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BRIDGEWATER TREATISES.

CAREY, LEA & BLANCHARD

HAVE PUBLISHED,

ASTRONOMY AND GENERAL PHYSICS, considered with reference to Natural Theology, by the Rev. WILLIAM WHEWELL, M. A., Fellow and Tutor of Trinity College, Cambridge; being the *Third Part* of the Bridgewater Treatises on the Power, Wisdom, and Goodness of God, as manifested in the Creation.

The series of Treatises, of which the present is one, is published under the following circumstances:—

The Right Honourable and Rev. FRANCIS HENRY, Earl of Bridgewater, died in the month of February, 1825; he directed certain trustees therein named, to invest in the public funds, the sum of eight thousand pounds sterling; this sum, with the accruing dividends thereon, to be held at the disposal of the President, for the time being, of the Royal Society of London, to be paid to the person or persons nominated by him. The Testator farther directed, that the person or persons selected by the said President, should be appointed to write, print and publish one thousand copies of a work, on the Power, Wisdom, and Goodness of God, as manifested in the Creation; illustrating such work, by all reasonable arguments, as, for instance, the variety and formation of God's creatures in the Animal, Vegetable, and Mineral Kingdoms; the effect of digestion, and, thereby, of conversion; the construction of the hand of man, and an infinite variety of other arguments; as also by discoveries, ancient and modern, in arts, sciences, and the whole extent of literature.

He desired, moreover, that the profits arising from the sale of the works so published, should be paid to the authors of the works.

The late President of the Royal Society, DAVIES GILBERT, Esq., requested the assistance of his Grace, the Archbishop of Canterbury, and of the Bishop of London, in determining upon the best mode of carrying into effect, the intentions of the Testator. Acting with their advice, and with the concurrence of a nobleman immediately connected with the deceased, Mr. Davies Gilbert appointed the following eight gentlemen to write separate Treatises in the different branches of the subjects here stated:—

I. The Adaptation of External Nature to the Moral and Intellectual Constitution of Man, by the Rev. THOMAS CHALMERS. D.D., Professor of Divinity in the University of Edinburgh.

II. The Adaptation of External Nature to the Physical Condition of Man, by JOHN KIDD, M. D., F. R. S., Regius Professor of Medicine in the University of Oxford.

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III. Astronomy and General Physics, considered with reference to Natural Theology, by the Rev. WILLIAM WHEWELL, M. A., F. R. S., Fellow of Trinity College, Cambridge.

IV. The Hand: its Mechanism and Vital Endowments as evincing Design, by Sir CHARLES BELL, K. H., F. R. S.

V. Animal and Vegetable Physiology, by PETER MARK ROGET, M. D., Fellow of and Secretary to the Royal Society.

VI. Geology and Mineralogy, by the Rev. WILLIAM BUCKLAND, D. D., F. R. S., Canon of Christ Church, and Professor of Geology in the University of Oxford.

VII. The History, Habits, and Instincts of Animals, by the Rev. WILLIAM KIRBY, M. A., F. R. S.

VIII. Chemistry, Meteorology, and the Function of Digestion, by WILLIAM PROUT, M. D., F. R. S.

The whole of these Treatises are nearly finished, and will be put to press as soon as received, and published in a cheap and handsome form.

THE PRINCIPLES OF CHRISTIAN PHILOSOPHY; containing the Doctrines, Duties, Admonitions, and consolations of the Christian Religion, by JOHN BURNS, M. D., F. R. S. From the fourth London edition. In the press.

CONVERSATIONS WITH LORD BYRON ON THE SUBJECT OF RELIGION. By J. KENNEDY, M. D. 12mo.

GLEANINGS IN NATURAL HISTORY, WITH LOCAL RECOLLECTIONS. By EDWARD JESSE, Esq. To which are added, Maxims and Hints for Anglers. From the second London edition, in one volume, being a Companion to the Journal of a Naturalist.

We have occasionally selected a paragraph from a very pretty volume, by Mr. Jesse, published under the above title. The author lives in the neighbourhood of Kew, and like Mr. White of Selborne,—who made a small village of Hampshire one of the most interesting spots to the lover of nature, by his ample descriptions of the natural objects which he saw around him,—Mr. Jesse has rendered his walks a vehicle for much instruction and amusement to himself and to others. He principally confines his attention to zoology—the most generally attractive of the departments of natural history; and he looks upon the animal world with so much practical wisdom, being disposed to be happy himself, and to see every creature around him happy, that there are few persons who will not read his slight sketches with improvement to their hearts and understandings.—*Penny Magazine.*

THE MECHANISM OF THE HEAVENS. By Mrs. SOMERVILLE. In 18mo.

Is it asking too much of Mrs. Somerville to express a hope that she will allow this beautiful preliminary Dissertation to be printed

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separately for the delight and instruction of thousands of readers, young and old, who cannot understand, or are too indolent to apply themselves to the more elaborate parts of the work? If she will do this, we hereby promise to exert our best endeavours to make its merits known.—*Literary Gazette.*

SALMONIA; OR, DAYS OF FLY FISHING. By Sir H. DAVY.

We are surprised in meeting with an American reprint of this delightful volume, that a work so universally popular has not been before republished in this country.—*N. Y. American.*

One of the most delightful labours of leisure ever seen; not a few of the most beautiful phenomena of nature are here lucidly explained.—*Gent. Magazine.*

THE NATURAL HISTORY OF SELBORNE. By the late Rev. GILBERT WHITE, A. M., Fellow of the Oriel College, Oxford; with additions by Sir WILLIAM JARDINE, Bart. F. R. S., E. F. L. S. M. W. S., author of "Illustrations of Ornithology."

White's History of Selborne, the most fascinating piece of rural writing and sound English philosophy that has ever issued from the press.—*Athenæum.*

JOURNAL OF A NATURALIST. With Plates.

——Plants, trees, and stones we note;
Birds, insects, beasts and rural things.

We again most strongly recommend this little unpretending volume to the attention of every lover of nature, and more particularly of our country readers. It will induce them, we are sure, to examine more closely than they have been accustomed to do, into the objects of animated nature, and such examination will prove one of the most innocent, and the most satisfactory sources of gratification and amusement. It is a book that ought to find its way into every rural drawing-room in the kingdom, and one that may safely be placed in every lady's boudoir, be her rank and station in life what they may.—*Quart. Review*, No. LXXVIII.

This is a most delightful book on the most delightful of all studies. We are acquainted with no previous work which bears any resemblance to this, except "White's History of Selborne," the most fascinating piece of rural writing and sound English philosophy that ever issued from the press.—*Athenæum.*

THE FAMILY CABINET ATLAS, constructed upon an original plan: being a Companion to the Encyclopædia Americana, Cabinet Cyclopædia, Family Library, Cabinet Library, &c.

[This Atlas comprises, in a volume of the Family Library size, nearly one hundred Maps and Tables, which present equal to *fifty thousand names of places;* a body of

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information three times as extensive as that supplied by the generality of *Quarto Atlases.*]

This beautiful and most useful little volume, says the Literary Gazette, is a perfect picture of elegance, containing a vast sum of geographical information. A more instructive little present, or a gift better calculated to be long preserved and often referred to, could not be offered to favoured youth of either sex. Its cheapness, we must add, is another recommendation; for, although this elegant publication contains one hundred beautiful engravings, it is issued at a price that can be no obstacle to its being procured by every parent and friend to youth.

This Atlas far surpasses any thing of the kind which we have seen, and is made to suit the popular libraries which Dr. Lardner and Mr. Murray are now sending into every family in the empire.—*Monthly Review.*

Its very ingenious method of arrangement secures to the geographical student the information for which hitherto he has been obliged to resort to works of the largest dimensions.—*Athenæum.*

THE RECTORY OF VALEHEAD. By the Rev. ROBERT WILSON EVANS, M. A.

Universally and cordially do we recommend this delightful volume. Impressed with the genuine spirit of Christianity; a diary, as it were, of the feelings, hopes, and sorrows of a family,—it comes home to all, either in sympathy or example. It is a beautiful picture of a religious household, influencing to excellence all within its sphere. We believe no person could read this work, and not be better for its pious touching lessons.—*Literary Gaz.*

We fearlessly pronounce this delightful little volume to be not only one of the most faultless, but every way valuable works it has ever fallen to our lot to recommend to public perusal.—*Stamford Herald.*

The Rectory of Valehead is a beautiful model of domestic life in the Christian home of a well-regulated family, and combines literary amusement with the most refined and intellectual improvement.—*Scotsman.*

A GENERAL VIEW OF THE PROGRESS OF ETHICAL PHILOSOPHY, chiefly during the Seventeenth and Eighteenth Centuries. By Sir JAMES MACKINTOSH, M. P. In 8vo.

The best offspring of the pen of an author who in philosophical spirit, knowledge and reflection, richness of moral sentiment, and elegance of style, has altogether no superior—perhaps no equal—among his contemporaries. Some time ago we made copious extracts from the beautiful work. We could not recommend the whole too earnestly.—*National Gazette.*

THE BOOK OF THE SEASONS; OR THE CALENDAR OF NATURE. By WILLIAM HOWITT. In one volume, 12mo.

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THE BRIDGEWATER TREATISES

ON THE POWER, WISDOM, AND GOODNESS OF GOD AS MANIFESTED IN THE CREATION.

TREATISE III.

ON ASTRONOMY AND GENERAL PHYSICS.

BY THE REV. W. WHEWELL.

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ET HÆC DE DEO, DE QUO UTIQUE EX PHÆNOMENIS DISSERERE AD PHILOSOPHIAM NATURALEM PERTINET.

NEWTON, CONCLUSION OF THE PRINCIPIA.

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ASTRONOMY AND GENERAL PHYSICS

CONSIDERED WITH REFERENCE TO

NATURAL THEOLOGY.

BY THE

REV. WILLIAM WHEWELL, M. A.

FELLOW AND TUTOR OF TRINITY COLLEGE,

CAMBRIDGE.

Philadelphia:

CAREY, LEA & BLANCHARD,

CHESTNUT STREET.

1833.

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TO THE

RIGHT HONOURABLE AND RIGHT REVEREND

CHARLES JAMES,

LORD BISHOP OF LONDON.

MY LORD—

I owe it to you that I was selected for the task attempted in the following pages, a distinction which I feel to be honourable; and on this account alone I should have a peculiar pleasure in dedicating the work to your lordship. I do so with additional gratification on another account: the Treatise has been written within the walls of the College of which your lordship was formerly a resident member, and its merits, if it have any, are mainly due to the spirit and habits of the place. The society is always pleased and proud to recollect that a person of the eminent talents and high character of your lordship is one of its members; and I am persuaded that any effort in the cause of letters and religion coming from that quarter, will have for you an interest beyond what it would otherwise possess.

The subject proposed to me was limited: my prescribed object is to lead the friends of religion to look with confidence and pleasure on the progress of the

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physical sciences, by showing how admirably every advance in our knowledge of the universe harmonizes with the belief of a most wise and good God. To do this effectually may be, I trust, a useful labour. Yet, I feel most deeply, what I would take this occasion to express, that this, and all that the speculator concerning Natural Theology can do, is utterly insufficient for the great ends of Religion; namely, for the purpose of reforming men's lives, of purifying and elevating their characters, of preparing them for a more exalted state of being. It is the need of something fitted to do this, which gives to religion its vast and incomparable importance; and this can, I well know, be achieved only by that Revealed Religion of which we are ministers, but on which the plan of the present work did not allow me to dwell.

That Divine Providence may prosper the labours of your lordship, and of all who are joined with you in the task of maintaining and promoting *this* Religion, is, my lord, the earnest wish and prayer of

Your very faithful

And much obliged servant,

WILLIAM WHEWELL.

Trinity College, Cambridge,
Feb. 25, 1833.

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NOTICE.

THE series of Treatises, of which the present is one, is published under the following circumstances:

The RIGHT HONOURABLE and REVEREND FRANCIS HENRY, EARL OF BRIDGEWATER, died in the month of February, 1829; and by his last Will and Testament, bearing date the 25th of February, 1825, he directed certain Trustees therein named to invest in the public funds the sum of Eight thousand pounds sterling; this sum, with the accruing dividends thereon, to be held at the disposal of the President, for the time being, of the Royal Society of London, to be paid to the person or persons nominated by him. The Testator further directed, that the person or persons selected by the said President should be appointed to write, print, and publish one thousand copies of a work *On the Power, Wisdom, and Goodness of God, as manifested in the Creation; illustrating such work by all reasonable arguments, as for instance the variety and formation of God's creatures in the animal, vegetable, and mineral kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of other arguments; as also by discoveries ancient and modern, in arts, sciences, and the whole extent of literature.* He desired, moreover, that the profits arising from the sale of the works so published should be paid to the authors of the works.

The late President of the Royal Society, Davies Gilbert, Esq. requested the assistance of his Grace the Archbishop of Canterbury and of the Bishop of London, in determining upon the best mode of carrying into effect the intentions of the Testator. Acting with their advice, and with the concurrence of a nobleman immediately connected with the deceased, Mr. Davies Gilbert appointed the following eight gentlemen to write separate Treatises on the different branches of the subject as here stated:

THE REV. THOMAS CHALMERS, D. D.

Professor of Divinity in the University of Edinburgh.

ON THE ADAPTATION OF EXTERNAL NATURE TO THE MORAL AND INTELLECTUAL CONSTITUTION OF MAN.

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JOHN KID, M. D. F. R. S.

Regius Professor of Medicine in the University of Oxford.

ON THE ADAPTATION OF EXTERNAL NATURE TO THE PHYSICAL CONDITION OF MAN.

THE REV. WILLIAM WHEWELL, M. A. F. R. S.

Fellow of Trinity College, Cambridge.

ON ASTRONOMY AND GENERAL PHYSICS.

SIR CHARLES BELL, K. H. F. R. S,

THE HAND: ITS MECHANISM AND VITAL ENDOWMENTS AS EVINCING DESIGN.

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THE REV. WILLIAM BUCKLAND, D. D. F. R. S.

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ON GEOLOGY AND MINERALOGY.

THE REV. WILLIAM KIRBY, M. A. F. R. S.

ON THE HISTORY, HABITS, AND INSTINCTS OF ANIMALS.

WILLIAM PROUT, M. D. F. R. S.

ON CHEMISTRY, METEOROLOGY, AND THE FUNCTION OF DIGESTION.

His Royal Highness the Duke of Sussex, President of the Royal Society, having desired that no unnecessary delay should take place in the publication of the above mentioned treatises, they will appear at short intervals, as they are ready for publication.

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CONTENTS.

[Within the last year or two, several works have been published in this country on subjects more or less closely approaching to that here treated. It may, therefore, be not superfluous to say that the author of the following pages believes that he has not borrowed any of his views or illustrations from recent English writers on Natural Theology.]

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ON

ASTRONOMY

AND

GENERAL PHYSICS.

INTRODUCTION.

CHAPTER I.

Object of the Present Treatise.

THE examination of the material world brings before us a number of things and relations of things which suggest to most minds the belief of a creating and presiding Intelligence. And this impression, which arises with the most vague and superficial consideration of the objects by which we are surrounded, is, we conceive, confirmed and expanded by a more exact and profound study of external nature. Many works have been written at different times with the view of showing how our knowledge of the elements and their operation, of plants and animals and their construction, may serve to nourish and unfold our idea of a Creator and Governor of the world. But though this is the case, a new work on the same subject may still have its use. Our views of the Creator and Governor of the world, as collected from or combined with our views of the world itself, undergo modifications, as we are led by new discoveries, new generalizations, to regard nature in a new light. The conceptions concerning the Deity, his mode of effecting his purposes, the scheme of his

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government, which are suggested by one stage of our knowledge of natural objects and operations, may become manifestly imperfect or incongruous, if adhered to and applied at a later period, when our acquaintance with the immediate causes of natural events has been greatly extended. On this account it may be interesting, after such an advance, to show how the views of the creation, preservation, and government of the universe, which natural science opens to us, harmonize with our belief in a Creator, Governor, and Preserver of the world. To do this with respect to certain departments of Natural Philosophy is the object of the following pages; and the author will deem himself fortunate, if he succeeds in removing any of the difficulties and obscurities which prevail in men's minds, from the want of a clear mutual understanding between the religious and the scientific speculator. It is needless here to remark the necessarily imperfect and scanty character of Natural Religion; for most persons will allow that, however imperfect may be the knowledge of a Supreme Intelligence which we gather from the contemplation of the natural world, it is still of most essential use and value. And our purpose on this occasion is, not to show that Natural Theology is a perfect and satisfactory scheme, but to bring up our Natural Theology to the point of view in which it may be contemplated by the aid of our Natural Philosophy.

Now the peculiar point of view which at present belongs to Natural Philosophy, and especially to the departments of it which have been most successfully cultivated, is, that nature, so far as it is an object of scientific research, is a collection of facts governed by *laws:* our knowledge of nature is our knowledge of laws; of laws of operation and connexion, of laws of succession and co-existence, among the various elements and appearances around us. And it must therefore here be our aim to show how this view of the universe falls in with our conception of the Di-

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vine Author, by whom we hold the universe to be made and governed.

Nature acts by general laws; that is, the occurrences of the world in which we find ourselves, result from causes which operate according to fixed and constant rules. The succession of days, and seasons, and years, is produced by the motions of the earth; and these again are governed by the attraction of the sun, a force which acts with undeviating steadiness and regularity. The changes of winds and skies, seemingly so capricious and casual, are produced by the operation of the sun's heat upon air and moisture, land and sea; and though in this case we cannot trace the particular events to their general causes, as we can trace the motions of the sun and moon, no philosophical mind will doubt the generality and fixity of the rules by which these causes act. The variety of the effects takes place, because the circumstances in different cases vary; and not because the action of material causes leaves anything to chance in the result. And again, though the vital movements which go on in the frame of vegetables and animals depend on agencies still less known, and probably still more complex, than those which rule the weather, each of the powers on which such movements depend has its peculiar laws of action, and these are as universal and as invariable as the law by which a stone falls to the earth when not supported.

The world then is governed by general laws; and in order to collect from the world itself a judgment concerning the nature and character of its government, we must consider the import and tendency of such laws, so far as they come under our knowledge. If there be, in the administration of the universe, intelligence and benevolence, superintendence and foresight, grounds for love and hope, such qualities may be expected to appear in the constitution and combination of those fundamental regulations by which the course of nature is brought about, and made to be what it is.

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If a man were, by some extraordinary event, to find himself in a remote and unknown country, so entirely strange to him that he did not know whether there existed in it any law or government at all; he might in no long time ascertain whether the inhabitants were controlled by any superintending authority; and with a little attention he might determine also whether such authority were exercised with a prudent care for the happiness and well-being of its subjects, or without any regard and fitness to such ends; whether the country were governed by laws at all, and whether the laws were good. And according to the laws which he thus found prevailing, he would judge of the sagacity, and the purposes of the legislative power.

By observing the laws of the material universe and their operation, we may hope, in a somewhat similar manner, to be able to direct our judgment concerning the government of the universe: concerning the mode in which the elements are regulated and controlled, their effects combined and balanced. And the general tendency of the results thus produced may discover to us something of the character of the power which has legislated for the material world.

We are not to push too far the analogy thus suggested. There is undoubtedly a wide difference between the circumstances of man legislating for man, and God legislating for matter. Still we shall, it will appear, find abundant reason to admire the wisdom and the goodness which have established *the Laws of Nature*, however rigorously we may scrutinize the import of this expression.

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CHAPTER II.

On Laws of Nature.

When we speak of material nature as being governed by *laws*, it is sufficiently evident that we use the term in a manner somewhat metaphorical. The laws to which man's attention is primarily directed are *moral* laws; rules laid down for his actions; rules for the conscious actions of a person; rules which, as a matter of possibility, he may obey or may transgress; the latter event being combined, not with an impossibility, but with a penalty. But the *Laws of Nature* are something different from this; they are rules for that which *things* are to do and suffer; and this by no consciousness or will of theirs. They are rules describing the mode in which things *do* act; they are invariably obeyed; their transgression is not punished, it is excluded. The language of a moral law is, man *shall* not kill; the language of a Law of Nature is, a stone *will* fall to the earth.

These two kinds of laws direct the actions of persons and of things, by the sort of control of which persons and things are respectively susceptible; so that the metaphor is very simple; but it is proper for us to recollect that it is a metaphor, in order that we may clearly apprehend what is implied in speaking of the Laws of Nature.

In this phrase are included all properties of the portions of the material world; all modes of action and rules of causation, according to which they operate on each other. The whole course of the visible universe therefore is but the collective result of such laws; its movements are only the aggregate of *their* working. All natural occurrences, in the skies and on the earth, in the organic and in the inorganic world, are determined by the relations of the ele-

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ments and the actions of the forces of which the rules are thus prescribed.

The relations and rules by which these occurrences are thus determined necessarily depend on measures of time and space, motion and force; on quantities which are subject to numerical measurement, and capable of being connected by mathematical properties. And thus all things are ordered by number and weight and measure. "God," as was said by the ancients, "works by geometry:" the legislation of the material universe is necessarily delivered in the language of mathematics; the stars in their courses are regulated by the properties of conic sections, and the winds depend on arithmetical and geometrical progressions of elasticity and pressure.

The constitution of the universe, so far as it can be clearly apprehended by our intellect, thus assumes a shape involving an assemblage of mathematical propositions: certain algebraical formulæ, and the knowledge when and how to apply them, constitute the last step of the physical science to which we can attain. The labour and the endowments of ages have been employed in bringing such science into the condition in which it now exists; and an exact and extensive discipline in mathematics, followed by a practical and profound study of the researches of natural philosophers, can alone put any one in possession of the knowledge concerning the course of the material world, which is at present open to man. The general impression, however, which arises from the view thus obtained of the universe, the results which we collect from the most careful scrutiny of its administration, may, we trust, be rendered intelligible without this technical and laborious study, and to do this is our present object.

It will be our business to show that the laws which really prevail in nature are, by their *form*, that is, by the nature of the connexion which they establish among the quantities and properties which they regulate, remarkably adapted to the office which is as-

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signed them; and thus offer evidence of selection, design, and goodness, in the power by which they were established. But these characters of the legislation of the universe may also be seen, in many instances, in a manner somewhat different from the selection of the law. The *nature of the connexion* remaining the same, the quantities which it regulates may also in their *magnitude* bear marks of selection and purpose. For the law may be the same while the quantities to which it applies are different. The law of the gravity which acts to the earth and to Jupiter, is the same; but the intensity of the force at the surfaces of the two planets is different. The law which regulates the density of the air at any point, with reference to the height from the earth's surface, would be the same, if the atmosphere were ten times as large, or only one-tenth as large as it is; if the barometer at the earth's surface stood at three inches only, or if it showed a pressure of thirty feet of mercury.

Now this being understood, the adaptation of a law to its purpose, or to other laws, may appear in two ways:—either in the form of the law, or in the amount of the magnitudes which it regulates, which are sometimes called *arbitrary magnitudes.*

If the attraction of the sun upon the planets did not vary inversely as the square of the distance, the *form* of the law of gravitation would be changed; if this attraction were, at the earth's orbit, of a different *value* from its present one, the arbitrary magnitude would be changed; and it will appear, in a subsequent part of this work, that either change would, so far as we can trace its consequences, be detrimental. The form of the law determines in what manner the facts shall take place; the arbitrary magnitude determines how fast, how far, how soon; the one gives a model, the other a measure of the phenomenon; the one draws the plan, the other gives the scale on which it is to be executed; the one gives the rule, the other the rate. If either were wrongly taken, the result would be wrong too.

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CHAPTER III.

Mutual Adaptation in the Laws of Nature.

To ascertain such laws of nature as we have been describing, is the peculiar business of science. It is only with regard to a very small portion of the appearances of the universe, that science, in any strict application of the term, exists. In very few departments of research have men been able to trace a multitude of known facts to causes which appear to be the ultimate material causes, or to discern the laws which seem to be the most general laws. Yet, in one or two instances, they have done this, or something approaching to this; and most especially in the instance of that part of nature, which it is the object of this treatise more peculiarly to consider.

The apparent motions of the sun, moon, and stars have been more completely reduced to their causes and laws than any other class of phenomena. Astronomy, the science which treats of these, is already a wonderful example of the degree of such knowledge which man may attain. The forms of its most important laws may be conceived to be certainly known; and hundreds of observers in all parts of the world are daily employed in determining, with additional accuracy, the arbitrary magnitudes which these laws involve.

The inquiries in which the mutual effects of heat, moisture, air, and the like elements are treated of, including, among other subjects, all that we know of the causes of the weather (meteorology) is a far more imperfect science than astronomy. Yet, with regard to these agents, a great number of laws of nature have been discovered, though, undoubtedly, a far greater number remain still unknown.

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So far, therefore, as our knowledge goes, astronomy and meteorology are parts of natural philosophy in which we may study the order of nature with such views as we have suggested; in which we may hope to make out the adaptations and aims which exist in the laws of nature; and thus to obtain some light on the tendency of this part of the legislation of the universe, and on the character and disposition of the Legislator.

The number and variety of the laws which we find established in the universe is so great, that it would be idle to endeavour to enumerate them. In their operation they are combined and intermixed in incalculable and endless perplexity, influencing and modifying each other's effects in every direction. If we attempt to comprehend at once the whole of this complex system, we find ourselves utterly baffled and overwhelmed by its extent and multiplicity. Yet, in so far as we consider the bearing of one part upon another, we receive an impression of adaptation, of mutual fitness, of conspiring means, of preparation and completion, of purpose and provision. This impression is suggested by the contemplation of every part of nature; but the grounds of it, from the very circumstances of the case, cannot be conveyed in a few words. It can only be fully educed by leading the reader through several views and details, and must grow out of the combined influence of these on a sober and reflecting frame of mind. However strong and solemn be the conviction which may be derived from a contemplation of nature, concerning the existence, the power, the wisdom, the goodness of our Divine Governor, we cannot expect that this conviction, as resulting from the extremely complex spectacle of the material world, should be capable of being irresistibly conveyed by a few steps of reasoning, like the conclusion of a geometrical proposition, or the result of an arithmetical calculation.

We shall, therefore, endeavour to point out cases and circumstances in which the different parts of the

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universe exhibit this mutual adaptation, and thus to bring before the mind of the reader the evidence of wisdom and providence, which the external world affords. When we have illustrated the correspondencies which exist in every province of nature, between the qualities of brute matter and the constitution of living things, between the tendency to derangement and the conservative influences by which such a tendency is counteracted, between the office of the minutest speck and of the most general laws; it will, we trust, be difficult or impossible to exclude from our conception of this wonderful system, the idea of a harmonizing, a preserving, a contriving, an intending Mind; of a Wisdom, Power, and Goodness far exceeding the limits of our thoughts.

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CHAPTER IV.

Division of the Subject.

In making a survey of the universe, for the purpose of pointing out such correspondencies and adaptations as we have mentioned, we shall suppose the general leading facts of the course of nature to be known, and the explanations of their causes now generally established among astronomers and natural philosophers to be conceded. We shall assume therefore that the earth is a solid globe of ascertained magnitude, which travels round the sun, in an orbit nearly circular, in a period of about three hundred and sixty five days and a quarter, and in the mean time revolves, in an inclined position, upon its own axis in about twenty-four hours, thus producing the succession of appearances and effects which constitute seasons and climates, day and night;—that this globe has its surface furrowed and ridged with various inequalities, the waters of the ocean occupying the depressed parts:—that it is surrounded by an atmosphere, or spherical covering of air; and that various other physical agents, moisture, electricity, magnetism, light, operate at the surface of the earth, according to their peculiar laws. This surface is, as we know, clothed with a covering of plants, and inhabited by the various tribes of animals, with all their variety of sensations, wants, and enjoyments. The relations and connexions of the larger portions of the world, the sun, the planets, and the stars, the *cosmical* arrangements of the system, as they are sometimes called, determine the course of events among these bodies; and the more remarkable features of these arrangements are therefore some of the subjects for our consideration. These cosmical arrange-

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ments, in their consequences, affect also the physical agencies which are at work at the surface of the earth, and hence come in contact with *terrestrial* occurrences. They thus influence the functions of plants and animals. The circumstances in the cosmical system of the universe, and in the organic system of the earth, which have thus a bearing on each other, form another of the subjects of which we shall treat. The former class of considerations attends principally to the stability and other apparent perfections of the solar system; the latter to the well being of the system of organic life by which the earth is occupied. The two portions of the subject may be treated as Cosmical Arrangements and Terrestrial Adaptations.

We shall begin with the latter class of adaptations, because in treating of these the facts are more familiar and tangible, and the reasonings less abstract and technical, than in the other division of the subject. Moreover, in this case men have no difficulty in recognizing as desirable the end which is answered by such adaptations, and they therefore the more readily consider it *as an end.* The nourishment, the enjoyment, the diffusion of living things, are willingly acknowledged to be a suitable object for contrivance; the simplicity, the permanence, of an inert mechanical combination might not so readily be allowed to be a manifestly worthy aim of a Creating Wisdom. The former branch of our argument may therefore be best suited to introduce to us the Deity as the institutor of Laws of Nature, though the latter may afterwards give us a wider view and a clearer insight into one province of his legislation.

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BOOK I.

TERRESTRIAL ADAPTATIONS.

We proceed in this book to point out relations which subsist between the laws of the inorganic world, that is, the general facts of astronomy and meteorology; and the laws which prevail in the organic world, the properties of plants and animals.

With regard to the first kind of laws, they are in the highest degree various and unlike each other. The intensity and activity of natural influences follow in different cases the most different rules. In some instances they are *periodical*, increasing and diminishing alternately, in a perpetual succession of equal intervals of time. This is the case with the heat at the earth's surface, which has a period of a year; with the light, which has a period of a day. Other qualities are *constant*, thus the force of gravity at the same place is always the same. In some cases, a very simple cause produces very complicated effects; thus the globular form of the earth, and the inclination of its axis during its annual motion, give rise to all the variety of climates. In other cases a very complex and variable system of causes produces effects comparatively steady and uniform; thus solar and terrestrial heat, air, moisture, and probably many other apparently conflicting agents, join to produce our weather, which never deviates very far from a certain average standard.

Now a general fact, which we shall endeavour to exemplify in the following chapters, is this:—That

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those properties of plants and animals which have reference to agencies of a periodical character, have also by their nature a periodical mode of working; while those properties which refer to agencies of constant intensity, are adjusted to this constant intensity: and again, there are peculiarities in the nature of organized beings which have reference to a variety in the conditions of the external world, as, for instance, the difference of the organized population of different regions: and there are other peculiarities which have a reference to the constancy of the average of such conditions, and the limited range of the deviations from that average; as for example, that constitution by which each plant and animal is fitted to exist and prosper in its usual place in the world.

And not only is there this general agreement between the nature of the laws which govern the organic and inorganic world, but also there is a coincidence between the *arbitrary magnitudes* which such laws involve on the one hand and on the other. Plants and animals have, in their construction, certain periodical functions, which have a reference to alternations of heat and cold; the length of the period which belongs to these functions by their construction, appears to be that of the period which belongs to the actual alternations of heat and cold, namely, a year. Plants and animals have again in their construction certain other periodical functions, which have a reference to alternations of light and darkness; the length of the period of such functions appears to coincide with the natural day. In like manner the other arbitrary magnitudes which enter into the laws of gravity, of the effects of air and moisture, and of other causes of permanence, and of change, by which the influences of the elements operate, are the same arbitrary magnitudes to which the members of the organic world are adapted by the various peculiarities of their construction.

The illustration of this view will be pursued in

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the succeeding chapters; and when the coincidence here spoken of is distinctly brought before the reader, it will, we trust, be found to convey the conviction of a wise and benevolent design, which has been exercised in producing such an agreement between the internal constitution and the external circumstances of organized beings. We shall adduce cases where there is an apparent relation between the course of operation of the elements and the course of vital functions; between some fixed measure of time or space, traced in the lifeless and in the living world; where creatures are constructed on a certain plan, or a certain scale, and this plan or this scale is exactly the single one which is suited to their place on the earth; where it was necessary for the Creator (if we may use such a mode of speaking) *to take account* of the weight of the earth, or the density of the air, or the measure of the ocean, and where these quantities are rightly taken account of in the arrangements of creation. In such cases we conceive that we trace a Creator, who, in producing one part of his work, was not forgetful or careless of another part; who did not cast his living creatures into the world to prosper or perish as they might find it suited to them or not; but fitted together, with the nicest skill, the world and the constitution which he gave to its inhabitants; so fashioning it and them, that light and darkness, sun and air, moist and dry, should become their ministers and benefactors, the unwearied and unfailing causes of their well being.

We have spoken of the mutual adaptation of the organic and the inorganic world. If we were to conceive the contrivance of the world as taking place in an order of time in the contriving mind, we might also have to conceive this adaptation as taking place in one of two ways: we might either suppose the laws of inert nature to be accommodated to the foreseen wants of living things, or the organization of life to be accommodated to the previously established laws of nature. But we are not forced upon

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any such mode of conception, or upon any decision between such suppositions: since, for the purpose of our argument, the consequence of either view is the same. There is an adaptation somewhere or other, on either supposition. There is account taken of one part of the system in framing the other: and the mind which took such account can be no other than that of the Intelligent Author of the universe. When indeed we come to see the vast number, the variety, the extent, the interweaving, the reconciling of such adaptations, we shall readily allow, that all things are so moulded upon and locked into each other, connected by such subtilty and profundity of design, that we may well abandon the idle attempt to trace the *order* of thought in the mind of the Supreme Ordainer.

CHAPTER I.

The Length of the Year.

A YEAR is the most important and obvious of the periods which occur in the organic, and especially in the vegetable world. In this interval of time the cycle of most of the external influences which operate upon plants is completed. There is also in plants a cycle of internal functions, corresponding to this succession of external causes. The length of either of these periods might have been different from what it is, according to any grounds of necessity which we can perceive. But a certain length is selected in both instances, and in both instances the same. The length of the year is so determined as to be adapted to the constitution of most vegetables; or the construction of vegetables is so adjusted as to be suited to the length which the year really has, and unsuited to a duration longer or shorter by any

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considerable portion. The vegetable clock-work is so set as to go for a year.

The length of the year or interval of recurrence of the seasons is determined by the time which the earth employs in performing its revolution round the sun: and we can very easily conceive the solar system so adjusted that the year should be longer or shorter than it actually is. We can imagine the earth to revolve round the sun at a distance greater or less than that which it at present has, all the forces of the system remaining unaltered. If the earth were removed towards the centre by about one-eighth of its distance, the year would be diminished by about a month; and in the same manner it would be increased by a month on increasing the distance by one-eighth. We can suppose the earth at a distance of eighty-four or a hundred and eight millions of miles, just as easily as at its present distance of ninety-six millions: we can suppose the earth with its present stock of animals and vegetables placed where Mars or where Venus is, and revolving in an orbit like one of theirs: on the former supposition our year would become twenty-three, on the latter seven of our present months. Or we can conceive the present distances of the parts of the system to continue what they are, and the size, or the density of the central mass, the sun, to be increased or diminished in any proportion; and in this way the time of the earth's revolution might have been increased or diminished in any degree; a greater velocity, and consequently a diminished period, being requisite in order to balance an augmented central attraction. In any of these ways the length of the earth's natural year might have been different from what it now is: in the last way without any necessary alteration, so far as we can see, of temperature.

Now, if any change of this kind were to take place, the working of the botanical world would be thrown into utter disorder, the functions of plants

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would be entirely deranged, and the whole vegetable kingdom involved in instant decay and rapid extinction.

That this would be the case, may be collected from innumerable indications. Most of our fruit trees, for example, require the year to be of its present length. If the summer and the autumn were much shorter, the fruit could not ripen; if these seasons were much longer, the tree would put forth a fresh suit of blossoms, to be cut down by the winter. Or if the year were twice its present length, a second crop of fruit would probably not be matured, for want, among other things, of an intermediate season of rest and consolidation, such as the winter is. Our forest trees in like manner appear to need all the seasons of our present year for their perfection; the spring, summer, and autumn, for the developement of their leaves and consequent formation of their *proper juice*, and of wood from this; and the winter for the hardening and solidifying the substance thus formed.

Most plants, indeed, have some peculiar function adapted to each period of the year, that is of the now existing year. The sap ascends with extraordinary copiousness at two seasons, in the spring and in the autumn, especially the former. The opening of the leaves and the opening of the flowers of the same plants are so constant to their times, (their *appointed* times, as we are naturally led to call them,) that such occurrences might be taken as indications of the times of the year. It has been proposed in this way to select a series of botanical facts which should form a calendar; and this has been termed a *calendar of Flora*. Thus, if we consider the time of putting forth leaves,* the honeysuckle protrudes them in the month of January; the gooseberry, currant, and elder in the end of February, or beginning of March; the willow, elm, and lime-tree

* Loudon, Encyclopædia of Gardening, 848.

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in April; the oak and ash, which are always the latest among trees, in the beginning or towards the middle of May. In the same manner the flowering has its regular time: the mezereon and snowdrop push forth their flowers in February; the primrose in the month of March; the cowslip in April; the great mass of plants in May and June; many in July, August, and September; some, not till the month of October, as the meadow saffron; and some not till the approach and arrival of winter, as the laurustinus and arbutus.

The fact which we have here to notice, is the recurrence of these stages in the developement of plants, at intervals precisely or very nearly of twelve months. Undoubtedly, this result is in part occasioned by the action of external stimulants upon the plant, especially heat, and by the recurrence of the intensity of such agents. Accordingly, there are slight differences in the times of such occurrences, according to the backwardness or forwardness of the season, and according as the climate is genial or otherwise. Gardeners use artifices which will, to a certain extent, accelerate or retard the time of developement of a plant. But there are various circumstances which show that this recurrence of the same events and equal intervals is not entirely owing to external causes, and that it depends also upon something in the internal structure of vegetables. Alpine plants do not wait for the stimulus of the sun's heat, but exert such a struggle to blossom, that their flowers are seen among the yet unmelted snow. And this is still more remarkable in the naturalization of plants from one hemisphere to the other. When we transplant our fruit trees to the temperate regions south of the equator, they continue for some years to flourish at the period which corresponds to our spring. The reverse of this obtains, with certain trees of the southern hemisphere. Plants from the Cape of Good Hope, and from Australia, countries whose summer is simultaneous with our winter,

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exhibit their flowers in the coldest part of the year, as the heaths.

This view of the subject agrees with that maintained by the best botanical writers. Thus Decandolle observes that after making allowance for all meteorological causes, which determine the epoch of flowering, we must reckon as another cause the peculiar nature of each species. The flowering once determined, appears to be subject to a law of *periodicity* and habit.*

It appears then that the functions of plants have by their nature a periodical character; and the length of the period thus belonging to vegetables is a result of their organization. Warmth and light, soil and moisture, may in some degree modify, and hasten or retard the stages of this period; but when the constraint is removed the natural period is again resumed. Such stimulants as we have mentioned are not the *causes* of this periodicity. They do not produce the varied functions of the plant, and could not occasion their performance at regular intervals, except the plant possessed a suitable construction. They could not alter the length of the cycle of vegetable functions, except within certain very narrow limits. The processes of the rising of the sap, of the formation of proper juices, of the unfolding of leaves, the opening of flowers, the fecundation of the fruit, the ripening of the seed, its proper deposition in order for the reproduction of a new plant;—all these operations require a certain portion of time, and could not be compressed into a space less than a year, or at least could not be abbreviated in any very great degree. And on the other hand, if the winter were greatly longer than it now is, many seeds would not germinate at the return of spring. Seeds which have been kept too long require stimulants to make them fertile.

If therefore the duration of the seasons were much

* Dec. Phys. vol. ii. 478.

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