacco, that strange herb, which, unknown to all former ages, has now become so general a luxury or almost necessity to mankind, may perhaps be deemed a more doubtful benefit. Mr. Marsh, somewhat unexpectedly in an American writer, utters as vehement a *counter-blast* against it as did our own King James:—

> I wish I could believe with some that America is not alone responsible for the introduction of that filthy weed, tobacco, the use of which is the most vulgar and pernicious habit engrafted by the semi-barbarians of modern civilisation upon the less multifarious sensualism of ancient life. But the alleged occurrence of pipe-like objects in Sclavonic and, it has been said, in Hungarian sepulchres, is hardly sufficient evidence to convict those races of complicity in this grave offence against the temperance and refinement of modern society.

Though it is not our business to argue the matter here, we may remark that this angry invective is justified in relation to *excess* only. The question is really one of use or abuse, as in regard to every article of ordinary diet, and very especially in relation to wine and other alcoholic liquors. Any allowance granted to a temperate use of these may at least as fairly and safely be conceded to tobacco, and even with some specialties in favour of the latter.

We have given largely also to America of our vegetables of culinary use. For most of these, indeed, as improved from their original wild state, England is itself indebted to the European continent. Until the reign of Elizabeth our gardens were very scantily provided, and with varieties far inferior to those we owe to a more select and careful culture. Exchanges of this kind must have gone on in all the old countries from unrecorded times. Europe is indebted to Asia for some of her finest fruits—the orange, the peach, &c.—all advanced in perfection as well as variety when becoming the objects of profitable or luxurious cultivation. In some instances, but not often, we can go back to the wild original stocks upon which Man has grafted by degrees the various perfections of his modern orchards and gardens, as well as the larger cereal products of his fields.

Not less remarkable than these exchanges in the vegetable world are those of animal life similarly effected. Recurring to America as an example, we find this new continent indebted to the old one for all the mammalia most valuable to mankind—the horse, the cow, the sheep, the ass, the pig, the goat—some of these, as already mentioned, multiplying on their new soil almost beyond human control. As an illustration the fact is worthy of notice that at the time of the discovery of America the milk of animals was unknown there as an article of human food. It is no injurious satire upon the European, as the chief emigrant to the New World, to ask what would have been the present condition of America had these animals not accompanied him thither? We may fairly assert that a century would hardly have sufficed to represent the actual progress of any ten years of the intervening time. Some more ambiguous gifts, it is true—as the rat, the mouse, the Hessian fly, &c.—have been carried in man's train, unconsciously to himself; while to repay these inflictions America has recently bestowed upon us a water-weed, which chokes many of our canals and smaller streams by its rapid and irrepressible growth.

Though with less present magnitude of results, all we have said of human agency in the peopling of America with new animals and plants is still more strikingly exemplified in the yet newer continent of Australia. This insulated region, before it began under the auspices of England its rapid career towards Southern empire, presented to the naturalist anomalies so strange and perplexing as well to justify the expression of Cuvier, that it seemed like 'a portion struck off from some other planet.' With slender affinity even in the types of animal and vegetable life, all particular species, with scarcely an exception, differed from those of the older world, and not a single animal existed there capable of being usefully domesticated. During the seventy-six years which have elapsed since English enterprise first directed itself to Australia, the face of the colonised part of this country has undergone a change marvellous in kind and degree. English trees, fruits, cereals, and grasses, despite the inversion of seasons in the transit, have flourished and propagated abundantly in their new abode; while the variety of climate in this great Southern land has allowed the introduction of several tropical plants, promising much to its future prosperity. Mr. Marsh asserts, in one passage of his book, that the wild plant is much hardier than the domesticated vegetable. This statement, we believe, requires a good deal of qualification. If we are rightly informed, it is contradicted by various facts derived from those Southern colonies of which we are now speaking. The native wild grasses of New Zealand are said to have been extruded when brought into contact with the artificial grasses imported from Europe; and analogies may be drawn from the animal kingdom to show that culture and selection are capable of giving increase of vigour, as well as those other qualities to which they are often more especially directed.

All the domestic animals we have named as given to America from the Old World, with many others—birds as well as quadrupeds—have been brought into these great colonies; and the sheep-farming in Australia is becoming, if not so already, the largest in the world. The silkworm, the salmon, and the sparrow are to be considered, we believe, as the most recent attempted acquisitions to their fauna; the latter in its valuable capacity as an insectivorous bird. As regards the silkworm, and its needful appendage the mulberry-tree, we consider their successful introduction into Queensland and other colonies to be almost certain. The effort to bring the salmon into the Australian rivers is yet of uncertain result, but the object has been assiduously and skilfully pursued; and success is well deserved, whether obtained or not. The Acclimatisation Societies of England and France are working actively at this time in promoting these exchanges of animal life over the globe.

As we have so often had occasion to cite England in illustration of the various subjects of this article, we are tempted to conclude it by some slight sketch of the contrast this island presents in its actual state with its condition as we have it pictured to us at different periods since the Conquest. For a mere outline the materials must be taken thus generally; but it would well repay a special labour to fill up the picture as far as possible for particular intervening periods, bringing them severally into this comparison.

Sir Francis Palgrave, in the concluding volume of his Norman History, has described the condition of England under the last of her Saxon Kings with something of that ingenuity and power which shine so conspicuously in Lord Macaulay's celebrated chapter on the state of the country in the seventeenth century. At the time of the Conquest, and during the reigns of the early Norman kings, little less than one-third of England was covered with woods, and a still larger part showed a surface only of heath, mountain-moors, marshes, and sea-fens. The small part left for arable uses and pasture sufficed nevertheless for the scanty population of the country, which at that period was probably less than three millions for the whole island. The old English forests are numerously perpetuated by name, even where they no longer exist as such. They were at that time, as we have stated, tenanted by the wild boar, by bears and wolves. The tribute paid to the king in wolves' heads did not prevent the ravages of this animal even near to London, and in remoter parts many centuries later. The beaver then built his habitation in many of our streams, as is testified by local names and other records—a more skilful architect probably than the human builders on their banks. The barren heaths, of which portions are still left, then circled widely around the metropolis, dangerous to the traveller even within a century of our own day. Sea-marshes and fens spread to great length upon the Eastern coast, and far into the interior of the country. A part of the scanty rental of these fenny districts was paid in eels. They abounded in cranes, bitterns, &c., which disappeared but a short time before the present generation. When that freespoken monarch Henry VIII. described Lincolnshire as 'the most brute and beastly shire of all my realm,' he probably pictured fairly enough for his day what is now one of the most prosperous and fertile of our English counties. Even the outline of this Eastern coast was once very different from the present—an estuary of the sea running up to Norwich, and a wide channel separating Thanet from the mainland of Kent.

It is difficult to draw any comparison as to climate where we possess no instrumental records of temperature, rains, winds, and other atmospheric states. From various incidental notices Sir F. Palgrave has drawn the conclusion that, at the era of the Conquest, it more resembled the climate of Canada in its extremes of heat and cold. The vineyards of Somersetshire, and the notices of perpetual snow on the summit of the higher hills, afford some evidence to this effect; while the large proportion of forest covering the island gives plausible reason for its being so.

The outward aspect of all that belongs to social life and habitation was in these early centuries rudely simple. The baronial mansions or castles frowned over the miserable villages or huts which lay around them. The grades in society were then few; and the passage an abrupt one from the feudal lord to the mere serf of the soil. Yet we must note here one strange anomaly of this period, viz., the earliest erections of those wonderful cathedrals which still excite the admiration, if not the envy, of the architectural science of our own day. There is something of mystery as well as anomaly in this matter, which has not hitherto been adequately explained. History, revelling in its record of battles and sieges, is wellnigh silent as to these better and more lasting triumphs of human power.

The country at large was nearly destitute of any other than rude lanes and little less rude highways, on which, but two centuries ago, a four-horse carriage could hardly accomplish in a day the distance which a railway-carriage now sweeps over in a single hour. The provision for travelling on horseback was of better kind; and we have the records of many extraordinary journeys thus performed; such as the night's ride of Henry II. from London to Dover, with the incident of an eclipse of the moon on his way; the sixty hours' ride of Sir Robert Carey from London to Edinburgh, to announce to James the death of Elizabeth; and the still more rapid communication by horse-messengers between Charles I., when at York in 1642, and the Parliament in London. The general state of travelling through England at the time of his history is excellently described by Lord Macaulay; and to his third chapter we would willingly refer our readers for all that further concerns the physical and social condition of the country at this period, and for a very striking picture of the contrast it presents with the England of our own day. Such contrast is the stronger, of course, when made with those earlier times of our history of which we have spoken.

We the rather make this reference, as no sufficient space is left to us here to dwell upon the present aspect of England in comparison with the past. In the preceding parts of this article we have, indeed, said much to illustrate it, and to suggest those modes of viewing the subject which may enable our readers to fill up the picture for themselves. It is, in truth, a wonderful picture of human progress—of progress continuous, yet so marvellously quickened during the last fifty years, that the dullest observer of the world around him feels that he is living in a new age; and the most cautious philosopher scarcely ventures to set a limit to what may hereafter be attained. While the instincts and acts of other animals have remained stationary from the earliest recorded time, human intelligence, working with, and in part controlling, the great forces of nature, has covered the globe with monuments of its activity and power. The whole may be received as evidence of the high destiny which God has given to man on the earth—a destiny mingled at present with much that is obscure to reason and painful to feeling, but capable of and intended, as we believe, for some higher and nobler development in the time yet to come.

Here, then, we bring to a close the summary view of a subject which might worthily occupy a much larger space. While adopting the suggestion of Mr. Marsh's title, we have in no way followed him in the method or details of his work. We think the outline we have given better fitted to convey to the reader a just idea of the nature and interest of the subject, and to suggest a more scientific and useful manner of pursuing it. A right method, important in every case, is especially needful where the details are thus endless in number, yet very different in import and value. If in any future edition of his work Mr. Marsh should be led to re-arrange, as well as enlarge, the materials in his hands, it will be satisfactory to us to believe that we may have contributed in part to this good result.

LAUGEL'S PROBLEMS OF NATURE AND LIFE.[1]

[CONTRIBUTED TO THE 'EDINBURGH REVIEW' IN 1871.]

In this Review will be found several extracts from the Papers published in the earlier part of this volume. The Editor has thought it best to retain the duplicate passages rather than to recast or omit the essays in question.

THE volumes we have placed at the head of this article are connected, not solely as works of the same author, but as containing, in their series and several subjects, a general view of the physical science of our time, in the most advanced stages of its progress. The position of M. Laugel as private secretary to the Duc d'Aumale—a prince whose learning and many accomplishments, even more than his birth, have given him merited reputation in the country of his exile—may be recognised as favourable in various ways to a work of this nature. A Frenchman, and intimate with all that is best in the science and literature of France, his quiet residence at Richmond and familiarity with English institutions have afforded M. Laugel facilities for portraying modern science in its largest aspects, and under those connexions

[1] *Science et Philosophie.* Par M. AUG. LAUGEL, ancien élève de l'École Polytechnique, ex-Ingénieur des Mines. 12mo. Paris: 1863.

Les Problèmes de la Nature. Par AUGUSTE LAUGEL. 12mo. Paris: 1864.

Les Problèmes de la Vie. Par AUGUSTE LAUGEL. 12mo. Paris: 1867.

which now more than ever tend to give it unity as a whole. He is not, we believe, himself a practical labourer in the field. If this be a disadvantage, there is some compensation for it in the larger and more impartial scope given to that intelligence which seeks to combine elements of knowledge separate in their earlier growth, but now claiming to be blended by higher generalisations. Our author stands fully on a level with the scientific acquirements of his time, as well as with those doctrines and speculations which have recently grown out of them. In truth, he everywhere shows himself disposed to adopt the latter in their extremest form. Whether from natural temperament of mind (a powerful agent even in the acceptance of scientific evidence), or from other causes, he boldly confronts, and handles without reserve, all older and more orthodox opinions on the great questions he approaches. The volumes before us, small in size as books, while thus large and bold in scope, are necessarily wanting in many of those details and illustrations which novel opinions require for their justification. This gives an aspect of dogmatism to M. Laugel's writings; not, indeed, without some reality, from the evident bias of mind to which we have just alluded. He often expresses as established truths things which are still matter of doubt and controversy.

Apart from this comment, we can give unequivocal praise to the style of these volumes. M. Laugel has an epigrammatic felicity of expression frequent in French writers even on the most abstruse topics. He is occasionally somewhat too florid in phrase, but there is no scientific pedantry about him. He comes at once to his subject without parade of preface, and puts what he has to say fairly in front. Whatever be thought of his doctrines, they are at least honestly and clearly pronounced. If expressed sometimes too dogmatically, you see that they are really his opinions, and reached by study and earnest thought on the several subjects before him.

In our review of these volumes we do not think it necessary to follow M. Laugel's course through all the topics with which he deals, but shall rather seek to select such as may best illustrate those methods and attainments of physical science which so strikingly characterise the age in which we are living. A summary view of the progress and state of this vast department of human knowledge we gave in an article some twelve years ago. Since that time the steps in advance have been not less gigantic than those we then described; rendering the present century, still not near its end, the most remarkable in the history of mankind. Happy would it be could we record commensurate change and progress in the moral conditions of human existence, of men and of nations of men! Such golden age is yet a Utopian dream of the future. The narrative of the year just expired tells nothing of it; save in the solitary hope that the horrors of warfare, thus augmented by the new weapons which science has furnished, may check at least, if not annul, the repetition of such calamities to the civilised world.

The first and second of M. Laugel's volumes, entitled 'Science et Philosophie' and 'Problèmes de la Nature,' discuss, in the spirit and style we have just denoted, the general principles, aims, and methods of modern science. His mind readily embarks in those bolder enterprises of speculation which formerly could only be deemed the vagaries of thought, but have now been sanctioned by deeper research into the mysterious laws of nature—more wonderful in their reality than any imaginations of untutored genius or of the wildest fancy. With the new licence, however, thus obtained, there is still need of much control over this modern spirit of philosophy. Hypothesis—in many cases an admirable minister to the discovery of truth—is often stretched too far, and into regions inaccessible to human research. The interlopers and dabblers in science—those who, to take Lord Bacon's words, 'will not wait the harvest, but attempt to mow the moss and reap the green corn'—are most at fault here; but these are many and active in their generation. The phraseology of true science is easily caught up and easily misapplied; and the genuine coin becomes discredited by the base. This evil partially remedies itself through the wonted incongruity of all such naked hypotheses. In physics nothing that is unproved can ever find permanent place.

On this general topic, however, we must carry our remarks a step farther. That truth is the sole legitimate object of human enquiry is easily and familiarly said; but in seeking for truth it is useful, and even needful, to recognise in the outset that there are things which man *troweth* not—things which, though *realities* in themselves, cannot be compassed by thought, and lie, therefore, beyond the scope of human research. In every enquiry we are bound to regard primarily what has been done, and what yet remains to be done. But also it is well to know and ever hold in mind the existence of these *unknowable realities*—a caution happily expressed by Malebranche, the most eminent disciple of Descartes: 'Il est bon de comprendre clairement qu'il y a des choses qui sont absolument incompréhensibles.' It is into their unfathomable depths that the metaphysical mind loves to dive; bringing back little more than a new coinage of words and phrases, more fitted to entangle and delude the understanding than to enlighten it. Speculations and reveries of this kind, indeed, are most prone to grow up where science has not yet begun to work by experimental research. The ancient philosophers, Greek and Roman, entertained them as a sort of intellectual luxury; those of mediæval time as a cloister occupation and refuge from the barbarism surrounding them. Even the most savage races of men cling to such questions, in rude expression of their wonder at those mysterious changes and convulsions of the material world to which they, in common with the philosopher, are unceasingly subjected.

We dwell the rather upon this point because the physical science of our day is marked especially by its close approach to these insoluble questions. Modern discovery, whether dealing with the infinitely great or the infinitesimally small, whether with stars or atoms, has been emboldened by its own success, and presents problems to us for future solution which Swift would have related as the reveries of Laputan philosophy. The Cavendishes and Wollastons of a prior generation, who shrunk back with a certain distrust and alarm even from their own discoveries, are now nowhere to be found. It may be admitted that many of what once appeared insuperable barriers have been removed, and that it is frequently as rash in science to impose limits as to seek to penetrate beyond them. Yet the few single words, Space, Time, Matter, Force, Motion, and Life, bring us into direct contact with problems which, though based on innumerable phenomena, forming the totality of our physical knowledge, leave reason utterly at fault. Take, for instance, the old question regarding that very Matter itself, which we are now so boldly handling, through the properties of its ultimate atoms and molecules. Is it actually created by the same Supreme Power which formed it into worlds and living existences? Or is it in itself eternal—the primitive material with which the Creator has thus wonderfully worked in evoking all that we see in the universe around us? It is obvious that reason is vainly spent in seeking to encounter a question where, *though one of the alternatives must necessarily be true*, no proof or argument can possibly be brought to determine which is so.

The same with regard to the Infinite, whether of space, time, or number. The mathematician may give technical expression to it, in certain forms to which his science conducts him, and the metaphysician may revel in the very vagueness of the conceptions it conveys; but it is a word unreal to all thought, and philosophy is bound to be sparing in the use of it. It might be well, too, were theology, in dealing with these terms of Infinity and Eternity, more thoughtful and forbearing on the doctrines and denunciations to which it applies them. Eternity has been well described as 'a negative idea clothed with a positive name.' Conceptions so vast are, in fact, only described by negative terms—the endless, the incomprehensible. We are all more or less enslaved by words; but it is the proper business, equally of religion and philosophy, to throw off this thraldom, when truth, as often happens, is fettered or distorted by it.

We have just named Matter, Force, Motion, and Life, as terms which in their most general sense give foundation to all science, and at the same time express its most profound and perplexing problems. The word Force especially, known to us through its relation to matter and motion in space, taxes the thought by a sort of harsh compulsion of use. It is a term too variously familiar in common life to be thus largely appropriated by science. No present definition has rescued it, in this higher sense, from a certain metaphysical obscurity of meaning. We know force as a reality only by what we term its effects; and we *pluralise* the word in speaking of the several forces manifested in the phenomena of the natural world—while at the same time finding, in these very phenomena, a correlation, by interchanges of material effects, so exactly equivalent that nothing which we can term force or power is lost in the translation. In this latter fact—one of the greatest discoveries of modern science—we gain a certain unity for the problem, in the conception of a single Power which, indestructible in itself, acts in different modes and degrees throughout the material universe—the source of all motion and change in the greatest and in the most minute phenomena of nature. But this at best is a cloudy conception, insusceptible of any direct proof, and incapable of being moulded into a definition. The abstract idea looms before us, but escapes before we can grasp it.

Nor can we shelter our ignorance under any of the various terms used by philosophers to designate this power—*δυνάμεις*, *ἐνέργεια*, vis viva, vis mortua, dynamic energy, potential energy, 'lebendige Kräfte,' or whatever else the diversities or impotence of language have suggested. These phrases, even were they congruous, do little more than repeat the problem in new words. We are still dealing with what is unperceived by any of our senses—itself, for aught we can tell, immaterial—and known only as the cause of sensible changes in the matter around us. Nor do we gain much here by seeking, as some have done, to conceive of force as a mere expression of the intestine changes which matter itself, in its atomical parts, is ever undergoing, and which are in perpetual translation and interchange from one material form to another. This is shifting the difficulty without solving it. Whence come these motions and innumerable interchanges in matter? What is the power initiating and propagating them? To say that it is one inherent in matter itself thickens rather than dispels the darkness. M. Laugel enters into these questions, and we give the following passage as a good example of his style:—

'La force est ce qu'il y a de plus mystérieux dans la nature. Elle est dans la substance et n'est pas la substance; ou plutôt la substance étant perpétuellement active et passive, en tant que passive elle subit l'action de la force, en tant qu'active elle devient force à son tour. Car il ne faut point imaginer la force comme quelque chose d'extérieur à la matière ordinaire, comme une entité d'une espèce particulière qui se mêlerait aux corps, y entrerait, en sortirait, au gré des circonstances. Avant qu'on eût bien compris le caractère de l'universalité de la *force*, telle était l'idée qu'on se faisait des forces particulières. On parlait du fluide électrique, du calorique, de la gravité, comme d'essences réelles, sur-ajoutées en quelque sorte à la matière. Le langage de la physique n'est pas encore débarrassé de ces locutions vicieuses.'

M. Laugel here and elsewhere shows the intrinsic difficulties of the subject, but provides no new or feasible way out of them. The science of our day has instructed us largely, though yet imperfectly, in the atomic and molecular properties of matter; and in those multiform changes by addition, subtraction, and substitution on which chemistry, as a special branch of knowledge, is founded. But it tells nothing of that secret *motive cause* on which these changes depend, and by which they are translated from one portion of matter to another, under exact equivalents of power and effect.

It is not surprising that this problem of force, as grand as obscure, presenting itself in naked form even to the rudest intelligence, should have been seized upon with avidity in all ages. Some of the questions just denoted struck the ancient philosophers as they do us, and were answered with even greater audacity, from the absence of those checks which inductive science imposes. The terms *τὸ πάσχον* and *τὸ ποιοῦν* briefly express the relation of matter and force in the Greek philosophy. Cicero and Seneca both denote the points in question clearly and compendiously. The science of our own time, though it illustrates these relations in a thousand ways unknown before—though it may be said to have added a new element of power to those already known, and by gigantic efforts of human genius to have converted all to the practical uses of man—yet, as regards the internal nature of matter and force severally, has scarcely carried our knowledge beyond that of our predecessors. Motion and change show us the results of their relation, and with these science has its dealings, leaving still open the cardinal question, What is Matter? What is Force? Some philosophers, as we have seen, standing on the brink of these profound problems, merge all matter in centres and lines of force; others see force only in the conditions and changes of matter itself. We have half-a-dozen books and papers lying before us in which this question is handled, under various conceptions of the points in dispute. And many others are announced as about to appear.

In the recent multiplicity of these writings on force, as an element in the natural world, we find justification for thus discussing the subject. The ambiguities besetting the term in its various relations have been rather multiplied than lessened by conflicting championship. Even in the case of heat as a force this comment has its application. This great power, so essential to life and all existence on earth, is now deemed to be a mode of motion of matter itself; and its variations to depend on interchanges of such atomic motions, tending to equalise their degree, or cause their conversion into mechanical or other kinds of force. The main fountain of heat to us, as well as of light, is the sun. This great body projects, through the ether of intervening space, waves or impulses so variously and wonderfully propertied as to produce, on reaching the earth, those several effects of light, heat, and chemical action of which the solar spectrum is the simple but sublime interpreter. To the sun, then, we must look for that astonishing initial force, whatever it be, which from age to age combines and emits those complex undulations of which heat and light are the exponents to us on earth, while they alike pervade every part of the solar system. We may admit that heat, as expressed by temperature in the grosser forms of matter, is simply due to intestine movements of their particles; but we cannot exclude the sun as the present primary source of that power which these motions distribute and equalise. The discoveries of Tyndall show by what subtle molecular adjustments the heat thus received is prevented from freely radiating back into space. The question whether the sun loses by this unceasing emission of power—for we are not authorised to call it *substance*—and how this loss, if real, is repaired, have been subjected to various recent hypotheses, but without any certain or even plausible conclusion. If, indeed, the notion of necessary repair be admitted, we are called upon to provide for more than two million times the amount which the sun transmits to the earth, such being the relative proportion of this power lost—if lost—by projection into circumambient space.

Latent heat, again—or what we are called upon to regard as synonymous, *latent force* or potential energy—is among the conceptions which modern science has embodied in its doctrines; a difficult conception, indeed, but based on the apparent phenomena of bodies passing successively through the solid, fluid, and gaseous states. Even if Dr. Andrews' recent discoveries did not throw doubt on the interpretation of these phenomena, we should still have to ask, What is this latent force of heat? The name implies an existing reality. In what does this reality consist? Theory can only answer, in some interior specific condition or arrangement of atoms, lasting until excited to fresh change. But see how much obscurity hangs over all this, when closely analysed! How much obscurity, too, in that general conception of *potential force or energy* stored up in matter, which furnishes so many startling illustrations to the scientific teaching of the day. It is deemed possible to say that Heat and Light, as forces or active powers, absorbed originally from the sun by vegetable life on the earth, and following the conversion of the latter into coal, have thus lain dormant for untold ages in a mineral form, to be finally extricated in the fires and furnaces of our own time. We cannot disprove this, or bring other hypotheses to meet the facts. But when we speak of heat as a force, consisting integrally in certain atomic motions of bodies, which force may be pent up for ages in these atomic recesses, yet ever ready for extrication, we are bound to look fairly at the abstract conceptions these things involve, if indeed they can be truly understood in any other way than as simply expressing phenomena. The word Force, with all the adjuncts imposed upon it, still looms before us, as a mysterious symbol, rather than an intelligible reality.

We have been led to dwell long on this subject from feeling that the conception of Force—the very backbone, we may call it, of physical science—has been grievously disjointed by the various and vague use made of the term. Whether any word or phrase could be devised giving more unity to the idea, and to the phenomena it embodies, may be doubtful. We do not ourselves venture to suggest one. The radical difficulty lies in the mysteries of nature itself, which we have not sufficiently penetrated to draw this unity from their depths. Such difficulty becomes more manifest as we pursue the subject into other of its ramifications. If we do so here, it is less for the purpose of exposing the deficiencies of our knowledge than to show what science has done, or is yet seeking to do, in the several cases where Force is brought in as the exponent of phenomena.

We pass over mechanical forces, though to these also some of the foregoing remarks will apply. Coming to gravitation, we are on smoother ground as regards the sequence of facts and the phraseology expressing them, though still ignorant of the intimate nature of this great power of the universe. Unlike other forces in the sublime simplicity of its laws, this very simplicity becomes a bar to research. The legacy of ignorance which Newton left behind him, declaring, with the wonted candour of genius, that he did so, has descended to his successors in the enquiry, who must, in their turn, bequeath it to posterity. Several mathematicians and experimentalists of our own time—Faraday among the latter—have adventured on the research, with the especial object of bringing Gravity into some direct relation with the other forms of force, but hitherto in vain. And we are compelled still to abide in the simple view of Gravity as a force incorporate in matter itself throughout the universe, and under every shape which matter can assume, in our own or other worlds. This itself is a grand conception; but it is a solitary and shapeless grandeur, which we might well desire to exchange for more substantial knowledge.

But while speaking of Gravity, can we rightly exclude from the name or conception of Force those *repulsions* which we recognise in the material world; most obviously in atomic actions and changes, and in electric and magnetic phenomena; but also, as we have some reason to suppose, in cosmical changes beyond the limits of our globe? Boscovich admitted such repulsions as a part of his theory of forces, and some modern physicists (we pray for a happier word denoting them) have adopted the same view. But it is a point less regarded generally than it ought to be by those who think or write on this subject. Other modes of action, again, we designate by the one short word the use or abuse of which we are now considering. Centrifugal force, though recognised only as an antagonism, yet has a special reality as such. The force of cohesion, denoting perhaps only one mode of action of a larger power, must nevertheless be admitted into use as the exponent of very important natural phenomena, which we cannot otherwise illustrate than by this or other equivalent terms. To treat fully, indeed, of all that may be attributed to the atomic and molecular forces of matter would be to fill a volume with facts, theories, and conjectures. The phenomena of crystallisation alone, seen under the microscope, and duly appreciated in all their bearings, bring before us a marvellous exemplification of these occult forces and actions in the atomic world.

There yet remain certain powers in the world of creation which, whatever their affinities to those already named, require to be regarded apart, viz., the Vital Forces, and the Force of Volition. In the first of these terms we indicate that mysterious agency which gives form, function, and hereditary succession to all living organisations of the earth, affording to science problems of supreme interest and supreme difficulty. The notion of a *vital principle* has been rejected by many physiologists as unproved and needless. But here, again, it is the old conflict of words. That there is some power or force, call it what we will, working upon matter as its subject or instrument in the creation and maintenance of the various forms of life, and that this power, however connected, has its own special character, cannot be denied without casting off at once all that our senses as well as reason teach us. The simple fact of the transmission of hereditary likeness through successive generations is in itself a volume of argument on the subject. To say that a *nisus*, or force or forces, inherent in matter itself, can create a series of living beings of definite forms and most complex functions, is either a naked assertion without proof or a virtual admission of vital force under another form of words. The generation of life from life is, and probably ever will be, one of the insoluble mysteries of philosophy. If asked what this vital force is, we may answer by the counter-questions —What is gravitation? What that force which puts the ether of space into those marvellous motions which we receive as light and heat? These problems are all of the same kind, involving questions with which no present reasoning or conception can cope.

We come, lastly, to a power closely associated with those by which life is engendered, viz., the Force of Volition, of the Will, an entity not less real in its action on matter than any of those other unseen powers with which we have been dealing. If, indeed, we phrase the whole question as involving the origin of force, there is none so direct and explicit in the relation of antecedents and effects. And there is none of which we have so clear a knowledge through the consciousness of our own powers. Man feels that he has a will; he knows that his physical and moral forces are governed by it; and he concludes that the operation of forces not directed by an intelligent will would lead to the return of chaos. We *will* a certain bodily action, and the action instantly follows, as mechanical in its effects as the fall of a heavy body or the stroke of the steam-hammer. Whatever definition of force be adopted, this comes integrally under it, though the question as to its nature and origin be still wholly unresolved.[1]

If we have pursued this subject of Force to the weariness of our readers, we must seek excuse from the large part these questions are made to play in the science as well as speculation of our time, and from the frequent confusion introduced by the vague or incongruous use of the word itself. We do not profess to have done more than simply indicate what is yet wanting to our consistent comprehension of the idea. Human reason is perhaps incompetent to grasp in its entirety this great problem of force; but a patient research into, and strict analysis of, phenomena may give us nearer approach to that unity of power which we have cause to consider the ultimate truth. There is little chance of entering *per saltum* into these secret places of nature. And the fine saying of Pascal may profitably be remembered: 'L'univers nous écrase. C'est le privilége de l'homme de savoir qu'il est écrasé.'

From the forces moving matter to the matter moved —a step downwards, it might seem, but which is in effect a descent from the clouds to the *terra firma* of

[1] An admirable paper by Sir J. Herschel, on the 'Origin of Force,' may most profitably be studied in reference to this point, as to all others connected with the general problem.

physical science. We might, indeed, plunge into mysteries here also, if seeking for a definition of Matter in the abstract, and that relation of its existence to the percipient mind which has been the metaphysical wrangle of ages. When Mr. Mill somewhere defines it as the 'permanent possibility of sensation,' we see, though dimly, what he means, but gain nothing by the definition. Fortunately, experimental science is seldom led far astray by the vague phrases of philosophy.

It regards matter in a real sense, as made up of parts or atoms of inconceivable minuteness and mobility—each atom, whatever its elementary nature, having its individual properties and relations to others, whether similar or dissimilar in kind—which properties and relations, brought into action by what we call forces, from within or without, give origin to all the motions, changes, and endless combinations and forms, living and lifeless, which we see around us. In saying this, we are denoting what is the true foundation of Chemistry—that great science which, while embracing some of the most important objects of human research, practical as well as purely scientific, is now so closely blended by correlation with other sciences that all limit is lost, even to a definition. The phenomena of electricity—those of light and heat in their innumerable aspects—animal and vegetable physiology—even astronomy and the mechanical sciences, and, yet more, all the practical arts, are thus interwoven with chemistry—a union continually advancing with the advance of knowledge; as must of necessity be the case in a science based on the elementary parts and motions of matter, and thus related to the forces on which these motions depend. The word Chemistry, feeble and partial as originally applied, now appropriates to itself a vast space in the domain of human knowledge.

We have stated our design of briefly illustrating in this article some of the more marked characteristics and attainments of recent science. Before dilating on that branch of it which thus deals with matter through its infinitesimal parts, we might invite the notice of our readers to that loftier study which has for its province the heavens and their numberless worlds. The progress of astronomy during the last few years has not been less rapid than that of the other sciences, with some of which it has become united by new and unexpected relations. To the most remarkable of these we shall have occasion immediately to refer, though with another object. But the discoveries due to spectrum analysis, the greatest astronomical achievements of our time, have been so fully described in a late number of this Review, that we may best avoid repetition by hastening to another subject, though loth to quit one replete with grandeur in itself, and exemplifying so wonderfully the genius and intellectual prowess of man in his higher grades of cultivation.

We revert, then, to Chemistry, the objects of which as a science and its rapid and various progress we have just denoted. Our further notice, however, must be limited to a few only of the attainments of recent years. A large proportion of these may be said to belong to, or to come in illustration of, the atomic theory, of which the two great processes of analysis and synthesis, in their most general sense, are at once the exponents and instruments. To this atomic theory we shall have occasion to allude again. Meanwhile we must treat of it here as practically the foundation of modern chemistry, of its researches, doctrines, and nomenclature. In its origin a rude and unformed bequest of ancient philosophy, it is now fashioned and perfected into a system to which the attributes of number, weight, and proportion give a character of proof next to mathematical in kind. The power of predicting results, and obtaining them after prediction, is the high prerogative of the chemist of our day. He may feel justly proud of those tables which, in the synthetical exactness of their series, even when most complex, express at once the certainty of the facts and the subtlety of the processes by which they were obtained. The gaps in these series have been gradually filled up, in accordance with the laws of numerical proportion, which determine the relations of atoms in their simplest form. The secondary relations of compound atoms, or *molecules*, as they are distinctively called, show the same fixity of combination according to atomic weights; even the most complex union of compound bodies ever taking place in multiples of the combining proportions. The curious facts regarding chemical equivalents, or the substitution of one elementary body for another in a given compound, all attest the same law of definite proportions; which, even apart from experiment, might be presumed a necessary consequence and corollary to the atomic theory. Securely aided by this theory, the chemist penetrates deeply into the intimate constitution of matter; and bringing this knowledge into practice, is able, by chemical processes, to extricate the most brilliant dyes from common coal-tar; and to derive from the nauseous dregs of distillation various compounds gifted with fruit odours fragrant enough to serve for the most delicate confectionery.

These topics, however, involve too many details to allow of our following them farther. But having named analysis and synthesis, the terms which summarily denote the processes nature employs, or man devises, to bring about the changes in question, we will briefly advert to the new channels, as they may fitly be called, which have recently been opened out to analytic chemistry. A new method of research may well take rank among the highest discoveries, when, as often happens, it is the prolific parent of them.

The first of these methods is that of the Spectrum Analysis, already abounding, as many of our readers are aware, in wonderful results, though but a dozen years ago the bare suggestion of a few men of genius who looked forward in advance of their time. The discoveries due to it are cosmical in the largest sense. They directly associate chemistry with astronomy, and give us a new knowledge of the sun and fixed stars which it might well seem beyond human compass to attain; but, being attained, becomes the best augury of what may hereafter be reached by similar research. Descending from celestial to earthly analysis, we may affirm it as probable that the four new metals—cæsium, rubidium, thallium, and iridium—would never have become known to man but for those delicate spectrum lines, betokening in each case the presence of some element hitherto unseen by human eye. Nor without this aid should we have learnt that lithium, before deemed one of the rarest of metals, is diffused more universally than almost any other in the organic as well as inorganic matter of our globe; attesting by this diffusion, however infinitesimally minute the quantities concerned, some hidden use in the economy of nature.

From this method again we obtain further evidence, were such necessary, of the inconceivable minuteness of those atoms and molecules of matter which have hitherto been subjected to the grosser processes of chemical analysis. The detection, by its yellow spectrum-line, of less than a millionth part of a grain of sodium in the air, is a striking instance in point; and many equivalent examples might be given. In truth, this very minuteness of the ultimate parts—the *σώματα ἀδιαίρετα*—of matter, as well as their exquisite mobility, if not indeed their *unceasing motion*, are necessary to any conception we can form of the phenomena of the material world. We must not here go aside to plunge into the depths of the atomic theory, otherwise we might add to these postulates that of *determinate figure*—a necessity, as we must regard it, of the functions they perform—the only key to the phenomena of definite proportions, isomorphism, allotropy, and other facts and doctrines embodied in chemical science. Adaptations, perfect and constant such as these phenomena present, can hardly co-exist but with forms equally perfect and permanent. But admitting this, what system of atomic morphology can be constructed to meet all the conditions of the problem? Nearly seventy kinds of matter are still elementary to our knowledge. Are we to suppose different figures of the component atoms of each of these? Or in sight of this difficulty, may we presume that many of them are really compounds of simpler elements, though beyond the reach of discovery as such? or allotropic conditions of the same element, as Dumas conjectures regarding chlorine, iodine, and bromine? Questions still more intricate offer themselves when we come to the molecular compounds of atoms. Here we are almost compelled, on physical conditions, to suppose a variety of configurations as great as the diversity of properties which these molecules exhibit, and which are in no way more curiously exhibited than in their various action on the animal economy. A slight difference in the proportions even of the same ingredients in a compound makes the difference between a food and a poison. Professor Tyndall's experiments on the transmission of radiant heat through gases have already furnished conclusions of great interest to our knowledge of molecular physics. We would willingly look to his labours and genius for further exploration in this field of research.

In close connexion with these questions we must refer to another new method of analysis—the growth, it may be said, of our own time. We allude to the admirable researches of the late Master of the Mint, whose death (following soon after that of a still more illustrious philosopher) we have much cause to deplore. Professor Graham, in devoting his long labours to the illustration of the phenomena of the effusion and diffusion of gases through each other, and through intervening septa of different substances, has done more than any other experimentalist in *materialising* atoms and molecules to our comprehension; by showing their distinctive and relative modes of action, their separation even from what we call chemical combination by other than chemical reactions, and their different capacity and rate of penetration through the porous media used to effect this separation. When we are told that the pores of graphite (one substance employed as a septum) are so minute that a gas cannot pass through in mass, but in molecules only, we obtain a certain relative comprehension of atomic elements, and an index to collateral enquiry in this very interesting branch of physics. Such enquiry cannot fail to be pursued further. In his paper on the molecular mobility of gases Mr. Graham enlarges upon and justifies the belief that continual intestine movement of atoms or molecules is an essential condition of matter in a gaseous state, these movements being different in different gases. This inference, indeed, is almost inevitable from the experiments he has recorded, and serves to interpret other known phenomena, which scarcely admit of being otherwise explained.

Let us here notice in passing that Lucretius, that wonderful poet and the predictor of much that has been proved and amplified by later research, foreshadows in some sort the recent discoveries of Graham and others on the diffusibility and penetrability of different kinds of matter (lib. ii. 288, *et seq.*). His great poem deserves to be read in its relation to more than one of the doctrines of our own day.[1]

We might almost mention among new modes of analysis, were it not that the products evade examination, those beautiful experiments of Tyndall in which he decomposes highly attenuated vaporous compounds by the solar or electric beam, passed through the tubes containing them. The delicate aerial clouds gradually developed in these tubes, while they illustrate the exquisite atomic tenuity of matter, suggest analogies or explanations of other physical phenomena occurring in our atmosphere, as well as remotely in the universe around us.

Before quitting the atomic theory we must briefly notice the remarkable conclusions drawn from the theory of gases by Sir W. Thomson and Clarke Maxwell, as to the minuteness of the molecules composing them—a minuteness of which a hundred-millionth part of a centimetre is but an approximate expression. More recently, again, Sir W. Thomson has denoted what he considers evidence of fixed physical limits to the smallness of atoms and molecules—one very ingeniously derived from the contact electricity of metals —others drawn from the theories of capillary attraction, and from that of gaseous actions; severally affording

[1] Speaking thus of Lucretius, we are tempted to transcribe a few lines we have not seen quoted in reference to the topic, now so much discussed, of the early condition of man, and the order in which he successively fashioned weapons and implements to his use :—

'Arma antiqua, manus, ungues, dentesque fuerunt;
Et Lapides, et item sylvarum fragmina rami.
Posterius Ferri vis est, Ærisque reperta.
Sed prior Æris erat quam Ferri cognitus usus.'

proof that such limits do really exist. These conclusions, though we can in no way contravene them in theory, and though they express what may perhaps be called necessary physical conditions, yet are hardly determinate enough to be recorded as scientific truths. The huge array of figures which modern science so often forces upon us in describing each extremity of the scale of magnitudes in nature—whether of matter, or space or motion—often creates distrust in men, even the most intelligent, not accustomed to physical evidence. The concurrent and co-ordinate nature of this evidence, and the power it so frequently gives of predicting results, furnish all needful reply to scepticism of this kind. That it should exist can hardly create surprise.

A word more we must say of the late Master of the Mint, in reference to the most recent of his researches—that which justified him, as he considered, in placing hydrogen, under the name of Hydrogenium, among the metallic bodies. We have little doubt that he was right in ratifying a suspicion which had before been broached to this effect. The singular resemblance to metallic alloys of the compounds of hydrogen with certain metals, scarcely admits of other conclusion than that this gas, the lightest of all known matter, is itself really the vapour of a very volatile metal! The most striking testimony is that derived from the absorption of hydrogen by palladium—amounting in some cases to nearly 1,000 times the volume of the latter metal—and producing a compound strongly characterised in its properties, as shown both in the results of charging with hydrogen, and in those which attend and follow its exclusion from the alloy.

This discovery, if we may so deem it, has much value, not solely in itself, but also in the collateral suggestions it affords. Familiar as we seem to be with oxygen, there are still certain anomalies regarding this greatest element of the natural world which are awaiting further solution. Such are its allotropic states, and the true theory of ozone. The same may even more especially be said of that other great element, nitrogen, so wonderfully associated with oxygen in the atmosphere of our globe—not chemically, we are told, and yet everywhere, and always present in such exact proportion that it is difficult not to suppose some atomic relation beyond that of mere admixture. But taking nitrogen singly, as an element to our present knowledge, we know few chemical objects better fitted to stimulate and reward research. Considered in its simplest state as a gas, it is chiefly defined by negative qualities; while in its compounds it furnishes some of the most violent agents, explosive and poisonous, which nature or art has produced. These explosive actions are explained by the phrase of *instability of combination* applied to them; but no explanation has yet reached those by which living organisms are affected. The natural relations, indeed, of this element to animal life, both in its structure and functions, are matter of high interest. Nor must we omit those recent discoveries which give to nitrogen a cosmical existence in planetary space, together with hydrogen and the several metals which have yielded their lines to the spectrum. Its relations to hydrogen in the form of ammonia are among the most important in the economy of nature; while the strange alloy produced by the union of ammonia and mercury affords suggestions which may fitly become the basis of future research. Under the same view we would notice the singular and exceptional relations of nitrogen to titanium and boron—all these things concurring to furnish motives as well as means for further enquiry.

In dwelling thus long on these parts of chemistry we have little space left to speak of the synthetical branch of the science; though this too has been greatly advanced of late years by the labours of chemists both at home and abroad. The most interesting discoveries here are those which bring the chemistry of organic life into connexion with that of the inorganic world. By processes successful in their subtlety various products have come out from the laboratory identical with those which were before considered exclusively due to the functions of animal or vegetable life. In regarding, however, these and other kindred achievements, we must not view analysis and synthesis as oppugnant or detached methods of research. The processes by which atoms and molecules are rent asunder from their compounds have close relation to those by which they are restored to the same, or to other combinations, often new and unforeseen. They mutually aid and abet each other, illustrating in this that great law of continuity which prevails throughout all nature.

In mentioning this law—first distinctly stated by Leibnitz, but verified and largely amplified since—we may again briefly advert to the recent experiments of Dr. Andrews, annulling the old view that the solid, liquid, and gaseous forms are severally assumed *per saltum*, and proving a continuous and gradual change from one of these states to another, subject to conditions of heat and pressure. These researches we regard as highly important; not solely in relation to the theory of gaseous bodies, but also to the doctrines of heat, and generally to all phenomena in which atomic actions are concerned.

We cannot close this short sketch of the state of chemical science without adverting to one great *hiatus* (*valde deflendus*, we may add) in this great department of knowledge; the want, namely, of some single system of chemistry, which, basing its classification and nomenclature on philosophical theory, may give true relation and congruity to facts now become appalling from their multitude and various interpretation. We have before us at this moment four several volumes, the works of chemists of high and merited eminence, each adopting and carrying into details its own special principles of arrangement and nomenclature. In some cases these differences involve cardinal points of chemical theory. In all cases they are embarrassing to the student; and very especially so in organic chemistry, the newest and most arduous department of the science. Still, we can hardly feel surprise at the deficiency we state, seeing the enormous complexities of the subject; augmenting rather than diminishing with the discoveries successively made and the new objects and methods disclosed. The various problems left only partially solved regarding atoms and molecules—their figure, magnitude, motion, relative weights and affinities—may well explain the difficulty of obtaining one single system, sufficient and permanent. Take the example of what are called 'compound radicals'—particular compounds having fixity enough to act as bases in other combinations. This conception is forced upon us by facts; but these facts admit of being differently construed, and actually are so by different chemists. With all this, we cannot doubt that science, advancing in every direction, will eventually construct some chemical system more simple and complete than any we now possess, though still not reaching that principle of unity and power towards which, as a basis, the aspirations of all scientific men are directed.

From Chemistry we come, by the correlation of numerous phenomena, to Electricity—that wonderful element—scarcely three centuries ago recognised only in the flashes of the thunderstorm, or in the trivial attractive power of amber and a few other bodies—now known to us as one of the great powers of the universe; penetrating and pervading all matter, and present under one form or other in every act of physical change. In no department of science has the research of the present century been more active and successful. The advance of later years, indeed, has consisted not so much in the discovery of new elementary laws, as in the application of those already known.

New modes of evolution, and augmentation of power through induction and the conversion of mechanical into electrical force, furnish notable instances of such progress. And yet more those inventions, admirable alike for their genius and boldness, by which the Electric Telegraph has been spread over the globe, and subjected to man's control even in the uttermost depths of its ocean channel. The relations of Electricity to Magnetism, though the identity of the element of power is proved, have received little further development; and many obscure questions are here awaiting solution from some higher law yet undiscovered. The influence of electricity on the vital functions is still a very unsettled problem, and the conflicting results obtained by experiment impair the evidence which science requires for their adoption.

But the great mystery here, to which all others are subordinate, centres in the simple question, What is Electricity? what the actual nature of the element thus wonderfully propertied, and, as we have reason to believe, fulfilling in other and remote worlds the functions through which we know it in our own? In that general conception of the unity of creation expressed heretofore in the phenomena of light and gravitation, but now enforced upon us by so many new and unexpected evidences, we cannot refuse to admit Electricity as one of those great cosmical agents which combine and control the elements of power and action in the universe at large.

But reason is not to be satisfied with magniloquent phrases. The question comes back upon us, What is

Electricity? It is one which has tried, but vainly, the genius of many philosophers of our time, Faraday among the latest. True genius like his can afford to admit failure, and is ever ready to make the confession. The question still remains unsolved; a problem for the labours—or, it may be, for some felicitous accident—of the future. We have spoken of electricity as an *element*, but this term does nothing more than shelter *elementary* ignorance of its nature. With all our various knowledge of electrical phenomena, the first letters are yet wanting to the alphabet of the science. We speak of positive and negative electricity, of poles and currents, of induction, of quantity and intensity, of electro-magnetic actions, &c., but we still conceive and define these conditions solely by their effects. The question still recurs, What is Electricity?

No step can be made to its answer without facing another question. Is Electricity a *material agent*, special in its endowments as such? Or is it merely a property or condition of matter, deriving its phenomena from the atomic and molecular changes which matter in its many known forms is ever undergoing? To halt before this question is virtually to suspend enquiry. But have we not cogent reason, taking the largest view of the phenomena, for regarding electricity as itself a *material element?* The methods by which we elicit, accumulate, and conduct it, whatever theoretical difficulties they involve, are far better comprehended upon this hypothesis than under the vague view of their depending on atomic actions of the bodies electrically affected. To speak of polar states or chemical changes in the atoms of matter as *constituting* electricity, is but to hide the real difficulty. In electrical actions there is *something evolved*—a power capable of conduction to unlimited distances with equal velocity to that of light. This conduction, as it occurs through wires, bears cogently on the question. The differences of effect produced by the varying material, thickness and length of these conductors, can hardly be reconciled with other views than that of a specific agent, acting in a certain ratio to its quantity and intensity, and capable of being estimated under these relations. The properties of quantity and intensity, and still more the faculty of being *concentrated and accumulated within determinate spaces*, especially characterise electricity, and associate it closely with those conditions which designate matter to our knowledge.

If we admit this, another question at once arises, Can we identify this electric element with any other known agent in the natural world? What we needfully require is some agent *cosmical* in the largest sense of the word, since the electric influence is present, not solely in the atomic and molecular changes of matter, but in regions of space far beyond our sphere. This universality led Faraday to conjecture some direct connexion between the force of gravitation and the electric power; but he failed in finding any experimental proof of this hypothesis, and avowed the failure.

But before hurrying to the theory of a new and special power (a bare assumption, complicating yet more the knotty problem of the elementary forces), we are bound to see whether any natural element, already recognised, will so far answer the conditions required as to be plausible in itself, and not to involve any physical impossibility. Such element we venture to believe may possibly be found in the *ether of space*; and as this hypothesis, though not wholly new to science, has yet been only partially advocated, we must ask to be allowed a few words in its illustration.

Under the provisional name of Ether we recognise in space around us, a *medium* capable of transmitting the direct and reflected waves of light and heat, and itself physically necessary for such transmission. While forced to call this medium *imponderable*, its *materiality* must be inferred from the very nature of the functions it performs. Vast and complex though these be, we cannot limit them to outer space only. We find full evidence from optical and other phenomena that ether interpenetrates and pervades the densest bodies on which it pours its waves. May we not assume the fact generally, that where it comes into contact with our atmosphere and the grosser forms of terrestrial matter, it assumes other conditions and properties than when diffused equably and continuously through space? Reflected and refracted we know its waves to be. May they not also be condensed, accumulated, evolved, conducted in currents, and otherwise modified by the kind of matter thus pervaded, and the changes this undergoes from other causes acting upon it? Without assuming a knowledge we do not possess of the infinitesimal actions of the atoms and molecules of matter, we may at least deem it certain that the agency of ether, impinging upon and penetrating them, cannot be limited to the phenomena expressed by light and heat only; or that its elasticity, tenuity, velocity of wave-motion, &c. remain unaltered, when coming into that close atomic coalescence which all analogy tells us to be the condition of most energetic physical action.

If failing to bring direct proof of the presence of ether in the subtle phenomena, let us see whether electricity may not fairly be invoked as its representative and real substitute. What, in short, is there to forbid the conception that electricity is the ether itself—not existing as when diffused through interplanetary and stellar space, but from its embodiment with terrestrial matter—solid, fluid, or gaseous—quickened into new conditions; acting or acted upon in all atomic changes; and in certain of these extricated in such quantity and manner as to become a power in the hands of man? Can an agent such as we must suppose ether to be lie dormant in the innermost interstices of matter, while the smallest change of condition, even by friction or the simple apposition of different bodies, awakens another power within them into life and energy? Is it probable or possible that two distinct elements should co-exist in the same interstitial spaces, with separate relations to the matter thus environing them? We put these points interrogatively, but they are surely such as may sanction hypothesis, in default of any more absolute answer to the question, 'What is Electricity?'

The velocity of the electric current in its close approximation to that of the ether waves of light may be admitted into the argument for identity. All such facts give proof of the astonishing subtlety and mobility of the element concerned, and of its capacity to assume altered physical aspects when brought into contact with the ponderable forms of matter.

It is not requisite to vindicate this hypothesis in its application to all the phenomena of electricity, when every other theory has failed to interpret them. The problem of the two electricities embraces the most arduous of these questions—departing from all recognised properties of other powers, and still a barrier to the boldest conjecture. But there is nothing here to contradict the view of ether as the agent concerned—nothing certainly to establish the claim of any other element. The difficulty, being equal and alike under any hypothesis, may fairly be eliminated from the argument. And the same may be said of those magnetic relations of electricity, which in the phenomena of diamagnetism and magnetic lines of force, of magneto-crystallic action, and of the direct action of the magnet on electric currents, offer many questions of supreme difficulty, but not more insuperable on the view which identifies the electric element with ether than on any other.

Several other points might be urged on behalf of the hypothesis, had we space for them—such as the meteorological relations of electricity, and the wonderful phenomena exhibited by the crystalline texture in connexion with light and electricity. Still, however, it is obvious that the argument is one of *presumption* only, and from the very nature of its conditions will never probably get beyond this. But we think that it merits to be brought thus far before our readers, both from its intrinsic plausibility and as an example of the great questions which are now currently discussed in the scientific world.

The third of M. Laugel's volumes comes before us entitled 'Problèmes de la Vie,' a title expressing at once the mysteries of the subject, and, to those who have read his preceding volumes, the line of thought and argument he is likely to pursue in dealing with them. Leaning towards materialism, yet not in the same hard and exclusive sense as Virchow, Vogt, and other German writers, he seeks, as far as possible, to bring vital functions within the domain of ordinary physics; and argues, as others have done, against the use or abuse of those terms, 'vital principle,' 'vital force,' 'vital energy,' which have been employed to veil our ignorance of the reality. Refraining from analysis, or any general adoption of his opinions, we think it better to present to our readers a summary view (in sequel to an article many years ago) of what science and speculation are still doing in this ample field of enquiry.

The first of the 'Problems of Life' lies in the question 'What is Life?' It has undergone a dozen definitions; some by eminent authorities, but all liable more or less to objections from error, incompleteness, or obscurity. The problem has pressed upon every age of mankind, and in our own time has been brought into connexion with the latest discoveries of physical science. Still, however, we need a definition which may satisfy all the conditions without becoming valueless from its generality. That given us by Aristotle, though clouded by some terms of Greek philosophy, is as good as any that have succeeded it. The well-known definition of Bichat, 'La vie est l'ensemble des fonctions qui résistent à la mort,' and that of the Encyclopédie, 'La vie est le contraire de la mort,' are too epigrammatically negative to be of any use. They omit, too, that which is the very essence of all life, viz., the faculty of reproducing life, more or less like in kind to itself. No definition can be good which does not include the condition of an organisation capable by sexual or other means of such reproduction.

We think, too, that *Time* should be admitted as one element in the definition sought for. Every form of life, endlessly dissimilar though these be, has its average period and limit of existence, as well as a certain defined chronometry of all its functions. Growth, maturity, final decay, and death belong to living organisation in its every shape on earth.

An eminent philosopher of our own time describes life as 'consisting in the continuous adjustment of internal relations to external relations'—a definition which loses value in its generality. A power of adjustment, indeed, brings us close to that conception of a vital principle, which we have just noticed as one of the vexed questions of physiology. We alluded to it cursorily when speaking of the vital forces, but must add a few words here, to denote more explicitly what we think to be the true conclusion on the matter. We cannot assert on actual proof that life is engendered by, or engenders, any power or force peculiar to itself. Nevertheless in recognising, which we must do, that there is some definite mode of action in living bodies, giving to them forms and properties unknown elsewhere in nature, and transforming known forces so as to appropriate them to the peculiar functions of life, we virtually admit a special and characteristic power, call it what we will. The facts connected with generation and those of hereditary resemblance are alone sufficient to point to some cause, physical it may be, but not known to us by actual identity or analogy with any other physical power.

Whence but from some such cause—occult to us—can it be that a single germ or germs, proteine or protoplasm (the names here signify little) should evolve by gradual accretion of matter the likeness of an anterior being, even in minute peculiarities of form and feature, these same peculiarities, morbid as well as natural, often recurring after one or two generations have been interposed?[1] The animal economy throughout, in its instincts as well as structure, enforces the same conclusion—a negative one, it may be called, but it is better to rest in this than to attempt a blind and useless definition. All that can be said is, that there *exists something* we do not comprehend. The controversy now going on will continue, because we possess no *crucial* proof or argument to close it. In this it is like many other questions similarly contested.

[1] This problem, if it could be solved, would carry us far deeper into the *arcana* of creation than any other attainment of science. Mr. Darwin, feeling this fully, has in his last work modestly but very ingeniously encountered the question by an hypothesis, which, if unproved, and in its nature incapable of proof, is at least as probable as any that can be devised. His chapter, entitled Pangenesis, deserves to be studied, if but to call attention to what we may term the *necessities* of the problem.

In what, and how, and when, did life begin on our globe? In its lowest aspects, whether animal or vegetable, we see nothing more than a few material elements, aggregated under the simplest forms; with few organic functions, yet these such in kind as to preserve existence for a certain time—to provide for a succession of similar existences—and this fulfilled, to expire. From these simple conditions (taking animal life as best for illustration) we find a series rising upwards to forms and functions the most complex and complete. In no part of this ascending scale is there any wide gap; what in many cases seemed such having been, partially at least, filled up by recent discovery in the living or the fossil world. However this series may have begun, and whether it has been worked out by derivation or evolution within itself, or by successive acts of creative power, equally must we affirm the unity of the whole, and the necessity of a First and Supreme designing Cause. If the endless forms, functions, and instincts of life which surround us be derived by progressive changes in unmeasured time from a few primitive types of being, such changes bespeak certain vital laws acting on matter through and concurrently with the other great forces of the natural world. Under any and every view of the subject, intention by a higher Power, however obscure to man as the interpreter, is manifest as the foundation of the whole—the sole standing-point to our reason, when regarding the origin, varieties, and perpetuation of animal life on the earth.

This recognised, we are better prepared to meet the several questions which science has suggested or speculation created upon the subject. And the first we encounter here is one of the most momentous; that, namely, which respects 'Spontaneous Generation,' an enquiry bequeathed to us in a vague form from remote antiquity, and recently revived under conditions of very delicate experimental research. The question simply is, Can matter of any kind, under any circumstances, generate life, without the presence of the ova or germs of prior life? Though the enquiry has applied itself only to the lower forms of infusoria, whose motions under the microscope may almost be called a mockery of life, yet it is one of deep interest, whatever the issue; involving, as it does, in connexion with recent doctrines of derivation and development, the whole question of the origin of life on the earth. This interest is testified by the keenness of controversy going on. The careful and refined researches of Pasteur and Pouchet, on opposite sides of the question, in France, have been carried forward by English observers, with not less skill in experiment; yet the contest still goes on, even angrily, as to these units of creation: whether the old doctrine shall be maintained, '*Omne vivum a vivo*,' or whether inorganic matter may not, under certain conditions, assume the lower characters of life?

If called upon to give any judgment where assertions are thus conflicting, and the tests of truth so difficult, it would be in favour of the former of these opinions; while admitting that we have no absolute proof to gainsay the latter. One might well borrow here the phrase of '*De minimis non curat lex*,' for the objects are too small and evanescent to furnish the evidence required for conviction. But the question is still under judgment; and the enquiry, even without any positive issue, will probably disclose collateral secrets in that great volume of nature which is now so diligently explored.

We have no room to speak of those many recent discoveries in zoology and fossil geology illustrating at once the ancient conditions of the earth, and the multitudinous forms of life which have successively existed and been extinguished on its surface. Vast as is now the catalogue of animal species, or what are called such, every year is adding to it. Nothing, indeed, more startles contemplation than the *quantity* of life upon the earth. Around us, above us, below us—air, ocean, lake, river, mountain, plain, and forest—all nature teems with it, from the whale, elephant, buffalo, and eagle down to the monads and vibrios of infusorial life. And in this contemplation we must include the great law of nature which makes animal life, in its every shape and grade, depend for evolution and maintenance upon life already existing—a law strikingly attested even in those parasitic creations now so numerously catalogued as to form a distinct portion of natural science. Death is the transmigration, not of *being*, but of the materials of *being*, into new forms and modes of existence. And connected with this law we are called upon to recognise another fact in the general scheme of creation, viz., the obvious and constant provision for the maintenance of succession, even at the expense of individual lives. Among the insects it is common to find those propagating life perish as soon as this function is fulfilled. We cannot explain these things, but must admit their reality.

Still less can we with our reason confront another problem of much deeper interest—viz., the relation of man to the other forms of animal creation peopling the earth. Surrounded on every side by living beings — using them, consciously or unconsciously, as food, and even inhaling them with every breath—this question inevitably and closely presses upon human thought. In one point (and that the very important doctrine of *derivation*) it comes into contact with the Darwinian theory, and carries much of present and future controversy with it in this connexion. But there are other and less equivocal modes of viewing the relation of Man to other animals. The simplest is that which regards him as the head of the living creation—the latest probably, certainly the loftiest—in that long series of existences which we follow downwards till animal life is lost in the lower organisms of the vegetable world. But this is a feeble outline of all that the question involves. Within the series just denoted lie whole volumes of facts, inviting or almost compelling research. The careless thinker may let his reason go to sleep on this admitted human supremacy. The philosopher, looking on the dog crouched at his feet, sees in him an animal with organisation variously akin to his own, and some senses even more perfect—with intelligence, memory, feelings, and passions of the same kind, however differing in degree and manner of use—with appetites and necessities of life similar also, though more in subordination to instincts and hereditary habits of the species. The idle spectator gazes on the anthropoid ape with mere merriment at this mockery of human form and gesture—*μιμήματα τῆς ἀνθρωπίνης ζωῆς*—as Aristotle calls it. The man of deeper thought cannot stand in face of these creatures without a certain feeling of awe, in the contemplation of that mysterious scheme which has brought them thus near to himself in the scale of being.

Pascal says, 'Il est dangereux de trop faire voir à l'homme combien il est égal aux bêtes sans lui montrer sa grandeur. Il est encore dangereux de lui trop faire voir sa grandeur sans sa bassesse.' The caution is chiefly needed for philosophers, since to mankind at large familiarity disguises this great wonder of the world of life. How few fairly accost the question, 'Whence and why this astonishing profusion and variety of animal existence, not solely that now under our eyes, but what has been entombed during uncounted ages in the rocks beneath our feet?' It cannot for a moment be contended that the great scheme of creation had Man solely in view. These innumerable vestiges of life, at periods far antecedent to his own time on earth, might alone suffice to disprove this. Equally is it negatived by our knowledge of existing life. It would not be too much to affirm, were such vague affirmation worth having, that not one-hundredth part of the animal creation, counted by species, has any direct relation or ministry to Man. He is at the summit of the series, and in his highest cultivation far above the summit; but still he is a member of this series, and to be regarded as such.

We here approach a very interesting relation of Man to the inferior animals, one involving the whole question of reason and instinct, and beset with difficulties not easy to overcome. Broadly speaking, indeed, we may assert, that in the whole scale of being, from Man downwards, these two faculties are found in inverse ratio to one another. But in reality it is often wholly impossible to separate them. They co-exist, and are in such way blended together that each has power to modify or contravene the other. It is difficult to gauge exactly in other animals faculties and functions which we find it hard enough to define in ourselves; and it is only by taking the most characteristic cases of reason and instinct in animals that we can rightly discriminate between them. Yet the distinction is a momentous one, and especially interesting in relation to Man as the intellectual ruler of the earth.

Had we space for it much might be said regarding that faculty of reason among the higher animals, both wild and domesticated, to which we have already slightly alluded. Its existence is familiarly recognised in the phrases habitually applied to them; yet this very familiarity enfeebles, as in so many other cases, that sentiment of wonder which the fact might well inspire. Of their reasoning faculty no happier definition can be given than that of Cuvier: 'Leur intelligence exécute des opérations du même genre.' Milton says in more guarded phrase, 'They reason not contemptibly.' Locke, while conceding reason, denied to them the power of forming 'abstract or general ideas.' Taking the simplest view, we may affirm with Cuvier, that the *kind* of reason is virtually the same, however narrow in its scope and combinations. The mute syllogism of the monkey, or the dog, or elephant, is perfect as far as it goes, and might be translated into speech or writing.[1] It is less easy to speak of *reflection* as a part of their intelligence, and yet this term cannot well be excluded. That they possess and largely employ the memory of objects and events is indisputable, but we have not equal proof as to that more intellectual faculty of recollection — the *μνήμη συνθετική* — to which the mind of Man owes so much of its power and attainments. Another question occurs as to their power of forecasting the future. An old English writer speaks of 'the boon to animals that they are nescient of evils to come.' Partially this may be true even as to the highest; but we cannot deny them the simple faculty of anticipating events near at hand, and which come into sequence with others of wonted occurrence. To these intellectual faculties we may add one more, in the '*sense of humour*,' so conspicuous in many animals, though not duly noticed in the inference it affords. The gambols and sly artifices of monkeys well depicture the sports and tricks of human childhood. The dog, toying with his master or gambolling with other dogs, evinces his feeling of fun as plainly as if it were put into words. And reflection will show how much lies beneath this single and simple fact.

[1] Cicero, indeed, speaks of the '*mens, ratio et memoria*' of the ant, qualities which, in this case, as in the bee, we now ascribe to instinct, though not without a certain hesitation where to draw the line.

As respects the passions and affections of the animals thus near to our confines, we must regard them as alike in kind to those which compose the moral nature of man, though very different in objects, and wanting the nice shades of human character in its various grades of cultivation. Without running into subtle distinctions of name or nature, it is enough to recite simply the common qualities open to all observation. Such are love and hatred, emulation and jealousy, anger and revenge, gratitude, boldness and fortitude, pride, and perhaps vanity, cowardice, and cunning. These qualities are not defined by difference of species only. As in man they characterise individuals of the same species, and are innate, more or less, in the temperament of each.

It does not concern us here to trace these animal faculties and feelings downwards in the scale till they vanish in the bare instincts of existence. On this subject of instincts, however, a few words must be said, though volumes would be needed to embrace their wonderful history. M. Laugel's title 'Problèmes de la Vie' well characterises phenomena which perplexed the mind of Newton, and continue to embarrass the philosophers of our own day. We have already spoken of the affinities of reason and instinct. There is, in fact, a *border-land*, where they are strangely and inextricably blended, each invading the domain of the other, and reciprocally producing changes, which variously affect the functions of both. Acts primarily of reason and volition pass by repetition into habits having the compulsory force of instinct, and often transmissible to offspring; while instincts, forcibly interfered with, often evolve new faculties of action, which, if we shrink from calling them acts of reason, can only be understood as newly-developed forms of instinct—a difficult conception, indeed, in seeking to realise which we plunge at once into the inner mysteries of the question. What is the power at work in the purely instinctive acts of animal life?—in the instincts, for example, of the bee, the ant, the spider, the salmon, the beaver, the tailor and weaver birds, and endless others? The instances most familiar to us represent in effect the marvel of the whole, and put the question of origin into its most cogent shape. Newton found no other solution than that the Author of life is himself the *moving power* in the innumerable forms of instinct—risking in this the charge of pantheism, that barrier at which so many attempts to reach what is unreachable come to an end.

We cannot err, however, in regarding life, and the generation of life from life, as integral parts of the same great problem. Instincts, define or distinguish them as we will, are strictly appurtenances of generation—of that power which transmits hereditary likeness from one generation of a species to another. The question whether, and how far, they are dependent on mere bodily organisation, merges in this, though we can hardly say that it thereby comes nearer to any sure solution. That many instincts have a special organisation adapted to them is too well known to need illustration; and it is equally certain that changes in organs, arising from external causes, may, and often do, produce modifications of the natural instincts, and render them hereditary in the race or species. But the fact still remains that there are numerous and extraordinary instincts which can in nowise be interpreted by organisation, though this is used for their fulfilment. The structural peculiarities of certain birds and fishes are necessary for their periodical migrations by land and sea. But the act of migration itself is the marvel; determinate as to place, time, and method—guided by no sense or reason we can define or conceive, yet fulfilling purposes with a certitude no reason could attain. Instincts prospective in their nature, as we admire them in the nests of birds—the sexual instincts and those connected with food, appetencies essential to life on the earth—the instincts of the bee-hive and ant-hill, which sacrifice the interests of the individual creature to those of the community—these and endless others come under the same head, as acts not due to reason nor to any apparent structure.

We are still, then, confronted by the profound problem of a power acting in and through the complex fabric of animal life, of which neither our senses nor reason can render any account. In connecting it with the larger problem of the generation of life from life, we suggest an absolute and necessary relation, but do not solve the mystery. Science is zealously working in this direction, but, as we believe, with an insuperable barrier at some point in its progress. We have spoken of a *border-land* between reason and instinct, where these two faculties variously and curiously commingle. It is here, if anywhere, that we may hope to obtain some enlargement and clearer definition of our knowledge. Little is gained by multiplying examples of individual instincts, wonderful though these be, and meriting a better classification than any yet adopted. What we need and desire is some great work, founded on actual research, but treating the subject also as one of general philosophy, and holding in view certain definite questions for solution. Such are the relation as to priority or causality between the organisation and the particular instincts of species—all that concerns the hereditary nature of instincts—their dependence on habits and the casual conditions of life, including here the separation of species into races—and the influence upon them of reason and the will. These questions, were there no others, present ample material for future enquiry. Time, as well as combined and zealous research, will be needed even for their partial solution. But we confidently hope for some such work as that we have indicated, giving us closer approach to that mysterious part of life where mental and material functions, intelligence and instincts, are linked together, either in co-operation or conflict. One result of all research must be deemed certain—the recognition of an Almighty Power far above our comprehension in its nature and attributes, but ruling throughout all creation, living and lifeless, by laws and forces which we may partially but never can wholly understand. 'I had rather believe,' said Lord Bacon, 'all the fables in the Legend, and the Talmud, and the Alcoran, than that this universal frame is without a mind.' To which Archbishop Whately adds, in his note upon the passage: 'That the possession of power, strictly so called, by physical causes, is not conceivable, or their capacity to maintain, any more than to produce at first, the system of the universe, whose combined existence, as well as its origin, seems to depend on the continued operations of the great Creator.'

Those who are familiar with the doctrine of Mr. Darwin as to the origin of species—a doctrine now so largely, though not unanimously, accepted in the scientific world—will at once see how closely it is interwoven in every part with the topics we have been discussing. The questions of origin, organisation, modes of reproduction and instincts, enter integrally and necessarily into any theory of which life is the subject. The naturalist is amply justified in seeking all possible evidence as to the progressive evolution of genera and species, and their distribution over the earth; and here Mr. Darwin has rendered services to science which will be fully recognised hereafter, whatever exception be taken to some of the views he has espoused. But these fundamental questions still remain, and our knowledge can never be complete as long as they are unresolved.

In the foregoing article, which we must here close, we have sought to make our readers acquainted with the principal questions and objects of research on which physical science is at this time engaged; necessarily, however, omitting many which might well merit notice. At no period has there been more of grandeur in these objects, or more of genius directed to their investigation. If sometimes this genius rushes beyond human bounds into the inscrutable mysteries of the universe, it is speedily checked by the sterner demand now made for evidence of fact and truth; while even these forays, as they may be called, of speculative science (in one of which we have ourselves partially indulged), though failing to attain their purpose, are not unfrequently useful in disclosing new paths and objects of pursuit collateral to those thus vainly attempted.

MAURY ON SLEEP AND DREAMS.[1]

[Contributed to the 'Edinburgh Review' in 1873.]

We place M. Maury's volume at the head of this article, as one of the most recent and remarkable on the phenomena of Sleep and Dreams. He is among the few authors who have made them the subject of experiment as well as of simple observation. But in reviewing his work we shall have occasion to refer to several others, in which these phenomena are treated of, either especially or as a part of human physiology; many of them works of much intrinsic value, though not, as we think, wholly exhausting the subject. Attention has been somewhat too exclusively given to the physical causes and conditions of sleep, without adequate notice of the wonderful characters which connect it with the other portion of our existence; rendering it, through dreams, an interpreter of many of those complex relations of mind and body which have perplexed philosophy in every age of the world. Sleep and dreams may justly be deemed one of the great mysteries of our nature. Our knowledge of them is far from having reached the realities of a science. Many of the problems, physical and pyschological, they involve are among the most profound in mental philosophy, and

[1] *Le Sommeil et les Rêves.* Par L. F. Alfred Maury, Membre de l'Institut. Troisième Edition. Paris, 1865.

meet us at the very threshold of the enquiry. And if some of these questions do admit of solution, others are so deeply hidden in the ultimate mystery of the mind itself as to be wholly inscrutable by any means human reason can apply to them.

It may seem strange to many of our readers that we should preface the subject of Sleep and Dreams by phrases thus grave and forbidding in their tenor. Acts so familiar, and periodically habitual in our lives, might be thought of easy interpretation. The sleep of the rocking-cradle, of the bed, of the arm-chair or carriage, witnessed in their ever-recurring routine, would seem to tell all that can or need be known on these subjects. But it is this very familiarity which disguises their nature, and begets indifference to the greatest marvel of our existence. This, indeed, is one of the numerous instances where we look heedlessly upon phenomena become habitual to us, but which, seen as solitary or infrequent events, are the subjects of admiration or terror. We gaze with careless eye on the daily march of the sun through the heavens, on the midnight magnificence of the starry sky. Our wonder and awe are reserved for the comet or the eclipse. We witness the flowing and ebbing of the ocean and river tides at their calculated times, ignorant or indifferent to the fact that these changes express the action of the greatest law of the universe. Travelling by railroad, we look with idle eyes on those thin wire lines, traversing the air beside us, which at the very moment are carrying currents of electricity under human bidding— the instantaneous transmitters of human language and thought. We think and speak, we see and hear, breathe and walk, indifferent as to the nature of these marvellous functions, or how their unceasing work is carried on. And well it is for our happiness, and for the integrity of the functions themselves, that it should be so. The mere act of mental attention to any one of them is enough to alter or disturb its natural action —a fact of supreme importance in human physiology.

All this is eminently true as regards the subject before us. An habitual indifference to the phenomena of sleep is found as much among men of general intelligence as in the mass of the unthinking world. Assembled in the morning round the breakfast-table, we laugh and jest over tales of the dreams of the night; not reflecting that these wild and entangled vagaries—illusions as to persons, time, and place—are part and parcel of that continuous personal identity which at other times manifests itself in acts of reason, discourse, and deliberate functions of the will. We are jesting here upon things which have perplexed the philosophy of all ages. No less a problem than the intimate nature of the human soul is concerned in these phenomena. Where more than a fourth part of life, even in its adult and healthiest stages, is passed in sleeping and dreaming, these functions must be taken as an integral and necessary part of our existence—not less natural than our waking acts, and associated with them by various intermediate phenomena, to which we shall presently allude. These phenomena, indeed, may be said really to maintain that unity of the thinking and conscious being which in other ways they seem so strangely to disturb. A line of rigid demarcation between the states of waking and sleeping might well appear to dissever this unity. But no such line exists; and it may readily be shown, under appeal to individual experience, that these various states endlessly commingle and graduate into each other; thus affording mutual illustration, and, as we believe, a more intimate knowledge of the mysteries of the human mind than can be obtained from any other source.

It would hardly be worth while to preface what we have to say on Sleep and Dreams by citing what ancient writers—philosophers, physicians, and poets—have bequeathed to us on the subject. The phenomena were to them the same as to us—the dream, perhaps, more exciting to the imagination from its connexion with various superstitions of the age. Seeing, indeed, the tendency of their mythology and poetry to deify whatever is wonderful in man or nature, it is not surprising that they should clothe these great functions of life with a personality, vague indeed in kind, but such as to satisfy the popular and poetic feeling of the time. Nor can we wonder that they should have been the subjects of superstitious belief, seeing how variously and strangely these functions are blended with the spiritual part of our nature. Even now, when science imposes so many new checks upon credulity, the inspired dream—the *Ὄναρ ἐκ Διὸς*—has its occasional place among other still less rational beliefs of the world.

Aristotle, whose chapters on Sleep and Dreams rank foremost of all that the ancients have left us on the subject, says on the question of inspiration of dreams, that it is not easy 'either to despise the evidence or to be convinced by it' (*οὔτε καταφρονῆσαι ῥᾴδιον, οὔτε πειθῆναι*). But with his wonted sagacity he indicates the reasons which justify distrust as to a Divine interposition, thus partial and frivolous in its alleged ministrations to man. He sees clearly that the event is often the parent of the prophetic dream, and that in the endless and complex relations of human life it must needfully happen that coincidences often occur without any real relation to the events so associated. These chapters of Aristotle well deserve perusal as evidences of the clear and acute intelligence of this great philosopher. We have acquired more knowledge of the physiology of sleep as a vital function, but in its connexion with dreams are little advanced beyond what he has told us.

Cicero, in his second book, 'De Divinatione,' discusses the question whether there be a divine influence occasionally embodied in dreams still more largely and conclusively. Called upon to confront strong popular superstitions, he meets them fairly and boldly. But beyond this negative conclusion his treatise does little to illustrate the phenomena or philosophy of the functions in question.

While revelling in the beauty of the poetry, ancient and modern, which has found a theme in sleep and dreams—and none more fertile for fancy to work upon—we cannot look for any fresh knowledge from this source. Lucretius, indeed, with his supreme mastery of verse, comprises something of the philosophy of dreams in his grand description of them. From Homer and the Greek dramatists down to Virgil, Ovid, Statius, &c., we have abundant passages finely describing or invoking sleep, but it is the poetry only of the subject. We must not, however, quit this topic without referring to those many striking passages in Shakspeare where the genius of the man revels in the wild, fantastic world of our sleeping existence. He grasped human nature too universally to leave untouched this wonderful part of it. We need but refer to the passages in 'Henry IV.,' 'Richard III.,' 'Romeo and Juliet,' 'Macbeth,' and 'Midsummer Night's Dream,' in proof of what we are saying. The memory of our readers will furnish them with numerous other passages on the subject from English, German, and Italian poets, but none, we think, so abounding in thought and poetry as those of Shakspeare.

We have already stated our reason for taking M. Maury's volume as the text for our article. We learn from his preface that he has zealously devoted himself to the subject for a long series of years, embodying his researches in successive publications, of which this is the latest. These researches comprise certain curious methods of experiment, ingeniously devised, and, as far as we know, never systematically used before. We cannot better illustrate these methods than by giving his own words. After speaking of the need of long, continuous, and cautious observation, to obtain any assured results, he adds :—

Je m'observe tantôt dans mon lit, tantôt dans mon fauteuil, au moment où le sommeil me gagne. Je note exactement dans quelles dispositions je me trouvais avant de m'endormir; et je prie la personne qui est près de moi de m'éveiller à des instants plus ou moins éloignés du moment où je me suis assoupi. Réveillé en sursaut, la mémoire du rêve, auquel on m'a soudainement arraché, est encore présenté à mon esprit, dans la fraîcheur même de l'impression. Il m'est alors facile de rapprocher les détails de ce rêve des circonstances où je m'étais placé pour m'endormir. Je consigne sur un cahier ces observations, comme le fait un médecin pour les cas qu'il observe. Et en relisant le répertoire que je me suis ainsi dressé, j'ai saisi entre des rêves qui s'étaient produits à diverses époques de ma vie, des coincidences, des analogies dont la similitude des circonstances qui les avaient provoquées m'ont bien souvent donné la clef.'

M. Maury goes on to state the necessity of having a coadjutor with him in this inquiry, not solely for the purpose here mentioned of being awakened at particular times, but also for the due observation of what may be called the *utterances* of sleep. Sounds made and words spoken by the sleeper, must be recorded in relation to the dreams afterwards remembered. Even simple attitudes and movements of the body, especially such as express agitation, require the same record, and for the same purpose. M. Maury mentions his own habits as to sleep, as being singularly favourable to these methods of observation; and we are well disposed to believe in the results thus obtained. Nevertheless, the chances of error are so great in this land of shadows, that we should be glad to find the research taken up by others, with such variations as individual temperament may suggest. It is obvious that the latter point is one of singular importance. The sleep and dreams of one man interpret only partially and doubtfully those of another, and we must check as well as multiply the proofs before setting down anything as certain. In common life, the very nature of a dream gives a sanction to a loose or exaggerated relation of it. No one is disposed to quarrel with the relater for filling up gaps in his dream with the little parentheses needed to complete his story ; or, if a little of the marvellous be brought into the subject—one of those strange coincidences to which the vision of the night contributes its part—we generally find truth more deeply trespassed upon. Stories, vague and loose in their origin, are made more compact by successive additions, and often go on from one generation to another, acquiring a sort of spurious credit from age, and from the impossibility of refuting them by any living evidence.

We come now more directly to the subject before us, embodying, as M. Maury has done, under a single title our consideration of these great acts of life—Sleep and Dreaming. They cannot, in truth, be treated of separately. Their conjunction is so general, if not universal, and they are linked together by such complex ties, that we are almost compelled to view them as a single function of our being. Still there are certain considerations which must be admitted as possible grounds of distinction. We cannot *prove* that the conjunction of sleep and dreams is absolute and universal. There may be times and conditions of sleep, in which there is a total inactivity of brain—a complete absence of those images and trains of thought which form the dream. In connexion with this comes the further consideration, that sleep is a necessity of our nature—a state required for the rest and repair of functions, both bodily and mental, which are incapable of being repaired in any other way. The same cannot be said of dreams. They depend on functions of the brain, which, though unchecked by the senses and the will, and distorted in their mode of action, are yet identical in kind with those which are exercised in evolving the thoughts and emotions of the waking state. The notion of repair and restoration can hardly therefore be associated with the act of dreaming. Frequent experience, moreover, teaches us that what we call 'unrefreshing nights' are attended by troublous dreams; and, though this may often admit of other explanation, yet is the fact significant as regards the distinction just drawn. The repose and restoration obtained from sleep would seem to be in an inverse ratio to the intensity of the dreams attending it.

Is there then any condition or moment of sleep absolutely devoid of dreaming? a state in which all thoughts and emotions, whether connected or vaguely incongruous, are annulled, and our mental or conscious existence lost in the simple physical condition of sleep? The import of this question will readily be understood. The answer might seem easy, but is far from being so. Positive proof is wholly wanting, and the only evidence attainable is that derived from the memory of the dreamer, or the observations of those who watch him during those hours of which he has no remembrance. It is certain from such observation, and indeed from common experience, that dreams are of very frequent occurrence, of which all instant memory is lost. Aristotle, in discussing this very topic, puts the question, why some sleep occurs with dreams, other sleep without? or, if always dreaming, why some dreams are remembered, others not? The question, so propounded, marks the clear intelligence of the philosopher. In the memory or oblivion of dreams we trace their connexion with our physical organisation, and thus gain a step, though a slight one, to the better understanding of their nature.

The doubt just denoted as to the universality of dreams during sleep, has continued to our time. If ever resolved, it must be by some such methods as those adopted by M. Maury. He does not himself, indeed, meet the question in its distinct form, or dwell upon its profound metaphysical relations. Other writers on the subject, among whom we may name Sir William Hamilton, Sir Henry Holland, Drs. Carpenter, Laycock, and Macnish, have severally, in one way or other, encountered this problem. Lord Brougham has grappled with it, amidst the many other questions which exercised his bold and facile pen. He considers dreams an incidental not a constant part of sleep—a sort of fringe edging its borders. Sir W. Hamilton, on the contrary, believes that no condition of sleep exists without dreaming; but all have felt the difficulty of dealing only with incomplete or negative evidence, and the question remains in abeyance for future research or hypothesis to work upon.

Hypothesis and speculation may well indeed be awakened by this particular mystery of our nature. In theory we cannot affirm that a total suspension of the mental functions is more impossible than the actual changes they undergo in dreaming, in the delirium of fever, insanity, intoxication, and other morbid conditions of the brain. The sleep of the newly-born infant cannot be construed otherwise than as a state in which sensorial actions either do not exist, or are limited to some vague recurrence of the simple impressions made on the untutored senses. An ordinary fainting-fit leaves no trace behind of anything having passed during the time of deliquium. To the patient this time is a nullity of his being. It may be that the memory only is annihilated, that the mind never actually ceases in its workings; but this view is little more than a subterfuge to meet a difficulty which we cannot otherwise encounter.

Plunging thus far into the metaphysical perplexities of this question, whether the mind, or sensorial consciousness, is actually *lost* during certain times of sleep, and *recovered*, as far as dreaming can be called recovery, we are bound to notice a doctrine closely connected with this enquiry, to which the name and writings of Dr. Carpenter, Dr. Laycock, and others have justly given authority. This is, the hypothesis of 'unconscious cerebration'—so termed, because it supposes the brain capable, under certain conditions, of acts or changes, utterly *without mental consciousness*, yet strictly analogous to those through which it ministers to mental functions—acts of intellect detached, as it were, from the intellectual personality of our being. This is a bold assumption; but curious cases are produced which might seem to authenticate it. Such are instances where some question left on the mind at bed-time unsolved, has been found in the morning thoroughly worked out. Verses—Latin as well as English—are said to have been made in the night, with no consciousness of the fact till they came to the morning memory. Nevertheless, we must regard the evidence here as insufficient, seeing how commonly such statements are careless or exaggerated; how broken and desultory are the conditions and memories of the night; and how likely it is that the time just antecedent to waking—'quum somnia vera'—may be that in which these curious feats are accomplished. The drowsiness of the evening is often as much an impediment to thought as the light sleep of the morning.[1]

We must, then, relegate this matter to the limbo of questions admitting neither of proof nor disproof. Like many others, in addition to its intrinsic difficulties, it is encumbered and perplexed by ambiguities of language. The very term of *consciousness*, so essential to the discussion, has hardly obtained a valid definition in its relation to sleep and dreams—an ambiguous one even in reference to our waking state. Everything, indeed,

[1] If adopting this term of '*unconscious cerebration*,' we might fairly apply it to various familiar acts of the waking state. For example: we try to recollect a name or word, fail to do so, and abandon the attempt. Soon afterwards, without intermediate consciousness or effort, the name in question rushes upon the memory, as if by a sudden inspiration. What has here been the intervening cerebral process?

In alluding to this common vagary of memory, we may notice another closely connected with it. A word is forgotten, and sought for in vain. But its initial letter, or some vague image of the word, hangs upon the mind, often furnishing a clue to its recovery. Such instances, trifling though they seem, serve well to illustrate the curious mechanism of this great faculty of our nature.

that concerns personal identity—the *Ego* of the different stages and states of our being—has been under the dominion of unsettled terms in all ages of philosophy. Words have not inaptly been called 'the counters of wise men, and the money of fools.' But even the wisest have been unwittingly governed by them in questions thus obscure or insoluble.

Quitting, however, this region of hypothesis, we willingly come to the more practical part of the subject—that which we learn from observation and experience regarding these phenomena. Here we must again mention the liabilities to error, which occur even in the simplest form of such investigation. Besides those already noticed, we find another in the undoubted diversity of the phenomena in different individuals. The writer on sleep and dreams is not entitled to repose on his own experience only. A dozen persons would probably give as many different versions of their particular consciousness in the matter; and it is not easy to draw averages from these fleeting shadows of the night. They change with age, and other conditions of life, moral and intellectual, which govern sleep and the dreams associated with it. The simple, but touching lines,

> 'Thou hast been called, O Sleep, the friend of woe,
> But 'tis the happy who have called thee so,'

point at one familiar source of this diversity, but there are many others, of which we shall speak hereafter.

In prosecuting the subject, we must first refer again to Sleep in its general sense, as the function of life, destined to the restoration of those vital powers which are exhausted or impaired by the very act of living. Here we are on firmer ground. Whatever anomalies may present themselves, it is certain that sleep fulfils, and is intended to fulfil, this great office of our nature. That which is taught us by universal experience is amply confirmed and illustrated by physiological inquiry. The wonderful power, to which various names have been given, but which may best, and most simply, be described as *nerve-force*—an element acting through the brain and nervous system in all the phenomena of sensation, of motions voluntary and reflex, and of every function essential to animal life—is now so far subjected to research, that even the velocity of its transmission through the nerves of sensation and voluntary motion has been approximately ascertained. This eminent discovery, and the subtle methods by which it was accomplished, warrant the hope that further research may accomplish a similar numerical expression for the *amount* or *quantity* of the nerve-force at any given time—a matter bearing still more directly on the subject before us. If, indeed, this were attained, it would be only formulating in figures a fact of the reality of which we are well assured. We know that the force in question, thus acting through the total nervous system of the body, is the product (*secretion* we may venture to call it) of a peculiar organised tissue—that it varies in amount in different individuals, and in the same individual at different times—that it is exhausted, more or less, by the vital actions, bodily and mental, to which it ministers

—and that it can only be restored by food and sleep, each severally needed for the process of repair. This manner of viewing the nerve-power, or force, as an element to be estimated by *quantity*—by excess as well as deficiency—we believe to be not only just in itself, but denoting a principle of singular value in every part of physiology, and through physiology, in pathology and the treatment of disease. Mr. Herbert Spencer, in commenting on this subject with his wonted ability, thus expresses the main facts, in which all other writers on Sleep more or less concur:—

'Between this state (of sleep) and the waking state, the essential distinction is a great reduction of waste. The rate of waste falls so low, that the rate of repair exceeds it. It is not that during the period of activity waste goes on without repair, while during the period of inactivity repair goes on without waste, for the two always go on together. Very possibly—probably even—repair is as rapid during the day as during the night. But during the day the loss is greater than the gain; whereas during the night the gain is diminished by scarcely any loss. Hence results accumulation. There is a restoration of the nerve-tissue to its state of integrity.'

Here, then, is a force, an agent, whether we call it *material* or not, generated within the body, necessary in its nature to all the functions of the body, but exhausted in maintaining them, and requiring periods of rest for its reproduction in adequate amount. When calling sleep 'Nature's kind restorer,' we use a poetical phrase, but express a physical fact. It is the restorer of that which is expended and lost. Its intermittent periods, its duration and degree, and even many of what seem its anomalies, have all reference, more or less direct, to this great function of repair—a function fulfilled, it may be, simply by suspension or modification of those actions which exhaust the nervous power, while reproduction of this force is going on—or possibly by changes in the brain itself, an effect of the conditions to which it is submitted in sleep.

For it must be remembered that sleep repairs not the vital functions only, but simultaneously those functions which we distinctively describe as mental attributes, and of which the brain is, to our present limited comprehension, the organic instrument. The intellectual part of our nature, taking the phrase in its largest sense, is exhausted by its continued exercise, in like manner as the bodily organs, and requires the same intermittent periods of repose and repair.

If other proof were needed of the great function which sleep fulfils in the economy of life, it may at once be found in the effects which follow the privation of this repair. A single sleepless night tells its tale, even to the most careless observer. A long series of such nights, resulting, as often happens, from an overtaxed and anxious brain, may often warrant serious apprehension, as an index of mischief already existing, or the cause of evil at hand. Instances of this kind, we believe, are familiar to the experience of every physician.

But here, as in so many other cases, the evil of deficiency has its counterpart in the evil of excess. Sleep protracted beyond the need of repair, and encroaching habitually upon the hours of waking action, impairs more or less the functions of the brain, and with them all the vital powers. This observation is as old as the days of Hippocrates and Aretæus, who severally and strongly comment upon it. The sleep of infancy, however, and that of old age, do not come under this category of excess. These are natural conditions, appertaining to the respective periods of life, and to be dealt with as such. In illness, moreover, all ordinary rule and measure of sleep must be put aside. Distinguishing it from Coma, there are very few cases in which it is not an unequivocal good; and even in the comatose state, the brain, we believe, gains more from repose than from any artificial attempts to rouse it into action.

There is another point to which we must here advert, in connexion with sleep as a function of repair. This is the fact familiarly known, that the portion of life so destined is not limited to man alone, but goes far down in the scale of animal creation—possibly, or probably, in one form or other, to the lowest grade and condition in animal life. The sleep even of plants has become a phrase, not merely of poetic fancy, but of scientific appropriation. The curious facts regarding the hybernation of certain animals, though they have kindred with the phenomena and even theory of ordinary sleep, yet present anomalies which associate them in some way with the vegetable world. But the circumstance of greatest interest in this matter is the *capacity for dreaming*, so clearly and curiously attested in those animals which come nearest to man in the scale of being. How far that condition which can rightly be defined as dreaming descends in the scale, it would be impossible to say. Probably there is a gradation downwards in the same ratio as the sensorial faculties, and vanishing with them. The fact of dreaming in the higher animals is most familiar to us in the Dog—that noble creature—*ad hominum commoditates generatus*, as Cicero says of him—at once a companion and solace to man, and a subject for profound thought to all who care to reflect on the great problem of our relations to the inferior animal creation. The admission of the fact does not, however, carry us beyond the presumption that the dreams of other animals are a vague copy of the sensations and acts of their waking lives; with little of the intellectual part—if such it may be called —of the human dream. 'To urge in dreams the forest chase' is the happy phrase of a poet, than whom no one better knew, or better loved, the Dog. And nothing is more likely than the fact here presumed. But seeing the difficulty of rightly remembering and expounding human dreams, there can be little chance of penetrating the mystery as presented to us in another and lower scale of being.

Thus far we have been speaking of the general characters of Sleep as a function of life. In what follows we shall seek, upon our own observation and that of others, to describe the phenomena more in detail; associating them with those of Dreams, from which, as we have seen, they can hardly be separated, even should there be certain conditions of sleep wholly free from this kindred.

The first step we have to make here is one essential to any successful prosecution of the inquiry. It is based on the clear recognition of the fact, that sleep, thus associated, is not *one state* merely, but a *multiplicity and continuous succession of states*; varying at every moment in kind or degree; graduating from the first yawn of drowsiness to the most profound sleep, and undergoing similar changes in the transition from this to the state of perfect wakefulness. Even thus simply stated, it will be seen how completely this fact governs and gives guidance to the whole enquiry, rendering its conditions, indeed, more complex, but affording a clue to many collateral phenomena otherwise wholly inexplicable. Sir H. Holland, who has two chapters on Sleep and Dreams in his volume of 'Mental Physiology,' strongly advocates this mode of treating the subject. We avail ourselves of a short passage from one of these chapters in illustration of our meaning:—

'Sleep, then, in the most general and correct sense of the term, must be regarded not as one single state, but a succession of states in constant variation—this variation consisting, not only in the different degrees in which the same sense or faculty is submitted to it, but also in the different proportions in which these several powers are under its influence at the same time. We thus associate together under a common principle all the phenomena, however remote and anomalous they may seem—from the bodily acts of the somnambulist; the vivid but inconsequent trains of thought excited by external impression; the occasional acute exercise of the intellect; and the energy of emotion—to that profound sleep in which no impressions are received from the senses, no volition is exercised, and no consciousness or memory is left on waking, of the thoughts and feelings which have existed in the mind.'

To this we may add, that such mode of regarding sleep brings its phenomena into closer relation with those of our waking existence, making them serve to mutual illustration, and to the solution of many anomalies which depend on this relation, and the manner in which the two states graduate into each other. It is impossible, indeed, for anyone at all observant of the facts to regard sleep as a single or simple function. We know that through the nervous system and circulation of the blood all parts of the body, and more especially the organs of sense, are affected and altered by it. But these changes of state are ever varying in the same organ, as well as in the different organs of our complex frame; and the inter-relations thus produced, were they more accessible to observation, would give us deepest insight into this mysterious part of our nature. Every organ may be said to have a sleep of its own. The several senses, the voluntary power, the functions of the brain in their totality, are not merely affected in different degrees at different times, but are differently affected in degree at the same time. These facts are now generally recognised by physiologists. Bichat (a man of original genius, prematurely lost to science) thus tersely expresses them:—'Le sommeil général est l'ensemble des sommeils particuliers.' M. Maury, though less explicit in his statement of it, manifestly adopts the same view, which, in truth, affords theonly just definition of sleep, and its concomitant phenomena. It is the view, moreover, which most clearly expounds the relation of these phenomena to the acts and changes of the waking state—a connexion which, however perplexed to our reason by the question of personal consciousness, will be found more intimate the closer we look into it. As in the series of waking thoughts, sudden changes are often made by impressions from without, so, as regards sleep and dreams, we may presume that the breaches which occur in their continuity depend on causes external to the brain itself, though, from the nature of the case, less open to observation. The links may escape observation, but we cannot hesitate in bringing these phenomena under the general law of continuity, so universal throughout nature, organic or inorganic, living or lifeless. This law, scarcely recognised in philosophy or science before the time of Leibnitz, is now receiving confirmation from every new discovery, and becoming the interpreter of endless phenomena hitherto unexplained. Leibnitz himself applies it to the question of the suspension of *thinking in sleep*; deeming it impossible, on this consideration, that such entire suspension should ever really occur.

We shall speak more explicitly hereafter on the physiology of sleep as regards the physical changes concerned in producing or modifying it. But there are various other facts, natural or abnormal, belonging to the physiology of this function of life, which require previous notice: some of them indeed so strangely anomalous as to have furnished food at once to sober philosophy and to the wildest dreams of credulity. We may best begin with what we may call the natural conditions of sleep, while admitting that these ever tend to graduate into more abnormal phenomena.

The various epithets applied to sleep—profound sleep, heavy sleep, light sleep, broken sleep, &c.—express actual realities of state; but these so mingled with each other, so fitful in change, and so perplexed by the vagaries of dreams and disturbing causes from within and without, that even the sleeper himself is generally at fault in defining them. 'I have not slept a wink,' is often the piteous exclamation of the morning, when only some short portion of the night has been made wakeful and restless by disordered digestion, or one of those compulsory trains of thought which fasten pertinaciously on the mind, despite every effort to shake them off. But, though we cannot measure the amount of sleep by hours, or the consciousness of the sleeper, there is much real difference in its degree in relation to the great function of repair. A certain quantity of work is to be done, but it is done at very different rates. This diversity occurs in different persons, and in the same person at different times. One hour in one case may comprise as much of what is true sleep, as two or many hours in another; and the only fair or probable test is to be found in the greater or less difficulty of arousing the sleeper by external action on the senses of touch and hearing. Individual temperament of body and mind, habits of life, and the immediate antecedents of sleep, are all concerned in this matter. The Duke of Wellington, in that hour of his recorded sleep on the field of Salamanca, when the two armies were closely pressing to their conflict, probably slept more soundly than any of the idlers of a city life at home. The 'Somnus agrestium lenis virorum' of Horace, is more powerfully expressed by Shakspeare in describing the dreamless sleep of the day-hireling,

> 'Who with a body fill'd and vacant mind,
> Gets him to rest, cramm'd with distressful bread,
> Sleeps in Elysium,' &c.

And who can forget that noble soliloquy in the Second Part of 'Henry IV.,' where the king upbraids Sleep for deserting 'the perfumed chambers of the great,' and giving its repose to the wet sea-boy in the midst of storms?—

> 'Wilt thou upon the high and giddy mast
> Seal up the ship-boy's eyes and rock his brains
> In cradle of the rude imperious surge?'

We might well go on through the whole of this wonderful passage. If forgotten by anyone, it ought promptly to be renewed to memory.

We need not dwell further on a fact so familiar to common experience. But the diversity of forms which sleep assumes is more interesting to the physiologist in its relation to the particular organs and functions affected by it. We have already alluded to this topic; one which, associated as it is with the phenomena of dreams, offers a special mode of mental analysis as connected with material organisation, and may even in certain cases be made the subject of experiment. It does not, indeed, carry us farther into the mystery than a similar analysis of the waking state. But in showing how the two states commingle and graduate into one another, it serves as a fresh proof of the unity of our nature; and explains many of those anomalous conditions which seem to violate this unity, and have furnished food for credulity in all ages.

Pursuing this analysis of the functions affected in sleep, the external senses—sight, hearing, and touch—are most obvious to familiar observation. Their sensibility is suspended to all ordinary impressions coming from without; and there are degrees, even of natural sleep, so profound—*θανάτῳ ἄγχιστα ἐοικὼς*—that it is difficult to arouse them from it. We cannot affirm that all the senses are equally affected at the same time; though under the conditions of sound and healthy sleep it is probable that they are so. In the passage from drowsiness and somnolence into actual sleep, it is interesting to note (and to a certain point the sleeper can do this for himself) the dimness gradually overshadowing those subtle organisations which connect us with the outer world. The condition is one so familiar that we are wont to regard these changes—if regarding them at all—rather as matter of amusement than curiosity. To the physiologist, looking on them with more watchful eye, they become the interpreter of much that is of deep interest to his science.

These natural and simpler conditions of sleep may be studied in various ways, but in no manner so effectually as by watching the moments of passage *into* sleep and the passage *out* of it. Each by circumstances may be rendered so sudden as to leave little scope for observation. But, under ordinary conditions, the passage is gradual enough to allow those successive changes to be marked which occur both in bodily and sensorial functions during this transition state. Take the instance of slumber supervening on a dull book, an easy arm-chair, a warm fire, and other appliances of repose. The somnolent himself is conscious of the early changes —the apprehension becoming dull, the page before him dim or partially lost to sight, the head nodding, the book tottering in his hands. Out of this state he may be momentarily aroused by some sound or excitement from without, or even by the loss of that muscular instinct or *balancing power*, as we may call it, which belongs to the waking state. He is startled by the book dropping from his hands, or the sudden fall of the head, but speedily lapses again into somnolency, ending in more perfect sleep. Here the consciousness of change ceases to himself; but in this gradation of state, and even in what may be deemed the soundest sleep, an observer without, if diligent in his watch, will detect many curious changes going on; due to the influence of passing dreams, of nervous sensations from the action of the vital organs within, and even from bodily posture. These are the changes to which M. Maury's methods of observation, already mentioned, especially apply. They are abundantly furnished by those nights of broken and disordered sleep which must be counted among the ills of man, though too often only the penalty paid for his luxury or other faults of life.

The most interesting part of such inspection is what may be termed the *disseverment* of the Will from the organs habitually acted upon by it. This is often strikingly testified during the passage from perfect sleep to the waking state. The sensibility is awakened before the Will, or rather we must say (for the very word is entangled in a metaphysical web) before Volition can bring the muscles into action. In the latter stage of sleep, when dreams are passing into realities of the senses, there is often an effort to speak, made distressing by the difficulty or impossibility of utterance. Or when under sleep in a sitting posture, the head, deprived of the controlling muscular support, has dropped upon the chest, the attempt to raise it is often for a time painfully frustrated by the impotence of the muscles in their relation to the will. At such times volition is more awake than the instruments through which it acts.

We have just mentioned the curious knowledge that may be obtained from broken or imperfect sleep. The rapidly-shifting changes and alternations of sleep and waking which then occur, can only be interpreted by regarding the two states as gliding gradually, physically and mentally, into each other—*interlacing*, it might be called, from the impossibility of drawing a definite line between them. Dante, with his wonted compression of language, finely describes this transition :—

‘ E ’l pensamento in sogno trasmutai.’

In this intermediate condition, as already remarked, and especially during the passage from drowsiness into natural sleep, these alternations may generally be noted by the sleeper himself, though, from their familiarity, little heeded or remembered. Under certain circumstances they may even be counted as they occur. From the slumber over a book, or in a carriage, or, yet more, in any situation where, from necessity or decorum, a struggle has to be made against sleep, we obtain an easy estimate, sufficient to know how rapid are the fluctuations which thus affect the most important organ of our frame. A sudden drop of the head awakens to consciousness, which is often lost again in a few seconds of time; and such alternations, as is well known, are repeated over and over again. Anyone who has passed a dozen or twenty hours on horseback (we speak from frequent experience) must well recollect the effects of this hurried repetition—the loss of balance from momentary slumber, the sudden awaking in the effort to retrieve it, and the distressing efforts to prevent relapse into sleep. Without pretending to exactness in a matter thus vague and fluctuating even in the terms applied, we venture to say on observation that three or four distinct alternations of sleep and waking—that is, of consciousness lost and restored—may, and do, occur within a single minute of time. Strange and sudden as these changes in our sensorial existence may seem to be, they are yet compatible with that continuity by gradation, already indicated as the sole method of rightly interpreting the phenomena.

Connected with this subject is the curious *chronometry* so often impressed upon sleep, testified by the power of awaking invariably at some one determinate hour. The explanation of this fact must be sought for in what may be called the general *chronometry* of life; in the tendency, more or less, of all vital functions to assume a periodical character, either from original constitution, or from engendered habits acquiring the force and persistency of natural functions. This topic has hardly yet received all the attention it deserves as a branch of animal physiology. It might merit a treatise in itself.

We have hitherto been speaking chiefly of what may be considered as the natural form of sleep. But there are many anomalous aspects of this great function which we are equally bound to notice—some of them depending on casual and not always obvious causes—others on artificial means used to produce sleep or those states akin to it in which there is a suspended action, more or less, of the senses connecting us with the outer world. Some of these states, which may well be called *waking dreams*, are of deep interest in the mental and moral, as well as physical relations they disclose to us; involving the intellectual faculties, and even the emotions, as well as the simple functions of the senses.

Somnambulism, though we may class it among the anomalous aspects of sleep, is probably not more than an exaggerated form of phenomena of ordinary occurrence. The retention of a certain voluntary power, while the senses are more or less wrapt up in slumber, and this unequal slumber of the senses themselves, are well known to us in the common case of *talking in sleep*, and other bodily motions associated with dreams. Somnambulism is doubtless always thus associated. Why in certain persons this connexion is so strikingly attested it would be hard to say; but still it is only a gradation of state, and not a detached phenomenon.

We may further presume (and many incidents related confirm this view), that somnambulism chiefly occurs during the time when the cerebral functions are already partially awake—another expression of the fact upon which we have so much dwelt, that sleep is a series of states ever fluctuating in kind and degree. We may accredit the statement that the passing dreams of those so affected are rarely remembered; and yet reconcile this with the view we have just taken of the phenomenon. The startling aspect of somnambulism, and the rarity of its occurrence, have given a mysterious colouring to this condition of sleep, and even made it a theme for dramatic representation, for poetry, and music. Like all other things unfamiliar to us, it is doubtless the subject of much exaggeration in particular instances. But enough remains to render it a striking exponent of these complex relations of the sensorial and other functions, in which so many of the mysteries of life have their source.

In following the history of sleep and dreams we are perpetually passing from one marvel or mystery to another. It may seem, perhaps, that these terms do not apply to the familiar effect of opiates and other soporifics in producing sleep. But it is this familiarity which conceals from us the wonder of the fact, that a mere grain or two swallowed of a particular vegetable extract should have the power for a time of bringing the whole mental and bodily mechanism under its control; or that a still more minute quantity of opium or morphia, inserted under the skin, should speedily subdue the most acute neuralgic pain. A physical cause must be concerned in all this, but no known physical law can be brought to its explanation. The only scope for speculation here is that afforded by reference to other facts more or less alike in kind. The whole class of poisons, as they are termed, may be quoted as instances of such analogy; some of these bodies—Strychnia, Woorara, the Upas-poison, &c.—furnishing curious examples of what may be called *selective power* in their action on the respective organs and functions of the body. The animal poisons, again, those which give material to contagious diseases, come under the same category. In all these cases there lies the great mystery of vital organs seized upon, and life itself often extinguished, by quantities incredibly small of substances, the elements of which, combined in other proportions, are perfectly innocuous in effect. We may seek to explain these things upon the theory of fermentation, and the doctrines of atomic and molecular affinities, but never do we get further than to *possibilities*, incomprehensible to our reason.

Within the same field of enquiry come those anæsthetic agents of artificial creation—Ether, Chloroform, the Nitrous Oxide, &c.—which, while inducing a state of stupor, more or less profound, do, at the same time, so wonderfully annul the sensibility to pain. The records of modern surgery copiously illustrate the practical value of this great discovery, which under its theoretical aspect is closely associated with the nature and phenomena of sleep. It affords another example of the manner in which these various states of the sensorium graduate into one another throughout.

We have yet to speak here of certain other phenomena, in which sleep, or states akin to it, assume still more anomalous and startling forms. We allude to conditions of the sensorium, occurring in persons of a peculiar temperament, and often associated with bodily or mental disorder, which are known under the names of *trance*, *catalepsy*, *mesmeric sleep*, &c.—names almost as vague as the aberrations they denote. These several states, and even the more familiar incidents of *reverie* and *absence of mind*, have all a certain community of character, the differences being chiefly of degree, or due to the immediate causes producing them. They all furnish examples of that *disseverment*, so to express it, of the sensorial functions, which leaves a portion of them awake, while others lie in a state of slumber more or less profound. What we have said, and shall further have to say, of dreams in their relations to sleep, may perhaps afford the best interpretation of many of these strange phenomena.

As regards the most notable of them—Mesmeric sleep—so much has been written and argued to and fro, and the simple question, as it first stood, been turned into so many collateral channels, that we shall not seek to go beyond what is essential to our subject. Is there, we may ask, any such special form or mode of sleep as that denoted under this name—produced by a certain subtle influence, emanating from one person, and affecting, even without actual contact, the body of another? We may say at once that neither in the sleep so produced, nor in the collateral effects assigned to it, do we find anything that has not kindred with the natural phenomena of sleep and dreams, and which is not explicable by the anomalous forms these so often assume without any external influences. As regards the simple effect in question, we believe we might as well speak of sermon sleep, of rocking-cradle sleep, of the sleep of an easy arm-chair, or of a dull book, as of Mesmeric sleep. The experiments of Mr. Braid, embodied under the name of Hypnotism, show the effects even of posture or fixed direction of vision in bringing on this state. So multiplied and various, indeed, are the conditions, bodily and mental, tending to it, that the marvel of being awake is almost as great as that of sleep produced by the manipulations and other appliances which the mesmeriser brings to his aid. Among these appliances we must especially reckon the age, sex, and personal temperament of those who are usually the subjects of these exhibitions. Anyone who cares to examine the records of them will see how important is the part these conditions play in the drama of mesmerism.

Granted that the facts are strange and difficult of explanation. But so, and from the same causes, are all the ordinary phenomena of sleep and dreams. Their familiarity disguises what is equally wonderful in them. It is well worthy of note in this, as in many other questions of the kind, how much subordinate objects usurp the place of those of higher import. In the so-called mesmeric phenomena, as proffered to our belief, the mesmeriser plays a far more important part than the person acted upon. The facts presented pass into utter insignificance, unless it can be shown that they depend upon some *direct emanation of power* from the former. Prove that such influence actually issues from one living being, thus changing the condition of another in its proximity, and we have a new and wonderful element, material or spiritual, brought at once into the arena of life. It is admitted, indeed, that this mysterious power is possessed by few individuals only—a limitation, if the facts be real, almost as strange as the power itself. But we may at once state our belief that no such peculiar power exists. The operator himself cannot furnish evidence of it. The effects he produces by his manipulations and other devices are closely analogous, often identical, with those to which individuals of a certain nervous temperament are liable from other and very different exciting causes. This, then, we apprehend to be the crucial question in all that appertains to mesmeric sleep, under its various aspects. The simple fact of sleep thus produced was known long ago; but it was reserved for our time to erect it into a mysterious principle, altering, were it real, all our views of mental phenomena.

But that it would be straying too far from our subject, we might speak here of certain bolder impositions upon human credulity which have gained a recent notoriety. Connected in some points with mesmeric effects, and often admitting of similar interpretation, they go far beyond these in their pretensions; bringing us into contact and communication with the world of deceased spirits, through the intervention of persons—*mediums* as they are called—

gifted with the power of thus summoning spirits from the dead. We put this in the simplest terms, because the mere enunciation of it may well annul the gross pretension it involves. And when examining further into the methods employed to exhibit and attest these spiritual appearances—the puerile and pantomimic devices of spirit-rapping, table turning, &c., and the vulgar and ignorant talk which these *revenans* are made to utter, we may be content to leave such things to their own eventual refutation. Argument is of little avail with those who can lend a facile faith to these fantastic performances, rendered more suspicious by a mercenary ingredient often mixed with them. The contrivances employed we cannot always explain. But exactly the same may be said of the performances of the fair-dealing professional conjurer, who puzzles and tells you that he means to do so. That some very intelligent men should have given partial credit to these illusions, is but another example of the incongruities which are found even in minds of the highest genius and culture. Human life abounds in such instances.

We have thus far been speaking of Sleep in its more general characters, natural or anomalous; connecting it, indeed, with that wonderful adjunct of Dreaming, from which it can hardly be separated. But some distinct consideration must be given to the latter—to those fleeting shadows, the *μιμήματα ζωῆς*, which so strangely divide, yet link together, the successive portions of our lives. In writing on this subject, the plural personality of an anonymous reviewer becomes somewhat inconvenient. If we have to speak of *our* experience, it must be understood only in an individual sense. Here, indeed, we may fairly ask our readers to become critics also; for each and all have some experimental knowledge of their own, wherewith to confirm or contradict what is set before them. But this knowledge, from causes already assigned, is generally vague and transient. The memory of the dream is speedily discarded by the waking events that follow, and dreams are often so intermingled in the same night that no effort of recollection can disentangle them. We doubt if anyone has ever attempted a successive written record of these erratic visions of our sleeping hours. If carefully and honestly executed, it would be more curious than many of those diaries of ordinary events which amuse the leisure, or innocently please the little vanities, of those who keep them. A certain number of records of dreams, coming from authentic sources, and indicating especially their relations to acts or events immediately or remotely antecedent, might justify conclusions attainable in no other way—a shadowy science, it may be admitted, yet better than none.

We have used the term *honestly* here, because from causes already assigned there is much proneness to exaggeration, as well as great facility for it, in the relation of dreams. To give completeness to a vague story is a temptation to the narrator, and it may be indulged without fear of contradiction. This temptation becomes stronger where a certain superstitious feeling creeps in, suggested, as we have elsewhere remarked, by some one of the many strange coincidences of events which, casual though they be, take strong hold of the imagination. We might vivify our subject by half-a-dozen stories of such dreams; some of them of old date, but keeping their vitality as anecdotes by the seeming mystery they involve. It is needless to say that these stories lose nothing of their marvellous character by long repetition. The original dreamers, we believe, would often be perplexed by the shapes their dreams have gradually assumed, with positive affirmation at each step of the story. A simple question will often disturb narratives of this kind. We recollect an instance where the mystery related was a dream by an officer in America of the death of a friend in India, whose death was stated to have occurred at the very hour of the dream. A dry sceptic at the table blighted the anecdote by asking if due allowance had been made for the difference of longitude of the two countries? So few of these harmless superstitions are left to us, that the interruption to the story might have been charitably spared.

We have already said much of the marvel of dreams, as a portion of life alternating with the higher functions of the waking state. Contrasting the two states, it could hardly be supposed that one should be the best expounder of the other. Yet such is in reality the case. Dreams, even in their strangest incongruities, are in no way so well interpreted as through the acts of the mind awake. The law of continuity is preserved here also, though often and variously infringed upon by those complex and intermingling relations of body and mind to which, whether awake or asleep, we are unceasingly subjected. As we *feel* and recollect them in ourselves, and note them in others, dreams go through every grade of intensity and reality; and this, probably, in a certain inverse ratio to the soundness of the sleep. We are using here terms of vague acceptation thus applied, but we possess no true vocabulary for the functions in question. What we may affirm is, that sleep in its purely physical part, and dreams in their aberrant intellectual phenomena, are ever acting upon each other, and in every degree of activity; such mutual influence being especially testified in the acts of going to sleep and awakening from it. It is the same mysterious union which pervades and gives continuity to life, and which has excited and baffled curiosity in every age of the world.

We have already discussed the question which here naturally recurs, whether there is any condition of sleep utterly devoid of dreaming? The vague and broken memories of dreams tell nothing certain as to their time or duration, and without this aid we are helpless as to any sure result. But, though failing in this particular case, the memory is the faculty on which we must mainly depend for our knowledge of them, and of the enigmas they present. Aristotle, as already noticed, put the question pertinently, 'Why do we remember some dreams, others not?'—implying, of course, what we know by observation, that the state of dreaming exists even when there is no after recollection to attest it. The question admits of being plausibly answered. The best remembered dream is that which immediately antecedes the moment of waking, when the functions suspended by sleep have partially regained their power. The dream itself, indeed, especially if sensational in kind, is often the direct cause of the change of state; and such dreams may occur repeatedly in the same night, each leaving its own impress on the brain. Whether there be any absolute blank in this complex series of changes is the question yet unsolved. Bearing on this point is the fact that dreams forgotten in the morning are sometimes suddenly recalled by later incidents of the day. A clue once got through some casual association, the recollection often retraces these past visions of the night, which, but for such casualty, would never have been revived.

We must not, however, speak of their annihilation. Dreams leave traces on the brain, the same in kind, though perhaps less forcibly marked than those impressed by the sensations, emotions, and volitions of the waking state. We may plausibly from this source seek explanation of those vague shadows of past events which now and then come across the mind, perplexing it with a sort of semi-reality, but not attested by any collateral recollection. Most of our readers have probably experienced this curious wandering of the mind amidst what we believe to be the shades of old dateless dreams, called suddenly into life, and as suddenly flitting away. If this be, as we suppose, an act of Memory reviving ancient dreams, it is but one of the endless wonders of this great faculty of our nature, the study of which, under its many anomalies—in health and disease, in its sleeping as well as waking moods—carries us further into the mystery of the mind itself than we can reach by any other approach. That there is a certain material mechanism of memory, an organisation upon which impressions are made and retained, the facts compel us to believe. Whether we shall ever acquire a more intimate knowledge of its nature is very doubtful. The minute anatomy of the human brain and its appendages, while disclosing much that is curious in structure and in relation to the senses and vital organs, has failed to detect any apparatus of memory, or those conditions which make recollection an act of the human will.

Ignorant here, we are still able to affirm that the memory and the recollection (*μνήμη, ἀνάμνησις*; the faculty and the act) are strictly analogous in their application to the visions of the night as to the events of the day. In each case the recollection works its backward way through the successive antecedent states of the sensorium; guided by the same associations, and stopped by the same impediments. Anyone caring to examine his own consciousness on the subject will see how similar the process is in kind, though, as regards the dream, rendered more partial and perplexing by the other conditions of sleep.

But we may carry this analogy on to another point. Many anecdotes are familiar to us, and these sanctioned by individual observation, showing how much and what variety of thought, emotion, and event may be comprised in a dream of the briefest duration. The chronology of the night is generally an obscure one; but this particular fact is easily tested, especially in the broken dreams of the morning hours. It proves that the period of a few minutes may include a whole story of incidents, in which the perceptions of place, time, and persons are removed from the outer world into those of the little world within. This may seem strange to the unobservant of themselves, but it will not so seem to any who are capable of examining with care the sequence of their waking thoughts. We live, the mind lives, in a constant series or succession of states, each one having its own individuality and excluding others, yet linked together by a mechanism which we vainly seek to interpret. No one without close examination can conceive the multitude of these sequent states which may be, and actually are, crowded into short spaces of time—ever liable, indeed, to be interrupted by causes from without and within, and merging into new series, which in their continuous succession form the totality of our mental life. Of the internal causes acting on these series, the Will is that most important—often, indeed, a slave to vagrant habits of thought, but capable of becoming their master. The highest faculty of man, intellectual and moral, lies in the power of controlling and guiding them in their passage through the mind; so directing them as to ennoble the character of thought itself, and the acts derived from it.

Without pursuing this subject, instructive though it be as a method of mental analysis, we proceed to another chapter in the History of Dreams, embodied in the question, What are the materials of these visions of our sleep? Of what 'stuff are dreams made?' The first and natural comment upon the question is, that dreams, like waking thoughts, must be different in different minds, and with some explicit reference to their individuality. Such is doubtless the case, and among classes of men as well as individuals. We have already alluded to this curious inquiry, one admitting of the strongest presumption, if not of direct proof. Passing by the dreams of infant life, as inaccessible to observation, can we suppose those of the idle schoolboy to be moulded like the dreams of a man immersed in worldly care and anxieties? or like those of old age wandering vaguely over the memories and feelings of past life? How are we to compare the dreams of the day-labourer in the field, the factory, or the mine, with those of men whose faculties have been exercised and exalted by literature, science, and the arts; or by the political struggles which enter into the government of the world? The sleeping minds of Bacon and Newton, of Dante, Shakspeare, and Milton, of Michel Angelo and Raphael, of Julius Cæsar and Napoleon, must have been tenanted with visions very different from those of ordinary men. Who, again, can tell us what are the dreams of madness in its many forms, some of these forms having close kindred physiologically with the act of dreaming? The dreams of the idiot may resemble those of early childhood, or the second childhood of old age. What shall we conjecture as to those of the man who has undergone years of solitary confinement, changeless in sensations and events? Such questions might be variously multiplied. They tell us how much we have to learn, and the difficulty of learning it. Hardly can we reduce into shape the fleeting memories of our own dreams. Harder still is it to authenticate those of others, especially of classes of mankind little prone to take account either of their sleeping or waking existence.

A word more here as to the relative rapidity with which the successive images and thoughts of dreams pass through the mind. The analogies we have been pursuing may again give an answer. Though we cannot bring numbers into the question, we have every reason to believe that the succession of mental acts, while awake, is habitually more rapid in some minds than others, and even in the same mind at different times. We *think more rapidly*, as well as *more vividly* in one state of the sensorium than in another. If this be so, we may fairly presume the same as to the conditions of dreaming in different minds. But we cannot go beyond this presumption.

Reverting to the question before us, what are the *materials* out of which dreams are formed? The obvious and sole answer is—from the sensations, ideas, emotions, acts, and events of antecedent life. Putting aside all notions, ancient or modern, of supernatural intervention, the phenomena of waking existence are those alone to which we can look for their interpretation. The passage of Cicero, quoted below, while well expressing this fact, denotes also those strange perturbations, which form the distinctive character of dreams and the great mystery of their nature.[1] We can understand (or fancy we understand) the memories of past images or events impressed upon the brain. But the manner of their grouping in the mind during sleep is the marvel with which we are here concerned. Loosened from all fetters of time and place, and freed from control of the will, the dream makes a little world of its own, bringing into strangely broken succession scenes which have no counterpart in actual life; conjunctions of persons, places, time, and incidents, which never did or could have occurred in such combination. The complete dream disregards all realities. It brings the dead back among the living without surprise to the dreamer, and embodies them in the entangled stories which have no recollected beginning or end; which run abruptly into one another; confuse personal identities; and blend impossibilities with the most common incidents of life. Shakspeare has well called dreams, 'the children of an idle brain.' That power in fact is dormant which gives sequence and congruity to the acts of the waking mind.

But still, even here, analogies press closely upon us. The images of sensible objects occurring in dreams would seem to be closely akin to those which the memory furnishes to the mind awake, either by effort of will or by mere automatic connexions of thought. In this case, as in the other, they are vague and fleeting. No effort of will can long detain them before the waking consciousness; and in dreams, unaided by will, they

[1] 'Animus incidit in visa varia et incerta, ex reliquiis inhærentibus earum rerum quas vigilans gesserit aut cogitavit; quarum perturbatione mirabiles interdum existunt species somniorum.'

are still more transient and disjointed. In both cases objects of vision minister chiefly to this *subjective* action, while the waking mind can create by will, or receive unbidden, a *sensorial memory* of rhythmical sounds, clothing itself often in actual melodies, the reflex music of the brain. This latter point, in its various physiological connexions, has scarcely had its due share of attention.

Regarding, then, the images of dreams, however perturbed in order, as derived from those of daily life, we still have to ask the question, whether this mimic imagery ever goes beyond, with inventions new to the senses? We think not. We may dream of the Centaurs or the winged Assyrian bulls, as we have seen them in the British Museum, but we do not in our sleep *create* monstrosities of this kind. Under the most fantastic grouping of persons and incidents, the individual images are not unnatural or distorted. We believe this to be so; but here, as often elsewhere on this subject, we must ask our readers to consult their own experience.

That dreams, however, are generally formed out of unwonted or impossible combinations of events, and that they undergo sudden and fantastic changes as regards persons, times, and localities, are facts familiar to all. These three sources of disorder are, indeed, mainly concerned in the illusions of the night. The personages of the dream appear and disappear, shift, and interchange their acts and positions with magical rapidity. The realities of time and place are lost in the medley of incidents of which the vision is composed.

One dream passes into another, as far as consciousness and memory can inform us, without continuity or connexion. This description, however, needs to be qualified in more than one respect. We have already remarked that the act of dreaming is varied by the greater or less completeness of the conditions which constitute sleep. As the time of awakening approaches these conditions change; the sensorial powers are partially revived, and the dreams, though still perhaps erratic in the points just mentioned, are more consecutive and consistent in the events they include. We may repeat our belief that to this fact we must look for explanation of those singular stories of problems solved, verses composed, and arguments logically pursued during the hours of sleep.

Again, as respects the erratic character of dreams, analogy is not wanting for its illustration. The mind awake, or nominally so, often wanders almost as strangely. Let anyone, even when thoroughly awake and under ordinary circumstances, seek to retrace the successive thoughts or mental acts of the antecedent half-hour. Unless the mind be engaged on some single and definite object, he will find the task difficult and laborious; and if partially successful in tracking backwards these sequent states, the chance is that they will be found variously broken and divergent, in effect of impressions from without or of internal conditions of the brain and other organs. Though we are all living in this unceasing series of mental changes, few take note of them, or mark how rapid and abrupt they often are even in the calmest moods of mind.

All such aberrations are repeated and exaggerated in dreams. The brain, physically affected in sleep, loses more or less those perceptions of time, place, and personality which are wont to guide the succession of mental acts. In the varying degrees of this influence we may best find explanation of many of the anomalies of somnambulism, trance, hypnotism, hysteria, &c., of which we have already spoken. Here, however, as in many questions of like kind, the explanation merely removes one difficulty to bring us in contact with others yet more insuperable.

It has been a question how far the course and objects of dreams can be changed by external stimuli applied to the several senses of the dreamer. Such excitements, it is well known, may be applied as to modify variously the conditions of sleep without actually suspending it. The cradle of the sleeping child affords sufficient evidence of the fact. Shakspeare had this matter in his ever-pregnant mind when he brings in Queen Mab as a fairy experimentalist upon dreams. But graver experiments have been made on the subject—some of them due to M. Maury himself. Though we cannot doubt the reality of such influence in different modes and degrees, seeing what we gather both from analogy and observation, yet are the particular proofs of difficult attainment, and experiments need to be often repeated and varied to give them their appropriate value. We have more certainty as to the influence of the internal organs on the course and character of dreams. The digestive organs more especially—disordered, it may be, by the dinner of the preceding day—betoken the *hesterna vitia* by troublous sensations and troubled dreams. Few so prudent as not to have had experience of nights thus disturbed. The nightmare is familiar as one example; but the particular effects are as numerous as the disorders producing them. The sensations arising from the excretory organs mingle themselves variously also with the incidents of dreams. Even posture, temperature, a hard or soft bed, have effect in modifying them, by altering the conditions of the sleep with which they are associated. Such influences cannot be doubted, difficult though it is to bring the facts into strict evidence. Dream-land is not the land of logic or close scientific induction.

Though less practically important, there is a deeper interest in tracing the connexion of dreams with the events of prior life, whether immediately or remotely antecedent. It may perhaps be affirmed that even in the most entangled series of incidents haunting the brain of the dreamer, there is always interwoven something of his own individuality, present or past. We have elsewhere spoken of the influence of personal temperament and habits of life on the character of dreams. Lucretius in some fine lines describes this, as does Chaucer in a striking passage of good old English verse. To the inimitable Queen Mab of Shakspeare we have just referred. But apart from all authority in verse or prose, we know from unequivocal experience how faithfully particular traits of character, emotions, passions, and personal propensities are portrayed in the dream. The feelings thus reflected from our waking lives, if sometimes pleasant, are often harassing and painful; rendered so in part by the physical conditions of sleep, and the impotence of the will in regard to bodily functions. There is the feeling of something to be done which we cannot do—of entanglement in difficulties which we cannot throw off—the hurried pursuit of some object which we cannot reach—the effort to speak without the power of utterance—dreams which often awaken the sleeper, and from which, especially where painful memories are involved, it is happiness to be awakened. In young children, however, who do not so readily dissever the real from the unreal, the images and agitation of a fearful dream often continue for an hour or two after sleep has come to an end.

It is a saying of Sir Thomas Brown, 'Virtuous thoughts of the day lay up good treasures for the night. Men act in sleep in some conformity to their awakened senses. Dreams intimately tell us of ourselves.' We remember to have read a sermon—and a very able one—inculcating the examination of dreams, as a means of recognising and rebuking our faults. They do in truth often denote not merely the grave, but also those lighter shades of character which are lost to our consciousness in the current and familiar events of the day.

We doubt whether the sense of personal identity is ever absent in dreaming, though some writers have supposed it to be so. Language here is incompetent to express things which even thought fails to comprehend. But we may perhaps affirm that the consciousness applied to these visionary events, however strange and incongruous their nature, is in essence the same as that which underlies our waking existence. To pursue the matter further would be merely to clothe poverty of knowledge with a garment of words.

The events immediately preceding dreams might naturally be expected to minister materials to them more largely than those of distant date. And such may probably be the case, especially when mental emotions are mingled with these events. But we may well marvel at the remoteness of those scenes of past life to which our retrospective dreams often extend. Incidents are repeated, and personalities restored, now never present to the waking thoughts of the dreamer, and which might seem wholly effaced from memory. Here again, as so often before, we come to analogy as the best mode of illustrating, if not explaining, these mysteries, and of bringing them into accordance with the unity and identity of our being. The memories of past life embodied in dreams have close kindred with those evoked by incidents, often very slight, of our waking hours. We know nothing of the actual nature of the impressions or images thus latent in the brain; but there they are—dormant, it may be, for ever, yet capable of being revivified at any time, sleeping or waking, by coming into sudden relation with present sensations, emotions, or thoughts. In sleep these distant memories are usually vague and dateless—when awake they receive correction from the senses and other faculties. Their origin, however, is the same; and the further we press such examination the more intimate will be found the relations and resemblances disclosed.

We have spoken already of those pale spectra of former dreams, as we may best deem them, which now and then flit across the memory, strangely mingling with passing events. Another phenomenon akin to this is the curious *hold on the brain* which certain dreams seem to acquire; shown by their frequent recurrence, with the same general incidents and feelings, yet without any actual reality of origin. Every observer of himself may here have his own particular tale to tell; but the general fact will probably be recognised. We know an instance where six such dreams, frequently but irregularly recurrent, and this during a period of very many years, are well attested by close observation of the person who is the subject of them. We may presume, though we cannot prove, that the peculiar grasp of these visions on the sleeping mind—the 'dreams of dreams,' we may call them—depends on the force of the impressions in which they originated—strengthened, it may be, by repetition. In all our reasonings on these obscure points we are forced to recur to the conception just stated of actual material changes—utterly incomprehensible in their nature—made and infixed on the brain, and probably most forcibly impressed at those times of life when the mental faculties are in greatest vigour. Admitting the latter fact, it explains to us several seeming anomalies of memory; such as the frequent and vivid recollections in advanced age of the events of earlier life, while those of recent occurrence vanish speedily from the mind; and as regards dreams, the similar wandering of the brain among past memories, when present sensations are dimmed by age, and life itself is beginning to assume the character of a dream.

One point remains to be noticed, of which, however, notwithstanding its deep interest to mental physiology, we shall only briefly speak. This is the relation of sleep and dreams to those abnormal or diseased states of mind which we call insanity—though, indeed, a single term feebly expresses the multiform shapes of such disorders which observation unhappily brings before us. A manifest distinction offers itself here in the outset. The one condition is natural, and periodical only—the other is abnormal, and more or less permanent. But, nevertheless, there are certain links connecting them which cannot be overlooked—relations noticed by Cicero and other ancient writers, and more explicitly described by several eminent authors of our own time.[1] Many of the strange hallucinations of insanity, though less changeful and fleeting than those of the dream, yet have various characters in common with the latter. Such especially are those where the mind may be considered wholly in a *subjective* state—the brain coining images, ideas, and associations within itself, uncorrected by the senses, or by any clear memories of the past. The singular phenomena of *spectral illusions*, in which the sense of hearing also is concerned, furnish a striking

[1] 'Quod si ita paratum esset, ut ea dormientes agerent, quæ somniarent, alligandi omnes essent, qui cubitum irent.' (Cicero *De Divinatione*, lib. ii. 59.) In the valuable work on the 'Physiology and Pathology of the Mind,' by Dr. Maudsley, will be found much that relates to this interesting topic.

example of this connexion. Images of objects which have no reality, voices equally imaginary, haunt the brain of the madman as they do that of the dreamer—less urgently, indeed, in the latter case, and with powerlessness as to any consequent action, yet still marking a state of the sensorium common to both conditions.

We might dwell further on this subject, and its curious relations to the phenomena of ecstacy, hysteria, the delirium of fever and drunkenness. But even if not admonished by want of space, we should be taxing the patience of our readers too severely by detaining them longer in this region of shadows, where realities and mockeries are so strangely intermingled, and where mental and bodily states mutually excite, control, or partially annul one another, leaving a long page of problems to be solved, if such solution be ever possible.

The only topic now remaining to us is that of the physical causes proximately concerned in producing sleep and dreams. Here, again, notwithstanding researches recently directed to this part of physiology, and valuable works describing them, we are still forced upon the admission of diversity of opinion and imperfect knowledge. These researches have chiefly regarded the influence of the circulation upon the functions of the brain, and upon sleep, as one of the most important of them. This varying influence is recognised in every part of the body, and at every minute of life; but the cerebral circulation has specialities distinguishing it from that of any other organ. The confinement of the brain within the close cavity of the cranium, and the peculiar distribution of the arterial and venous system in the medullary and cineritious substance, in the membranes and sinuses of this organ, have embarrassed hitherto every question on the subject. It has been the most general opinion of physiologists that a certain amount of pressure on the brain, chiefly from congestion of venous blood, was necessary for the state of sleep. More recently, this opinion has been modified, if not contradicted, by the experiments of Mr. Durham, Dr. Hammond, and others; furnishing evidence that sleep depends on a lessened quantity and force of blood in the brain, and especially in the arterial part of the cerebral circulation. Though this inference is fortified by various known facts, such as the sleep produced by exposure to intense cold, by loss of blood, by pain, and other causes of vital exhaustion, it still leaves the physical theory an ambiguous one; embarrassed by our ignorance of the relative proportions of arterial and venous blood during sleep — by questions as to the mode of action of the vascular portion of the brain upon the medullary and other cerebral tissues—and by a further question, of higher interest but harder of solution, viz., the nature of those changes in the cerebral substance itself through which dreams, and other concomitant phenomena of sleep, have their origin.

The latter question involves difficulties which, with all just regard to the prowess and high attainments of modern science, we must yet believe to be insuperable. It is in truth the selfsame problem as that put before us by the normal and waking state of our sensorial existence. The dream of the night is connected with the same organisation which ministers to the sensorial functions of the day. Through the microscope and other means much has been discovered of the minute anatomy of the brain and its appendages. Medullary cells and fibres, ganglionic centres, and new nervous intercommunications have been disclosed; and though less assuredly, certain functions localised as regards the parts of the brain fulfilling them. But of the infinitesimal motions and changes in the nervous substance itself, we are as entirely ignorant as we are of that mystery which associates these changes in invisible mechanisms with the intellectual and spiritual part of our nature—with the sensations, thoughts, memories, and emotions, which in their succession and combinations constitute the mental being of man. We must not indeed vaunt our knowledge of the brain until all dispute is settled as to the functions of the Cerebellum—one of the most prominent parts of the cerebral system, and unquestionably fulfilling functions essential to the integrity of the whole.

What, however, we are mainly concerned with here is the fact that actions analogous in kind, though variously altered in operation, occur alike in the sleeping and waking brain. In reasoning upon the physical causes of these phenomena, we do not reach our end in merely proving the influence of changes in the cerebral circulation and of varying pressure thus produced. We advance a step, but only one step, by this demonstration; leaving it unsettled whether the exhaustion of nerve force, the primary cause of sleep, is not also the immediate cause of these very changes in the vascular system of the brain. The many cases where sleep, or states closely akin to it, can be produced by causes in which the circulation is little, if indeed at all, concerned, but where the nervous system is directly and powerfully acted upon, suffice to show how important is the influence of the latter in connexion with these complex and ever-changing phenomena.

A treatise on Sleep and Dreams, to be complete, should comprise also the pathology of these states, and the remedies—useful or useless—which have been suggested to remove or relieve the disorders affecting them. These topics, however, belong rather to professional works, and we cannot here do more than refer to them, important though they are to the physiologist as well as to the physician. It has been our object in the foregoing article, which we now bring to a close, to place before our readers simply and clearly what we may best call the Natural History of Sleep and Dreams. While avoiding as far as possible all technical language and the metaphysical subtleties into which such questions are prone to pass, we have sought to inculcate larger and more distinct conceptions of these great functions of our inner life, the very familiarity of which obscures them to our contemplation. And at the same time we have endeavoured, by pointing out the close relations and analogies of the phenomena to those of our waking existence, to establish here, also, that continuity and identity of Being, upon which these phenomena on first view seem so strangely to infringe.

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