NATURE AND MAN

William B. Carpenter

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ESSAYS

SCIENTIFIC AND PHILOSOPHICAL

BY

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A MEMORIAL SKETCH.

WILLIAM BENJAMIN CARPENTER.

THE Essays contained in this volume represent chiefly the later phases of their writer's thoughts on the problems concerned with the interpretation of nature and man. Some of the conclusions which they embody he believed to be of high importance in the guidance of life; they were the result of long observation and reflection, and in some cases differed widely from the ideas which his early education and his first studies had led him to adopt. It is the aim of this sketch to indicate some of the processes which contributed to this change, and to present, as briefly as possible, the connection between Dr. Carpenter's widely varied work and the personality from which his many-sided energy flowed out. The long list of writings which bear his name exhibits an extraordinary range of labour; and the historians of different branches of science will come upon the traces of his activity in fields that are rarely cultivated by the same hand. It is not now desired to estimate the precise value of his numerous contributions to knowledge, but rather to show what were the hidden purposes and guiding aims of his life, what were the gifts of mind and heart which he brought to their fulfilment, and how these took outward shape and form.

I.

William Benjamin Carpenter was born at Exeter, on October 29, 1813. His father, Dr. Lant Carpenter, was then one of the pastors of George's Meeting; but the removal of the family from Exeter to Bristol, in 1817, when William was only in his fourth year, made the latter city the true home of his early life. It was there that the Rev. Dr. Carpenter's labours, which were to leave so deep an impress on all his children, bore their ripest fruit. Schools were created in connection with the congregation of Lewin's Mead; he took a prominent share in the foundation of the Literary and Philosophical Institution; he was an ardent promoter of Catholic Emancipation and Reform. This was, indeed, only the outer fringe of his home activities. To the work of his ministry he added the long and patient toil of the student, and the ceaseless diligence of the teacher. And the qualities which shone conspicuously through all these phases of his energy, his strong affections, his deep religious earnestness, his commanding sense of duty, his eager zeal for the public good, and especially for education, appeared in one after another of his family. William was his fourth child, and eldest son. Hardly less did the boy owe to his mother, a woman of unusual endowments of mind and heart, who fully shared the austere and high view of life characteristic of her Puritan ancestry. With few advantages of education, her native abilities had been, nevertheless, carefully cultivated; she had a vigorous and independent mind, which often made it a pleasure for the trained scientific investigator to ask her opinion of his most advanced speculations; and in the wisdom of her judgment, springing from the clear insight of a pure and tender heart, her children found again and again in their perplexities a secure repose.

To the education which he received under his father's superintendence, Dr. W. B. Carpenter always looked back with gratitude. Those who recall the tall spare figure and the iron-grey hair of his later years, will find it difficult to think of him as a child of rounded limbs and golden locks, who grew into a stout and chubby boy. In the home discipline no time was lost. He used to say that he "knew his "Latin grammar at five," though the extent of this knowledge was never defined; and he had already before that gained a firm mastery of certain external realities, to which he attached the highest value. In a discourse delivered in connection with University College, Bristol, in 1880, he recalled one of these items of early acquisition.

> Our whole fabric of geometrical knowledge is based upon ideal representation. My own feeling is very strong that all geometrical teaching ought to be from time to time shown to consist with actual objective facts. Going back to my own experience, I can remember the fact of our having in our nursery a box of cubes, which my father had happened to purchase from a lecturer who was disposing of some articles of the kind. The box of cubes was ten inches each way, and each cube an inch, and therefore the box contained a thousand cubes; and this plaything of our nursery has been of the greatest value to me through life, in giving me a conception of the relation of solids to each other, for I have found continually that young people who have learnt and can repeat glibly arithmetic tables, have not the least idea what these tables mean. Hence the importance of bringing the reasoning powers of the mind to bear upon the facts which observation reveals to us.

This was one of the aims which Dr. Lant Carpenter invariably held up before the boys under his care. His school was remarkable for the prominence assigned to the enforcement and illustration of scientific principles. This side of knowledge was more congenial to his son William than literary or historical culture. He acquired, indeed, a fair mastery of the classical languages, and retained to the last a warm affection for his Greek Testament. But his intellectual sympathies were enlisted rather by the air-pump and the geological cabinet than by Homer or Horace. He received a good grounding in mathematics, and formed a strong desire to become a civil engineer; he delighted (like his father) in construction of all sorts. A tradition still remains of a model of a ship made in the boys' workshop at the bottom of the garden; while a maturer effort, in which he was aided by Mr. W. J. Odgers, then a resident master in the school, produced "a most beautiful transparent instrument for showing the climates, which, being "rectified for any latitude, shows the length of the day and "night at the solstices and equinoxes, the altitude of the "sun at noon, and illustrates very well the reason why the "days are longer as we approach the higher latitudes." This love of workmanship remained with him in after-days. He fitted up his study with all sorts of small devices; and he had a penetrating insight into the most intricate machinery. But he was never able to give effect to his early preference for the profession of engineering.

The railway system had not then been developed, and no suitable opening presented itself for the indispensable and costly training. So he finally agreed to submit to the wishes of his family, and under the kind proposals of Mr. Estlin, a leading general practitioner in Bristol, and a member of his father's congregation,* resolved to devote himself to the study of medicine. His cherished hopes were

* Mr. Estlin was the son of the Rev. Dr. Estlin, the predecessor of Dr. Carpenter at Lewin's Mead. He was a man of wide scientific culture, and frequently lectured at the Bristol Institution and the Mechanics' Institution. He was specially eminent as an oculist; and weekly, for forty years, attended the Eye-dispensary which he founded. In later life he took a lead in philanthropic and religious movements.

relinquished for what seemed to him an obvious duty, though to the end of her life his mother regretted the sacrifice, and doubted whether it had been right to demand it. He set himself to work with a grim determination to make the best of it, and on July 2, 1827, he wrote to his sister Mary, whom he addressed as "Dear Sister soft Sea-urchin:"—

> I have been over to Mr. Estlin for an hour this morning, to learn about the weights and measures used in surgery, and he recommends me to come over every morning, when I can spare time for an hour, to vaccinate children, and to pull out their teeth, and to make up pills and medicines. I think I shall like it pretty well.

On his fifteenth birthday, in 1828, he was formally apprenticed. He sent a mock account of the proceedings to his sister, adding—

> I am telling you all these things in a humorous way, but I assure you I felt it very much; and at the end of the day, when I had time for quiet reflection, I formed many resolutions, which I hope I shall have strength and faith to carry into execution.

The beginning of a professional career did not, however, wholly remove him from the school. But he remains rather to teach than to learn. He discourses to the boys on chemistry, and hears his younger brother, Philip, his Latin. His mind is cultivated through the various lectures at the neighbouring Institution, and the books and reviews which pass in turn through the Reading Society. One of these awakens his early interest with a first attempt at demonstrating the correlation of the physical forces.

> There is a book come into the society (he announces to his "dear old Poll"), Mr. Exley's "New Theory of Matter," by which he explains all the attractions of gravitation, cohesion, electricity—chemical, magnetic, etc.,—upon the same principles. Mr. Exley read a paper at the Institution, in which

he gave an outline of his theory, which greatly excited my curiosity to see the book.

The consciousness of power is increasing within him, and the longing to exercise it. He is in his sixteenth year, and so in May, 1829, he communicates his plan to the same "dear old Poll," with a droll touch of boyish self-justification for so forward a step.

> I am thinking about delivering some lectures on optics at the Mechanics' Institution next winter. I shall be glad if you will give me your opinion about it when you write next. I have paid a good deal of attention to optics lately, and feel myself pretty well qualified to do it, so far as information is concerned. I am grown a good deal during the past year, and look more of a man than I did.

The manly look, indeed, came early enough; his speedy absorption in severe intellectual labour gave to his demeanour a gravity which caused him to be habitually regarded as older than he really was. Moreover, a serious illness completely altered his appearance, and the plumpness which he lost he never regained.

It was greatly to William Carpenter's advantage that while he was prosecuting his medical studies under Mr. Estlin, and subsequently at the Bristol Medical School and the Infirmary, he remained in close connection with the home circle in Great George Street. There he learned, under his father's guidance, to take an active interest in public affairs; and the incidents connected with the Bristol riots in October, 1831, left an ineffaceable impression in his mind. The boys' school had by that time been given up, and his mother and sisters had opened a girls' school instead. They felt in no danger, but it fell to him to escort a number of neighbours to a place of safety in Clifton, and as he looked back over the city, lighted with the blazing glare of gaol and custom-house, Mansion-house and

Bishop's Palace, he received a lesson which he never forgot. In the slavery question he was also trained to take a lively interest; but his views on the subject of emancipation were somewhat modified by a few months' stay in the West Indies, during the year 1833, as the companion of Mr. Estlin, whose health required a sojourn in a warm climate.

It was his first long separation from his family, and the closely written sheets which he sent back to England, bore witness to the strength of the feeling to which he had felt unable at parting to give expression. On his first Sunday on board ship, his thoughts go out with longing to the dear circle singing their evening hymn in the library, perhaps (in remembrance of him) to one of his favourite tunes; his minute observations on sky and sea, and on the beautiful landscapes of St. Vincent, are all illustrated by familiar comparisons with objects nearer home. The estate on which he resided was remarkably well managed, and he was greatly struck with the physical comfort of the slaves, contrasted with their total want of mental and moral culture. This degradation of character filled him with far greater horror than the loss of personal liberty.

> What I have hitherto seen does not in the least diminish, but rather increases, my aversion to slavery; but the causes of it are certainly altered, and I am led to make more allowance for the planters, when I see more plainly the difficulties by which they are surrounded.

To this experience he frequently recurred in after-life when he was tempted himself, or saw others tempted, to a sternness of judgment which wider knowledge might have modified: "We should learn," he said, "to be tolerant of "others' intolerance." On his return in the summer, the record of his observations was communicated by his father to one of his Parliamentary friends, who was so much struck by them that he sent them on to Mr. Stanley (afterwards Lord Derby), then in charge of the Government Emancipation Bill, just passing through the House of Commons. But the clause which they chiefly affected had been already adopted.

The medical studies interrupted by the voyage to the West Indies were resumed for another session in Bristol; but in the autumn of 1834, William Carpenter proceeded to London. There he attended lectures at University College—sometimes as many as thirty-five in a week—and medical and surgical practice at the Middlesex Hospital, where he acted for a time as clinical clerk to Dr. Watson. Widening the ordinary range of professional study, he entered for the course delivered by Dr. Grant on Comparative Anatomy; and to this he afterwards looked back with peculiar interest, not only for the information which he gained through it, but for the mental quickening and special love of the subject which it roused within him. In the meanwhile the severity of his studies was relieved by the one pursuit which in later years afforded him unfailing recreation, his music.

> You ask me (he wrote to his brother Russell) how I get on with my music. I consider pretty well, seeing that I am entirely a self-taught genius. My instrument is a seraphine, which is made with keys like a piano or organ, and sounds by small reeds like those of the mouth-æolians, which you may remember, only better tuned, and worked by bellows. I chose it in preference to a piano, because it has exactly the touch of the organ, which it is my great ambition some time or other to play.

Then came the inevitable examinations, with the natural comments of a successful candidate, not perhaps forgotten when in later days he himself sat in the examiner's chair.

To R. L. Carpenter.

London, October 24, 1835.

I am now a member of the Royal College of Surgeons, and a Licentiate of the Apothecaries' Company. I passed through the latter examination a month ago, and the other last night. In both cases I had the felicity of kicking my heels in the waiting-room for more than five hours, and you may suppose the state of agitation I was in when summoned into the awful room. . . . The College was much the most awful of the two, as only one candidate was examined at a time, whilst ten of the first surgeons in London were weighing every word I said, sitting at a long cross-table, so that all looked me in the face. However, I did not see any of them through fright, except Sir Benjamin Brodie, who examined me. . . . It was rather curious that I spent the last week before going up to the Hall in getting up a quantity of technical knowledge of which I was *asked nothing*, whilst the subject I was most questioned on at the College I had looked over just before leaving Regent Street, and therefore had it all *pat*. Indeed, Sir Benjamin Brodie complimented me upon the attention I had paid to the subject, which I really knew little of compared with other points, and I was continually afraid lest he should get out of my depth. So much does chance govern affairs of this kind.

He was on the eve of starting for Edinburgh, where new companionships were to be formed, which would profoundly affect his subsequent course. But he had already his own plans, for he confided to his brother his intention of publishing the next year a little work on the philosophical study of Natural History. And he had just received what was to be one of the most powerful and enduring of the intellectual impulses of his whole life. It was a somewhat curious coincidence that it should come indirectly through the American philanthropist whose recent visit to Bristol had so deeply stirred his sister Mary.*

* See the "Life and Work of Mary Carpenter," chap. ii.

I had a pleasing little *pignus* from Dr. Tuckerman lately (he wrote to his brother Russell, in the letter just quoted), as he desired my father to lay out a sovereign owed by him to Dr. Tuckerman in a book for me. I chose Lyell's "Geology." I have been much interested in reading his third book "On the Distribution of the Animal Kingdom."

To this treatise he ever afterwards felt himself most deeply indebted. In returning thanks for the Lyell medal, which was awarded to him in 1883, in recognition of the value of his investigations into the minute structure of various fossil Invertebrates, and his deep-sea researches, he thus referred to this early influence :—

This distinction is yet more gratifying to me from its having been founded by one whom I have held in the highest honour from my boyhood, when (as I well remember) I heard Charles Lyell spoken of as a young man who was advancing in the Geological Society doctrines of a most heretical kind, but was defending them so ably as to hold his own against the most weighty opponents. The study of his "Principles" was not only the delight of my youth, but a most valuable part of my scientific training; and the privilege of subsequent intercourse with him through nearly forty years was one which I ever highly esteemed; for whilst it brought me under the immediate influence of his philosophic spirit, it also afforded me the continual stimulus of his kindly encouragement. I would recall a little incident which is doubly illustrative. When, in 1855, I made my monograph of the genus Orbitolites the basis of a disquisition on the general subject of the variability of species (a doctrine impressed on me by Dr. Prichard), I sent him a copy of the memoir (published in the "Philosophical Transactions"), with a sort of apology for having tried to make so much out of what might be thought so small and trivial a subject; he replied with a most kindly approval of the object and manner of my work, adding "any single point is really the universe,"—a remark whose pregnancy left an impression on my mind that time has only deepened.

Beside the influence of Lyell's "Principles" must be set that of another writer no less eminent, Sir John Herschel, whose "Preliminary Discourse on the Study of Natural Philosophy" contributed another potent element to the formation of William Carpenter's intellectual character. Just before his departure from London to Edinburgh, at the end of October, 1835, he wrote to his parents—

> I quite agree with you in all your feelings respecting the valuable influence of my stay here upon me. I feel, however, that the high standard I have set myself of intellectual excellence is no small assistance to religious principle; and I should say that I have derived more benefit in a moral point of view from Sir John Herschel's book than from any other than my Bible.

II.

To his residence at Edinburgh, William Carpenter always looked back afterwards with deep and abiding pleasure. He formed there some of the most valued of his friendships; he laid the foundations of some of his most fruitful work; he felt a more vivid mental stimulus from the society around him than he had found in London; and he gained a heightened confidence in his powers. He carried with him letters to some of the most eminent teachers of the University, and the leaders of the literary and scientific coteries of the Northern Athens. One of his first visits was paid to Professor Wilson, who had been a class-mate of Dr. Lant Carpenter's, at Glasgow. The following account of it in due time found its way to Bristol:—

> Edinburgh, November 15, 1835.
>
> I was not a little astonished to be introduced to a very wild-looking man, with a velveteen shooting-coat, and his hair straying down his shoulders in all directions, looking as little as possible like a professor of moral philosophy. . . . On a little

conversation, he discovered me to be the son of his old fellow-student, and we began to talk about Dr. Blair, with whom he keeps up a correspondence. He subsequently asked me to dinner, where I met Taylor (author of "Philip van Something"), who was the lion of the last London season, Professors Pillans and Muir, and some more intelligent men. Wilson and Taylor had some interesting conversation on Wordsworth, which would have delighted Mary. Both seemed to think him too minute in describing nature, and that he has been very much soured by his early want of success. They also began to discuss the various translations of "Faust," and, the conversation turning on Goethe in general, I was able to edge in a word as to his having been the first propounder of the doctrine of morphology in plants. Professor Muir and I fell out about the date of this production. I set it as far back as 1795, but allowed that it was not noticed until at least fifteen years later. Professor Muir was positive that it was not more than twenty years ago. I, of course, yielded, but had the satisfaction when I returned home, on referring to Lindley, to see that it was 1790.

Many friendly houses were soon open to the young Bristol student, who found more sympathy with his heresy than he expected; for he wrote shortly after: "As far as I "have seen, the moderate party of the Scotch Church are "extremely liberal, and I believe that many of them are "Unitarians at the bottom." But he was astonished at the superior freedom from conventional restraints which marked the education of women; and though he had been accustomed to see his own sisters trained in the principles of science, and familiar with the fossils or the shells in their own cabinet, yet an extension of the same method of education caused him an amusing shock.

The tone of society (he wrote to his father) is certainly much more well-informed here than in London. At least, there is less reserve among the ladies with regard to scientific pursuits, which many pursue here to an extent which even I think hardly feminine; such as practical (hammer-in-hand) geology, practical chemistry in classes—a row of young ladies performing experiments all at the same time, like a company of soldiers going through the exercise.

The subject remained in his mind, for he recurred to it a few weeks later:—

> I should be very sorry to see women restraining their natural feelings by reason and philosophy as much as men ought to do. I have often been afraid myself lest too close attention to scientific subjects should blunt my natural feelings; and I should think that the new-fashioned system of female education might be in danger of making the pupils too much matter-of-fact.

Shortly after his arrival in Edinburgh, William Carpenter joined the Medical Society, formed in connection with the University, and at once began to take an active part in its debates. "I find it exceedingly useful," he said, in writing home; "and in nothing more so than in showing me my "deficiencies, for I find many here who in purely professional "knowledge are far before me." His mind at this time preferred to dwell on large and general conceptions, to discover analogies, to follow out principles, rather than to come into close contact with actual facts. He was capable, as many of his subsequent writings showed, of minute and laborious investigations; and he could marshal details with singular skill as soon as he could reduce them into classes. But though his memory was well-trained and retentive, it did not easily assimilate much of the material presented to him in the lecture-room, or prescribed for an examination. When the news reaches him of the college successes of his younger brothers, Russell and Philip, "Alas, poor me!" he exclaims (July 4, 1836), "I seem doomed to get no prizes." But he adds: "However, it does not make me despair of "myself, for I feel a good deal more confidence in my powers, "if I have strength to exert them, than I have ever done;

"and, I believe I may say, a well-grounded confidence." Three weeks later he, too, can announce an addition to the family honours: "I had the pleasure this morning of re-"ceiving a gold medal as a prize for an essay on a depart-"ment of Physiological Botany."

By this time he had fairly entered on the labours of authorship. These were not indeed lightly undertaken. His home-training had impressed him with a serious and steadfast purpose; and while circumstances had led him to the profession of medicine, in which he had no expectation of special success, he had embraced the study of science with a vivid moral ardour which gave it, for him, the force of a vocation. This vocation he sedulously nourished; he threw into it the whole power of his being. The life of Kepler awakened in him an eager and enthusiastic devotion; and he recurred to it again and again long afterwards as a support in protracted and perplexing inquiries. A collection of passages from the works of Herschel, Whewell, Mrs. Somerville, Channing, and other writers, entered in his commonplace-book, reveals some of the guiding motives of his thought; one of these, to which he often referred through half a century of teaching and research, is here subjoined. It was derived from a Lecture on Universal History by Schiller, with whose life and spirit he was acquainted through the pages of Carlyle.

> Just as sedulously as the trader in knowledge severs his own peculiar science from all others, does the lover of wisdom strive to extend its dominion and restore its connection with them. I say to restore, for the boundaries which divide the sciences are but the work of abstraction. What the empiric separates, the philosopher unites. He has early come into the conviction that in the dominion of the intellect, as in the world of matter, everything is linked and commingled, and his eager longing for universal harmony and agreement cannot be satisfied by fragments. All his efforts are directed to the perfecting of his

knowledge; his noble impatience cannot be restrained till all his conceptions have arranged themselves into one harmonious whole, till he stands at the central point of arts and sciences, and thence overlooks the whole extent of their dominion with a satisfied glance. New discoveries in the field of his activity, which depress the trader in science, enrapture the philosopher. Perhaps they fill a chasm which the growth of his ideas had rendered more wide and unseemly, or they place the last stone, the only one wanting to the completion of the structure of his ideas. But even should they shiver it into ruins—should a new series of ideas, a new aspect of nature, a newly discovered law in the physical world, overthrow the whole fabric of his knowledge, *he has always loved truth better than his system*, and gladly will he exchange her old and defective form for a new and fairer one.

Under such intellectual impulses as these, he had conceived the idea, while still only in his twenty-second year, of a work which should serve as an introduction to the philosophical study of Natural History. The treatises of the day appeared to him deficient in grasp of the underlying principles of physiological science; they were filled with facts and observations which were sometimes ill understood, because their true relations were only imperfectly apprehended. He boldly grappled with the difficulty, and resolved to aim at nothing less than a general view of the entire realm of organic nature, so as to set forth the fundamental laws which might be discerned in the life alike of plants and animals. His thoughts had been playing round special questions in this wide domain as far back as his voyage to the West Indies. The subject haunted him during the session which he spent at University College, and rose into a positive though immature design. His first printed paper, published before he left London, in the *West of England Journal*, October, 1835, dealt with "The Structure and Functions of the Organs of Respiration in the Animal and Vegetable Kingdoms."* Starting from the recognized

* It was continued in January, 1836.

facts of chemistry, comparative anatomy, and physiology, he dwelt at length on the analogy between the forms of the respiratory apparatus in the two great classes; he showed that it held good with regard to their functions also, and he even extended it to digestion. Nor did he fail to point out the simplicity and uniformity of the processes into which these apparently complicated phenomena might be resolved, and the similarity of the means by which they were carried into effect.

The theme thus started continued to occupy his mind while he was pursuing his professional studies at Edinburgh, in the University and the Infirmary, under Professors Alison and Christison. Immediately after his arrival, he had reported to his sisters, in November, 1835, the actual commencement of his cherished project.

> I have begun to work at *my book*, and have nearly finished the organs of support, in which I shall bring forward a number of most beautiful analogies which Roget has omitted from his evident ignorance of Vegetable Physiology. I shall read it soon as a paper at the Royal Medical Society, of which I am a member. I think these debates will be of great service to me, as they evidently are of a very high character.

This central idea, accordingly, runs through the essays of the next few years, which contain the germs of various biological principles destined to receive clearer enunciation afterwards from himself and others. In the summer of 1836, he is already in communication with Dr. (subsequently Sir John) Forbes, who had enrolled him among the contributors to the recently established *British and Foreign Medical Review*. Dr. Forbes had entrusted to him a number of new books on vegetable physiology; but the reviewer told his father (July 4, 1836) that his essay would be "principally devoted to pointing out the analogies "between animals and vegetables, and the advantages of "studying general physiology or the most universal laws of "life, before applying to any particular branch." This purpose was thus vindicated in the article, which did not appear until July, 1837.

> We should be glad to see the science of physiology based upon a more extensive generalization of the phenomena of vitality than has usually been thought necessary: the study of comparative anatomy is now recognized as the surest means of arriving at accurate results on many disputed questions, since the different forms of animals may be regarded, to use the language of Cuvier, as "so many kinds of experiments "ready prepared by Nature." Vegetables present us with a greater simplification of the vital functions than is afforded by the lowest animal, since all the changes necessary to the support of the individual and the continuance of the species are performed without the influence or interference of those powers which are possessed in a greater or less degree by the whole animal kingdom. Hence the physiologist may advantageously resort to the study of vegetable life for the explanation of many of the proximate causes of those phenomena which are complicated in the higher forms of organized beings by so great a variety of secondary influences.

The purpose here implied received further illustration in two essays, produced in March and April, 1837, on "The Voluntary and Instinctive Actions of Living Beings," and on "The Unity of Function in Organized Beings." In the first of these, William Carpenter (who had now become President of both the Royal Medical and the Royal Physical Societies) sought a common ground of action in the irritability or contractility which he recognized as a vital property of vegetable tissues equally with those of animals. But the paper was further remarkable for its analysis of the functions of the nervous system in the higher vertebrates, in which the writer opened a path for his future researches in "mental physiology." The second paper was designed to apply to *function* one of the laws propounded by Von Baer with regard to *structure*,—"a special function "arises only out of one more general, and this by a gradual "change;" to which the Edinburgh student added another, —"in all cases where the different functions are highly "specialized, the general structure retains, more or less, the "primitive community of function which originally charac-"terized it." In working out these principles, the writer sketched "an outline of the doctrine of unity of function "with regard to the changes essential to the maintenance of "individual organisms, both of plants and animals;" and finally expressed his belief that "even in tracing the gradual "development of the functions peculiar to animals, namely, "sensation and voluntary motion, we may find that the "special type is evolved from one more general."

After reading these papers before the Royal Medical Society, William Carpenter returned to Bristol. He had already lectured in Edinburgh, on Natural History, making his appearance, on one occasion, to his extreme disgust, at Wombwell's menagerie, where he was expected, in accordance with a precedent set by a former lecturer—"like "myself, very respectable"—to meet his class before the cages of the wild-beast show. He had now to deliver his first course as lecturer on Medical Jurisprudence at the Bristol Medical School, and he began at the same time the actual practice of his profession. His leisure hours, however, were devoted to his scientific pursuits, and he became a competitor for the Students' Prize, raised by the students, and adjudged by certain of the Professors at Edinburgh. The subject (proposed by Professor Alison) was highly congenial to him, "On the Difference of the Laws regulating Vital and Physical Phenomena." * In language whose clearness showed how clearly he had already trained him-

* His essay proved successful; he devoted the prize (£30) to the purchase of a microscope, and from that time microscopic research continued to absorb more and more of his attention.

self to think, he laid down the meaning of the word *law*, and its place in science.

> The term *law* expresses the *conditions of action* of the properties of matter. In our study of the phenomena of nature, it is our object to ascertain their laws by the inquiry into the conditions under which the occurrences present themselves; and a *law* deduced from this source is nothing more than a general expression of the conditions common to a certain class of phenomena, leading us to the belief that under the same conditions the same phenomena will constantly occur. When this is found to be the case by the experimental application of the law to unknown cases, the law is said to be verified, and it may then fairly rank as a general fact to be included with others of like standing in a still higher expression of the conditions common to all these, and therefore to all the particular instances included in them. By successive generalizations of this nature, we aim to ascend from the most complicated and restricted to the most simple and universal statement of the phenomena of the universe; and in so far as this is attained in every science, giving us the means not only of explaining new phenomena as they arise, but of predicting otherwise unexpected occurrences, *that* science may be regarded as perfect.

Starting from this view of Law, the essayist affirmed (in words afterwards quoted by Dr. Roget, in his article, "Physiology," in the "Encyclopædia Britannica") that "there is nothing essentially different in the *character* of the "laws regulating vital and physical phenomena, either as to "their comprehensiveness, their uniformity of action, or the "mode in which they are to be established by the general-"ization of particular facts." He recognized a practical distinction between the properties of inorganic matter and those of living organized matter; but he declared that "the properties of any aggregation of matter depend upon "the method in which its ultimate molecules are combined "and arranged;" that "the vital properties of organized "tissues are not less the result of their material constitu-"tion;" and that "vital properties are not added to matter "in the process of organization; but those previously existing "and hitherto inactive are called out and developed." He ventured, therefore, on the speculation that "the vital and "physical properties of matter may ultimately be shown to "result from some higher, more general quality; an advance "in the path of philosophy, should it ever be proved, far "beyond any which has been already attained, or which we "have in immediate prospect."

The same thought is developed in an article published in the *British and Foreign Medical Review*, in April, 1838, entitled "Physiology an Inductive Science," criticizing the portion of Dr. Whewell's "History of the Inductive Sciences," which relates to that subject. A few passages from this essay, which was much admired at the time, will be found on a later page of this volume.* They strike the keynote of much of his subsequent "Philosophy of Nature."

Side by side with this article, in the same number of the *Review*, stood another from the same busy pen, more than fifty pages in length, on "The Physiology of the Spinal Marrow." It contained a full treatment of the doctrine of reflex action, then recently propounded as new by Dr. Marshall Hall; and it was generally accepted by competent judges as a fair statement of the aspect which the question presented at that date, though it did not give satisfaction to Dr. Hall. The author was recognized as having placed the discussion upon a broader basis, as regards both the general doctrines of the Physiology of the nervous system and their history, than that to which Dr. Hall had been himself disposed to restrict it.

Such were the preliminary labours by which the young man of twenty-four prepared for the accomplishment of

* See p. 155.

his long-cherished design. He was now anxious to get a lectureship, which might enable him to devote himself unreservedly to the pursuit of Physiology. The Bristol meeting of the recently established British Association for the Advancement of Science, in 1836, had brought him into connection with the leading men of various departments. Dr. Forbes proved a most kind and faithful promoter of his advance. In the spring of 1838 he tells his brother Russell that he has been to London to ascertain the probability of his getting an appointment as teacher of his favourite science, and that Sir James Clarke, Principal Physician to the Queen, is interesting himself much in his prospects. And he adds, "By the advice of my friends, I "am now working vigorously at my book on 'General and "Comparative Physiology,' for publication in the autumn."

To this task he now girded himself up in earnest. It was a bold attempt for so young a man, for it aimed at surveying the entire field of what is now termed Biology. He described it himself as an introduction to the study of human physiology, and a guide to the philosophical pursuit of natural history. Its enormous range—for it began with a description of the whole animated world—made it impossible for him to have himself verified the statements which he was obliged to take on trust. Its originality lay rather in the effort which it made to view the science of life as a unity, and lay down some simple and universal laws. Looking back upon it from the more advanced position of a quarter of a century later, the author said of it, that the novelty of its plan and the general merits of its execution obtained for it a more favourable reception than might have been justified by a severe scrutiny; his knowledge had been drawn rather from books than from nature; he had systematized the facts collected by others, rather than added to the store by independent research. Yet ever in its first crudity he believed that the work was of service in giving a scientific direction to the studies of others, just as the preparation of it had consolidated his own. In subsequent editions it was entirely re-written, enlarged, and modified. Two thoughts may here, however, be named, for the sake of their bearing on his future views. Doctrines of "progressive development" and evolution were already vaguely in the air; and he applied them to the evolution of structure in the following passage:—

> In the early stages of formation in every animal or vegetable, we may observe as great a dissimilarity to its ultimate condition as exists between the lower and higher members of each kingdom. And if we watch the progress of evolution, we may trace a correspondence between that of the germ in its advance towards maturity, and that exhibited by the permanent conditions of the races occupying different parts of the ascending scale of creation. This correspondence results from the operation of the same law in both cases. If we compare the forms which the same organ presents in different parts of the series, we shall always observe that it exists in its most general or diffused form in the lowest classes, and in its most special and restricted in the highest, and that the transition from one form to the other is a gradual one.

Secondly, he criticized the principle which Cuvier and other writers had endeavoured to erect into a law, under the name of the "harmony of forms." It implied that there was a specific plan, not only for the formation, but for the combination of organs; that there was a constant harmony between organs apparently the most remote, and that the altered form of one was invariably attended with a corresponding alteration in the others. But, argued William Carpenter—

> A little consideration will show that the existence of this adaptation of parts is nothing more than a *result* of other laws of development. It is evident that if it were deficient, the race must speedily become extinct, the conditions of its existence

being no longer fulfilled; these conditions being, for the whole organism, what the vital stimuli already described are for its individual properties. . . . The statement above given cannot, therefore, be regarded as a *law*, since it is nothing more than the expression, in an altered form, of the fact that as the life of an organized being consists in the performance of a series of actions, which are dependent on one another, and all directed to the same end, whatever seriously interferes with any of those actions must be incompatible with the maintenance of existence.

Thus was a young naturalist already feeling after the doctrine afterwards to be formulated as the "survival of "the fittest." The principle implied in his view led immediately to a striking modification in the doctrine of design, as it had been taught since the days of Paley.

Those who have dwelt most upon this adaptation of the structure of living beings to the external conditions in which they exist, appear to have forgotten that these very conditions might be regarded with just as much propriety as specially adapted to the support of living beings. We have as much ground to believe that this earth, with all its varieties of season, temperature, light, moisture, etc., was adjusted for the maintenance of plants and animals upon its surface, as that these plants and animals were created in accordance with its pre-existing circumstances. The Natural Philosopher does not regard it as a sufficient explanation of the astronomical or meteorological changes which he witnesses, that they are for the benefit of the living inhabitants of the globe, and yet, as it has been already shown, they furnish conditions of vital action as important as those afforded by organized structure. The Philosophical Anatomist, therefore, does not regard the object or function of a particular structure as a sufficient account of its existence; but in attaining the laws of its formation independently of any assumption of an end, he really exhibits the primary design in a much higher character, than in deducing it from any limited results of its operation.

Shortly after the publication of this treatise, William Carpenter proceeded to Edinburgh, where an alteration in the University regulations enabled him to graduate by three months' additional residence. Once more on the students' bench, in the winter of 1839, he had the pleasure of hearing his book quoted in class with high approval by the Professor. There, moreover, he renewed old friendships, and took his place again at the meetings of the Royal Medical Society, to which he read the dissertation afterwards sent in for his degree of Doctor of Medicine. He chose for his subject "The Physiological Inferences to be deduced from the Structure of the Nervous System of Invertebrated Animals." Like his earlier productions, this was based less upon results of original anatomical or experimental inquiry, than upon facts already determined. But he gave a fresh interpretation of these facts: he showed that the doctrines hitherto taught by Dr. Grant and Mr. Newport, for example, were inconsistent with them; and he proceeded to apply to the nervous systems of articulated and molluscous animals the principles of reflex action, of which he had already elsewhere discussed the higher forms. His views were at once adopted by Professor Owen and other eminent physiologists. Mr. Newport, indeed, at first contested them, but subsequent inquiry convinced him of the correctness of his critic's position, which he frankly adopted in a Memoir published in the *Philosophical Transactions* for 1843.

From Edinburgh, Dr. W. B. Carpenter returned to Bristol, to resume his lectures at the Medical School, and to make another effort to acquire a practice. He found himself among a circle of friends whose varied tastes and powers in some degree compensated him for the loss of the intellectual stimulus of the northern University. To Dr. Prichard, the author of the well-known "Physical History of Mankind," who resided in the old Elizabethan mansion known as the Red Lodge,* he looked up with almost filial

* Afterwards converted by Mary Carpenter into a Reformatory for Girls.

reverence and gratitude. In his old master, Mr. Estlin, he had the kindest and most judicious of counsellors. From Mr. Stutchbury, the curator of the Museum in the Philosophical Institution, he derived many a valuable fact in natural history. The refined and cultivated companionship of Dr. Symonds, afterwards the leading physician of the West of England, and the beautiful musical skill of the Rev. S. C. Fripp,* who played the organ at the Lewin's Mead Chapel, ministered to a different side of his nature. And another intimacy belonging to this period was a source of great pleasure to him in after-years, when circumstances again brought the two men together,—his acquaintance with Mr. Francis William Newman, under whom his brother Philip had studied at the Bristol College. When proposals were started for removing Manchester New College from York to Manchester, and it was known that this step would involve the loss of the services of Mr. Kenrick, its eminent teacher in the languages and literature of antiquity, Dr. W. B. Carpenter wrote to his brother Russell in the following terms:—

November, 1839.

I wish, when you see Mr. Martineau, you would mention Mr. Newman to him as classical tutor. He would also undertake mathematics. I do not know whether it is considered essential to have all Unitarians, but Mr. Newman is, I believe, nearer one than anything else, and I cannot imagine any greater advantage to the College than to have such a mind as his in connection with it. Freedom of inquiry is his leading principle. You know how logical he is, and what a beautiful spirituality there is in his character.†

The practice which Dr. W. B. Carpenter had now resolved to seek, was not, however, easy to find. His

* Mr. Fripp, father of the well-known artists, George and Alfred Fripp, had left the Church of England on theological grounds.

† The arrangement here suggested was, some time after, carried into effect.

reputation as a writer proved rather injurious than beneficial to him. Moreover, he longed more and more to devote himself to the pursuit and exposition of scientific truth, and he found the distractions of professional work in the highest degree irksome. Besides the difficulties rising from such interruptions, he was peculiarly susceptible to the feeling of responsibility in connection with his cases. They haunted him painfully, and he could not put them aside. He was often ready enough in other relations to incur responsibility without flinching; but in the treatment of disease his sensitiveness caused a continuous distress which time and use failed to overcome. The summer and autumn of 1839 were partly spent in harassing attempts to obtain a more remunerative lectureship than that which he held at the Medical School; though he was able, in addition, to gather general audiences at the Philosophical Institution for popular courses on Natural History. A step in this direction was made in 1840, when he exchanged the subject of Medical Jurisprudence for that of Physiology in the Medical School. He made up his mind finally to seek his livelihood as a teacher and writer, and abandon all further idea of medical practice. A second edition of his treatise on "General and Comparative Physiology" was required in 1841; and in 1842 he brought out a new work entitled, "Principles of Human Physiology."

These years were marked for him by important family incidents. He had lived so much away from home, and his intellectual interests had been so keen, that he felt afterwards that he had been too much absorbed by his own aims. In the home labours, where his mother and sisters were carrying on the school which provided the means for his education, he had had no share—he had only accepted their results. The strain of study, of thought, of production had often been protracted and severe; and he had not the elasticity of nature which enabled him easily to throw off its effects. He was conscious that he had often failed, as he said, to make his outward conduct conform to his real sentiments in family intercourse; he knew that his manners had "a rough and sometimes prickly exterior." The death of Dr. Lant Carpenter, who was drowned in the Mediterranean in the spring of 1840, while on a voyage for his health, brought these sentiments of self-reproach into strong prominence in his mind. He occupied himself during the summer with the preparation of a volume of his father's sermons; and recorded in a letter to his old and much-valued friend, Mrs. Wright, of Dalston, the thoughts which they awakened in his mind.

Kingsdown, Bristol, September 6, 1840.

There has been to me a melancholy pleasure in thus renewing, as it were, my intercourse with my father's mind by retracing his writings with more care than as an ordinary reader I should have bestowed upon them. . . . How much I wish that in my moral character I had more of his spirit. I often think of him as one who has shown us how nearly it is possible for frail human nature to approach the great Pattern by steadfastly keeping before his eyes the object of his imitation, and it is encouraging at times when a deeply humbling sense of one's own shortcomings might otherwise lead to despondency and doubt of the possibility of acting up sufficiently near to the Gospel standard.

I can dwell now without pain on the events of the past few months, for my mind, though generally violently affected by the first shock, more easily reconciles itself than that of many persons to what is certain; and the nature of my pursuits, too, causes the thought that all is the ordination of a wise and loving Parent, to become interwoven with it—so far, at least, as to check the murmur, if it cannot repress the sigh. I trust that this source of consolation may not fail me in any trials to which it may be the will of Providence that I should hereafter be subjected.

This sorrow passed away in the establishment of a home of his own. On October 24, 1840, Dr. Carpenter was married at Exeter, to Louisa Powell. Her father, who had died during her girlhood, had been a well-known merchant in the city; her mother was a daughter of Henry Cort, whose invention of iron-puddling, though it brought ruin to himself, proved the source of enormous wealth to the English nation. In the little house on Kingsdown, at the top of a steep flight of steps leading up from the square below, and commanding a splendid view of the valley in which lay the busy city with its towers and spires, its factory chimneys, and the masts of its shipping, there was planted the beginning of a happiness which grew with deepening experience through five and forty years. A certain quaintness marked the arrangements of the little morning room, where the young wife saw behind her husband's chair, at the other end of the table, a human skeleton set up erect. There was never any other. From first to last they lived in undivided trust.

Round the home gathered many intellectual and social interests. Music brightened it continually. This had been always a favourite taste, almost a passion. When the Medical Society at Edinburgh had celebrated its centenary in 1837, William Carpenter, then its senior president, on whom devolved the duty of delivering the oration of the day, had lamented that it debarred him from sharing in the vocal entertainment which followed the feast: "a "number of the members, with Dr. Christison at their head, "got up some capital glees. I could not join in this, as I "had not time for previous practising." There was more time now, in the intervals between lecturing and literary work. With the fruits of one of his prize-essays he had purchased an organ, in Edinburgh; it was regarded by his family as a kind of idol, and bore the familiar name of

Dagon, the piano coming in only second, as Dagonella. The microscope also was busily employed in the evenings in the drawing-room, and Dr. Carpenter began a series of investigations into the microscopical structure of shells, which first made known his capacities for independent research. The chapel and its organ were not forgotten. And the whole was crowned in 1841 by the birth of a son. Here is a glimpse of his life, as it was shaping itself in the spring of 1842, when he was just finishing his winter courses of lectures:—

> I have been working a good deal with the microscope, and have made some discoveries which I think quite worthy of being communicated to the Royal Society. I am also busy in preparing our collection of psalm-tunes, which we are about to publish. There have been several good reviews of my "Physiology." Little Billy is thriving very well, and is really a very intelligent, good-tempered child. I am glad he does not take after his papa in the latter particular.

III.

Dr. Carpenter had now acquired a reputation as a scientific writer, which justified him in becoming a candidate, in the summer of 1842, for the Professorship of the Institutes of Medicine in the University of Edinburgh. Many of the eminent teachers of the faculty would have welcomed such a colleague ; but the chair was not in their gift. The election lay with the Lord Provost and the Town Council, who regarded his Unitarianism as a fatal disqualification for the teaching of physiology, and declined even to consider his claims. It was a bitter disappointment to him ; and the repetition of it some years later, when he again came forward as candidate for the post vacated by the lamented death of his friend, Professor

Edward Forbes, reopened an old wound. But he had the happiness of feeling, long before he himself passed away, that, through the spread of larger views of Christianity, this ground of objection was for ever removed.

In the mean time he was obliged to labour incessantly with his pen. In 1841 he had undertaken, single-handed, the issue of a "Cyclopædia of Natural Science." Treatise after treatise, on Animal Physiology, Mechanical Philosophy, Horology, Astronomy, Vegetable Physiology, Botany, and Zoology, poured out in a stream of yellow-backed numbers with punctual regularity for three years. Such a production gave him a wide range of knowledge, and enabled him often to enrich his lectures and essays with varied illustrations. But the struggle to maintain his position was severe; and the acquaintance which he formed in the autumn of 1843 with Lady Byron and her daughter, Lady Lovelace, led to his removal to Ripley, in Surrey, to undertake the superintendence of certain branches of the education of Lord Lovelace's two children at his country-seat at Ockham. The only available house was small and inconvenient; the precious organ had to be left behind. Withdrawn from the circle of his friends in Bristol, he was more closely occupied than ever with his scientific studies, of which he felt his grasp becoming stronger and deeper. When the second edition of his "Human Physiology" was called for in the summer of 1844, he wrote to his brother Russell:—

> It is very interesting to me to see how much progress my own knowledge of the subject has made during the last two years and a half, which many people think have been unprofitably occupied in writing the Cyclopædias; and to find how many views which I advanced hesitatingly have since been so far sanctioned by additional facts that I can now state them with almost certainty.

At Ockham, and at the hospitable house of Lady Byron, at Esher, Dr. Carpenter had occasional opportunities of making acquaintances outside the range of his own pursuits. The Dissenters' Chapels Act, passed in the summer of 1844, had relieved the Unitarians from the danger of being dispossessed of the chapels which they had inherited from their Presbyterian ancestors. Among the promoters of this measure was Mr. Samuel Smith, with whom Dr. Carpenter was thus brought into contact.

> He had taken an active part in the Committee for the Chapels Bill, and I was glad to learn that a subscription is being entered into for making a present to Mr. Field, who most liberally declines receiving any remuneration for his services, though (as I have heard from several sources) all his time this Session, and much of his time for the two preceding, has been taken up about this business. Mr. Smith fully confirmed my previous impressions: that without his exertions, and the influence he has gained by his thorough probity and professional skill with the Government Law Officers, the Bill would never have passed. I know it to be a fact that nearly every Government speech was got up from materials supplied by him, and taken with the utmost confidence. Gladstone's speech was prepared within thirty-six hours of the Debate.

These passing glimpses into the outside world could not, however, compensate for the absence of the religious sympathy to which he had been accustomed.

> I feel the loss of public worship (so he wrote to his brother Russell, in December, 1844) more than any other kind of inconvenience of my situation here. I have a most particular attachment to Lewin's Mead Chapel, and to the worship as there conducted; and you can scarcely think how strong is my yearning to be at my old post, and to feel that I am endeavouring, however feebly, to lead the devotional feelings of the congregation by that form of expression which is, in my own mind,

so closely related to what there is of heaven in mortal feelings. I shall be better pleased when I have Dagon again, for at present I do not feel the music of our little service as connecting me with public worship—a piano and organ are *so* different—but perhaps you may not understand this, and may think that I set too much value on trifles. But you know that different minds are differently constituted, and that the feelings, especially, are affected in different ways. It takes a greal deal to move me on some subjects, but I am susceptible enough (with all my philosophy) on others. . . .

Never since I have begun to look at the subject at all, have I felt so much hope of human progress as I do now. The advance, almost silently for a long time, but now manifesting itself in a variety of ways, towards what I deem right views on a great variety of subjects, is to me most wonderful and cheering, and I hope I shall never feel discouraged at want of success in any of my own individual efforts to forward it.

The year 1844 was distinguished by the publication of the remarkable book entitled "The Vestiges of Creation," which first suggested the theory afterwards known as "genetic development," or the lineal descent of the higher forms of plants and animals from the lower. The parallel between many of its conceptions and those expounded in Dr. Carpenter's writings, led some readers to ascribe it to him. Early in 1845 he met, at Lady Byron's, the Hon. Miss Murray, one of the Queen's maids of honour.

She was very amusing (he reported), especially as she was full of royal and noble opinions upon phrenology and mesmerism, and especially upon the "Vestiges," which is being very extensively read in the highest circles, and generally attributed to me. Prince Albert is reading it aloud to the Queen in an afternoon. This is his customary employment, and they read through many valuable works in that manner.

In an article in the *British and Foreign Medical Review*, published in January, 1845, Dr. Carpenter expressed his sympathy with many of the author's positions, though he criticized various errors of detail. But he was not prepared to accept the main doctrine, for which he regarded the evidence as altogether inadequate. And on more abstract grounds, he somewhat hesitatingly suggested that if it were admitted as possible that any combination of inorganic matter could under any circumstances produce a living being, there was no reason why such a combination should not be the real origin of every race, including man himself. Every species would thus have been called into being in accordance with the original plan and the pervading energy of the Creator, just when that coincidence of circumstances occurred which was favourable to its development and continuance. It was characteristic of his state of imperfect emancipation from the traditional view of Biblical revelation in which he had been trained, that he added—

> That the Creator formed man out of the dust of the earth, we have Scriptural authority for believing; and we must confess our own predilection for the idea that, at a certain period, however remotely antecedent, the Creator endowed certain forms of inorganic matter with the properties requisite to enable them to combine at the fitting season into the human organism,—over that which would lead us to regard the great-grandfather of our common progenitor as a chimpanzee.

A little later, however, he seemed to be somewhat more favourably inclined to the general proposition, as a matter of *à priori* probability, though the evidence of science then appeared to him clearly to indicate "the *non-convertibility* of species really distinct;" and in one of a series of papers published in the *Inquirer*, in 1845, on "The Harmony of Science and Religion," he thus pointed out the important analogies on which he afterwards dwelt so much, between the presence of design in the evolution of the solar system, in the evolution of any given human form from its first germ, and in the evolution of the entire organic world.

In this hypothesis I cannot see anything that is either abstractedly improbable, or that in the least tends to separate the idea of Creative Design from the Organized Creation. There is surely nothing more Atheistical in the idea that the Creator, instead of originating each race by a distinct and separate act (the notion commonly entertained), gave to the first created Monad those properties, by the continued action of which, through countless ages, a Man would be evolved,—than there is in the idea to which we are irresistibly led by Physiological study, that the Creator has given such properties to the first germ-cell of the human ovum, as enable it to become developed into the human form in the course of only a few months;—or in the idea, to which Astronomical research seems to lead, that the Deity, instead of establishing the present system of the Universe by creating each star and planet in its present form, setting it in a particular place, and giving it a certain motion, produced this result by the creation of Nebular Matter, and by the endowment of it with certain properties, whose continued operation *necessarily* wrought it out. If we believe that to the mind of the Deity, the past and the future are alike present, and that His prescience is so perfect as to comprehend all the results of the plan on which He conducts the operations of the Universe, we see His hand in the mode of creation supposed by this hypothesis of development, fully as much as in the one commonly attributed to Him. And if we believe that what we call *laws* and *properties* of matter are nothing else than human expressions of the constancy of the mode in which the Creator operates, we see that the hypothesis coincides with all which Science and Religion alike teach, respecting the invariability of His mode of working. To imagine that the Creator was obliged to *interpose*, or to exert some *special agency*, for the production of new races of plants and animals, every time that the conditions of the earth's surface became incompatible with the continued existence of those previously existing, and at the same time became prepared for others,—

appears to me the same thing as to suppose that He was obliged, through want of previous acquaintance with the changes on the earth's surface, to meet the emergencies as they might arise, and to compensate for the unforeseen extinction of one race of beings, by the special creation of another.

The course of Dr. Carpenter's thought had at this time only appeared to confirm the view of the world and of life in which he had been brought up. He had accepted the Biblical record as a supernatural revelation accredited by miracles. He said, indeed, that—

> We must allow a great deal in regard to the form of what we call revelation, and that physical science, in the form in which it is now developing itself, is another revelation which is adapted to convince the intellect of those who could not receive the same doctrines as mere matters of faith.

And he added—

> As the mind of man advances, I believe that the Biblical revelation will come to be regarded in the light in which I now view it, *i.e.* as specially designed for those periods when the human mind would more passively receive the truths it teaches, and would give more ready credence to the proofs by which it was then supported; that, as less confidence comes to be placed in the *external* evidences, the strength of the *internal* will be found to increase; and that, in fine, the fundamental truths of religion will rest on the generalizations of science, blended with the express declarations of God, the latter being received chiefly as such, because in full accordance with the former.

The "internal evidences," however, on which Dr. Carpenter was then disposed to rely, were not those of the moral and religious affections; they were almost wholly of an intellectual kind; they were such as were suggested by the contemplation of the "plan of creation," and the indications of the presence and energy of mind in the world around. In such a mood of thought, miracles still had their place and value. His attention had not yet been called, either by literary criticism or by the study of the conditions under which beliefs are formed, to the origin and composition of the Gospel narratives.

> To impugn the miracles as facts (he wrote to his brother Russell, in the letter just quoted, February 2, 1845), seems to me to indicate a very incorrect view of the nature of evidence; and the desire to do so which prompts the attempt shows, I think, a very perverted view of the real character of revelation as well as of the import of "natural laws."

Miracles were, in fact, the manifestation of some higher law.

The conception of the uniformity of the Divine action in the universe had at this time so complete a sway over Dr. Carpenter's mind that he surrendered to it even the entire range of human thought and volition. In later days he became known as the ardent opponent of that interpretation of our consciousness now designated as "de-"terminism." But his earlier studies had only strengthened him in the strict necessarian ideas of his original education. He had been trained by his father in the principles of Hartley; his psychological text-book had been James Mill's "Analysis of the Human Mind;" and his acquaintance with John Stuart Mill, and the perusal of his treatise on Logic, had not tended to weaken the general notions thus impressed upon him. These notions appeared confirmed by his scientific inquiries, which had hitherto dealt entirely with the world of matter, and had not yet extended to the processes of the mind. He was saved from the consequences of the elder Mill's dissection of the idea of God by his acceptance of a doctrine of revelation; and, under the strong belief in the presence of design in nature, his empirical philosophy and his religion found a comfortable shelter together. Accordingly, in another of the *Inquirer* papers already quoted, he affirms (§ 97) "that all human actions "(being the results of the operation of circumstances upon the "mental constitution of each individual according to fixed "laws) are to be regarded, like the phenomena of the Physical "Universe, as the expressions of the will of the Creator," and (§ 108) "that all the actions of the human mind are as "much the expressions of the Divine will as are the opera-"tions of man's bodily frame, or the movements of the "heavenly bodies." Where all mental operations are but the working out of the Divine plan, the belief in our own freedom is, of course, a part of that plan. "Hence we are "to ourselves perfectly free. We do as we wish, notwith-"standing that our volitions are all the necessary results of "our constitution and circumstances, and are prearranged "by Deity."

> We must in consequence (argued Dr. Carpenter) recognize in the phenomena of mind the same determinateness as in those of physics and vitality. The difficulty which affects us in regard to the prediction of them is precisely that which affects the meteorologist, viz. a very imperfect acquaintance with the conditions under which the phenomena occur. If these conditions are fully known, the result may be accurately predicted.

This absolute abandonment of all individual causation, which was thus merged in the only true self in the whole universe—namely, God—required an immediate revision of the meaning of the common terms of the moral consciousness. The current ideas of responsibility, merit, guilt, all disappeared. With them passed away, likewise, the ordinary view of rewards and punishments, and all justification for the doctrine of eternal torments.

> It cannot be regarded as consistent with either the justice or the benevolence of the Deity (concluded Dr. Carpenter) that he should, by the infliction of additional suffering, as a *retribution* for acts which are really his own, increase the burden

of evil under which the human race already lies as a necessary consequence of its imperfection. All ideas of punishment, as necessary to *satisfy* Divine wrath, or to *expiate* human offences, are excluded on the present scheme. But it does *not* exclude the idea of *suffering*, as on the one hand a necessary consequence of human error, and on the other as requisite for the eradication of that error, and for the purification and elevation of the human soul.

It was characteristic of his fidelity to the steadfast rectitude of his moral training, however imperfectly it might harmonize with his theoretical interpretations, that he still sought to maintain our accountability to the Deity even for the "acts which are really his own."

We are as much *accountable* to our Creator for the use we make of our powers as if he had committed them to our charge in ignorance of the result; and our virtues and faults are *to us* as much under the control of the self-regulating power with which he has endowed us as they could be if we had no relation to him whatever as a Creator, but were self-existent beings.

Nature had been driven out with a pitchfork, but it persisted in coming back. What use Dr. Carpenter was afterwards to make of the meaning of the "self-regulating power" which he thus recognized, the essays on "Human Automatism," written after thirty years more of experience and reflection, will abundantly show.

IV.

In the spring of 1845, the arrangement with Lord Lovelace was brought to a close, and Dr. Carpenter moved to London. He had been appointed in the preceding year to the Fullerian Professorship of Physiology in the Royal Institution, and he had been elected a Fellow of the Royal Society. He now undertook the course of General Anatomy and Physiology at the London Hospital, where he continued to lecture for the next twelve years. He settled in a small house in Stoke Newington, which he exchanged shortly after for a more convenient residence near the Regent's Park. The usual home life went on without interruption, broken only by occasional excursions to various parts of the country for courses of popular lectures on Natural History. The constant toil of production must be kept up, and in 1846 appeared a "Manual of Physiology," in which the doctrines of the larger treatises were condensed. He continued to contribute to the *British and Foreign Medical Review*, of which he became editor in 1847, on the retirement of Dr. Forbes, who warmly expressed his great indebtedness to him for his ever-ready aid. For the next five years he bestowed upon it a large amount of time and energy; besides his general supervision, he wrote numerous articles for it, on a still wider range of subjects than he had hitherto discussed. Another post was conferred on him in 1847 by his election to the Examinership in Physiology and Comparative Anatomy in the University of London; and when the Fullerian Professorship at the Royal Institution expired in the same year, the trustees of the British Museum designated him for the Swiney Lectureship on Geology. This list may be completed by the record of his succession, in 1849, to the chair of Medical Jurisprudence in University College; and, in 1852, to the Principalship of University Hall.

These different appointments brought Dr. Carpenter into connection with a larger circle of friends engaged in kindred pursuits, and enabled him to form ties which were severed only by death. With Dr. Sharpey, Professor of Physiology in University College, with Mr. (now Sir James) Paget, Dr. (now Sir Joseph) Hooker, and Mr. George Busk, he remained always in relations of cherished intimacy. Mr.

Robert Chambers sought him out in an early visit, and the suspicion which he had already formed through correspondence with him as to the authorship of the "Vestiges," was strongly confirmed by their subsequent intercourse, which ripened into warm friendship. His researches into the microscopic structure of shells brought him the acquaintance of Mr. Darwin, who requested him to examine for him some specimens of the great Pampas formation, for the "Geological History of South America," on which he was then engaged. These shell-inquiries, which he had begun at Bristol, and continued at Ripley, were conducted with the aid of grants from the British Association, and the results were published in its Reports for 1844 and 1847, with forty plates lithographed from original drawings. They established his reputation as an original investigator, and prepared the way for his future labours on the great class of Foraminifera, on which his first paper was published in 1850. His discoveries among the Brachiopoda, in particular, were extended and summarized in an Introductory Memoir on the microscopic structure of the shells of that group, contributed to Mr. Davidson's elaborate work on British Fossil Brachiopoda in 1853.

Other friendships also entered his life from another side. He became acquainted with Mr. A. J. Scott,* and at his house he witnessed one evening an encounter between Mr. Carlyle and Professor F. W. Newman, who had left Manchester to become Professor of Latin in University College.

> I have only left myself space (he related to his sister Mary, in the spring of 1847) to tell you briefly that I met Carlyle in society last night, and listened to a long debate between him and Newman, in which Carlyle vehemently denounced toleration as the destruction of all individuality. His language was

* Then Professor of English in University College, London, and afterwards Principal of Owen's College, Manchester.

very forcible, and many of his views had much truth; but he evidently pushed them to an extreme, either intentionally or through habit.

In fact, on this occasion, Carlyle went so far as to defend Calvin for burning Servetus; and Dr. Carpenter used often to relate how, when he had departed, Mr. Newman held up his hands in amazement, and asked, "Does Mr. Carlyle always talk like that?" In his house at Regent's Park Terrace, Dr. Carpenter's nearest neighbours were Mr. Scott and Mr. Wills, the fellow-worker with Dickens in the management of *Household Words.* Mrs. Wills was a sister of Mr. Robert Chambers, and in her society the hard-working man of science often found relief for his wearied brain among the drolleries of Scotch humour and the pathos of Scotch ballads, which he specially loved.

Dr. Carpenter's residence in London also secured for him a renewal of the religious fellowship which he had so sorely missed in Ripley. He saw, indeed, some tendencies among those to whom he was otherwise drawn by theological affinity, of which he seriously disapproved; and with a touch of sarcasm very rare in his conversation or letters, he pointed out the danger to his brother Russell.

> I think that Unitarians are pretty nearly as likely to be Pharisaical as Trinitarians, if placed in the same circumstances. "God, I thank Thee that I am not as these poor blinded "idolaters that pray to Father, Son, and Holy Ghost," is, if I mistake not, a form of thanksgiving often felt among us, if not uttered.

This dissatisfaction found expression in the year 1848, when he made an earnest and public protest against the refusal on the part of some who were regarded as leaders of the Unitarian body, to extend the Christian name to those who rejected the historical character of the Gospel miracles. The influence of German criticism was beginning to be powerfully felt in this country. The translation of Strauss's "Life of Jesus" had just appeared; and the writings of Theodore Parker were exciting a vigorous interest, partly friendly, partly hostile, among English as among American Unitarians. Dr. Carpenter had not then entered on the psychological studies which were afterwards to modify his view of the conditions of belief under which the miraculous narratives grew up; nor had he investigated the composition of the Gospels. "To "me," said he, "the evidence for the Christian miracles, taken "as a whole, is quite as much as is requisite to obtain my "intellectual assent." But that assent was practically tendered upon other grounds than historical testimony. It was on the character and teachings of Jesus that he really took his stand. "For myself, I should say with Locke, "'The doctrine proves the miracles, rather than the miracles "'the doctrine.'" With some of the most respected members of the Unitarian Association, therefore, he felt himself in imperfect sympathy; and partly from this cause, and partly from the continued pressure of his lecture engagements, and subsequently, owing to his official connection with the University of London, he took no active share in it for many years. But in worship he found the satisfaction of his religious needs. His removal to Regent's Park Terrace enabled him to join the congregation at Rosslyn Hill, Hampstead, with whose pastor, Dr. Sadler, he formed at once a warm and intimate friendship. The musical portion of the service appeared to him, however, cold and bare, with its antiquated accompaniment of fiddles. With characteristic energy he propounded a plan for the purchase of an organ and the formation of a choir. In this little sanctuary, enlarged and enlarged again as the congregation increased, was he to be found at the organ, Sunday by Sunday, for the next seventeen years; and when this duty was relinquished, he remained till the last a regular worshipper. How completely his religious interests crowned his life, and supplied him with a point of view from which to look on social affairs, may be seen from a passage in a letter to his mother, at the close of 1848.

To MRS. CARPENTER, *Bristol.*

London, December 31, 1848.

We can never forget this year. How vast and wonderful have been its convulsions, and yet how insignificant at present seem its results. Yet I cannot but believe that it is only the commencement of a more enlightened and progressive state, and that the demonstrations of popular force which it has exhibited will prevent for the future anything like a return to the arbitrary systems of the past. And one most hopeful sign has been that there has been nowhere any reaction against religion, as in the first French Revolution. I cannot but think that the increased freedom of action in Germany will contribute to much more practical freedom of religious inquiry. It is wonderful how difficult that people have found it to carry their speculative freedom into action, owing as it would seem to a certain torpor of that part of their psychical nature which brings abstract principles into actualities. I have been very much struck with this in reading an article on Gfrörer's "Origin of Christianity" in the last *Prospective Review.* The article interested me very much, and gave me clearer views as to the philosophy of the Alexandrian school than I had before. I have been much dwelling on the idea I mentioned to you that the Gospel of John was composed by John of Ephesus (the probable writer of the Epistles), from material supplied by the Apostle John; and the more I trace in it the pervading influence of the Neo-Platonic philosophy, the more unlikely does it seem to me that the simple-minded apostle, whose Jewish and material mind is so strongly displayed in the Apocalypse, should himself have penned such a finished and metaphysical composition.

For some time past the Temperance movement had been exciting more and more of Dr. Carpenter's interest.

It had been earnestly espoused by the rest of his family; and he was led to deal with it from the scientific side. Accordingly, in an article in the *Medical Review*, published in 1847, Dr. Carpenter discussed the effects of alcoholic drinks on the human system in health and disease. Two years later he obtained a prize of one hundred guineas for the best essay on the use and abuse of alcoholic liquors, which was published in 1850. He himself practised total abstinence, and trained his children to it, until repeated illnesses in later years (especially one of many months' duration in 1864–5) led him to take a moderate amount of stimulant. But he always remained a hearty friend to the Temperance cause. In an address on the "Physiology of Alcoholics," delivered in 1882, in the Tremont Temple, Boston, Massachusetts, at the request of Governor Long and other leading men, he reaffirmed many of the positions of his earlier essay.

The five years during which Dr. Carpenter occupied the editorial chair of the *Medico-Chirurgical Review*, were perhaps the busiest of all his busy life. His professional appointments kept him constantly at work as a lecturer. He poured out article after article in the *Review*. He was carrying his physiological treatises through new editions, into which so much fresh matter was absorbed that there sometimes seemed but little of the original structure left. And his natural history researches engaged his constant attention. Brief holidays only could he allow himself. His day began at six, and often ended only at midnight, an hour or two over the microscope in the evening forming his only recreation, while his wife played or sang, or beguiled him to join her in a duet. In this continued strain he had little time for family intercourse, and his correspondence was reduced to the smallest dimensions. Every now and then, however, the occurrence of some anniversary led him to open his heart, or some fresh fact or idea kindled his enthusiasm, and impelled him to look for sympathy in the old Bristol home. The press of affairs often drove the returning birthday from his mind till he wrote the date, and the recollection of brother or sister surged up in his consciousness, and prompted his pen. The following passage from a letter to his sister Mary, shows the attitude of his thought to the memory of the great bereavement which had never long been absent from her imagination. It was written on her birthday, but it would arrive on the anniversary of her father's death, a day

> that must be felt by all of us to be one of deep interest, though time modifies the painful part of the associations connected with it, and makes us dwell (or, rather, should do so) on the mutual happiness we enjoy as a family, notwithstanding our diversity of tastes and pursuits. . . . The memory of our dear father should not be to any of us, I think, associated with painful feelings, even when thus specially recalled; for we can all feel that we are occupied as he would approve, and carrying out in our various modes the objects in which he was most deeply interested. And while we may all of us at times regret the loss of his counsel and guidance, yet we may also feel that if it had been longer continued to us, we might either by resting too much upon it have too little cultivated our own self-reliance, or, on the other hand, carried as we have been into circumstances in which he could not follow us, we might have been often led to give him pain, by preferring our own judgment to his. Affection never dies, though it may sleep; and whether he be or be not *at present* regarding us with love, I no more think of his love as lost to us, than I do of that of my wife or children as extinguished when they are asleep.

A year or two later he steals a few minutes from the rush of business to announce to the same sister a discovery among the Foraminifera at which he has been so long working.

To Miss Mary Carpenter.

London, November 3, 1850.

I have had a regular torrent of interruptions, so that if it continues I shall really be driven for a month or so to a country lodging where I may experience the blessed consciousness that no one can come in upon me. I try to exercise Christian charity towards the many people who bother me; but it is really very difficult to do so when one feels driven to desperation by the want of power to fulfil one's engagements, to say nothing of the misery of having one's trains of thought interrupted, and the provoking consciousness that no sacrifice of one's self will remedy the evil, since my brain (and it is well for me that it is so) breaks down at once under overwork, and refuses to labour for more than twelve hours a day, by the very simple process of going to sleep over my pages. So when it will spin nothing more, I betake myself upstairs to tea, and finish in the evening with music and microscopizing; the latter being a special delight to me at the present time, as I have found the most interesting things possible among my Australian dredgings, namely, the recent types of all my most interesting forms of fossil Foraminifera (I only last night discovered the one wanting to complete the list), confirming all that I had advanced respecting them, with other forms entirely new. I do not know when I have been more fascinated by anything.

By the side of these minute investigations he was at the same time pursuing two important lines of thought, not wholly unrelated to each other, both of which had for a long time engaged his attention. The connection subsisting between the different forces of Nature had excited his boyish interest when Mr. Exley had expounded to a Bristol audience that "new theory of matter" by which all the attractions of gravitation, cohesion, electricity, and the rest, might be explained upon the same principles. In dealing with the "laws regulating vital and physical phenomena," he had looked forward to a time when it might be shown that the vital properties of matter resulted from some higher and more general qualities from which the physical might also be derived. He was now about to place this speculation on a more assured basis of fact and reasoning. And the study of the nervous system which he had begun in Edinburgh, was to be pursued more and more eagerly till it was to result in a complete reversal, largely on physiological grounds, of that interpretation of the moral consciousness which he had recently put forward with such security of faith.

The publication of Mr. Grove's views on the "Correlation of the Physical Forces," in 1846, gave a vivid stimulus to Dr. Carpenter's reflections on this subject. He saw at once that they could be applied and extended within the domain of physiology. He had himself for some time urged that what were commonly called the vital properties of organic matter were simply the result of the capacities for action, with which its constituent molecules were endowed, when called into play under conditions suitable for their combination into living forms. He was now prepared to give more coherent shape to this conception. When the British Association met at Oxford, in 1847, he twice presented it for discussion. "In the Medical Section, where I spent "most of this morning," he wrote to his wife, on June 25, "I "gave some views which I had formed on the correlation of "the Vital and Physical Forces suggested by Mr. Grove's "pamphlet. I shall bring these forward also in the Physical "Section, where I think they will be better appreciated." Discussions such as these helped him to consolidate his thoughts; they were further developed in scattered hints in the pages of the *Medico-Chirurgical Review*; and in due time he felt that they were ripe enough for communication to the Royal Society. The following letters, to his mother, and to an old fellow-student, show the general drift of his ideas:—

To Mrs. Carpenter, *of Bristol.*

London, 1849.

I am longing for a little leisure to write out my paper for the Royal Society, on the "Vital and Physical Forces;" and will now try and give you some idea of it, as well as of some speculations which have arisen in my mind in connection with it, and on which I should like to have your opinion.

The whole is built upon the views that Physical Philosophers have been lately coming to—that Light, Heat, Electricity, Magnetism, Chemical Affinity, and Mechanical Motion, are all to be regarded as forms or modes of *force*, and that they are mutually convertible, each being capable of producing the rest, either *directly* or through the medium of electricity, which is a sort of connecting link among them all. Thus the friction of two similar bodies produces heat; of two dissimilar, electricity; the heat and the electricity being more abundant as the motion is retarded, *i.e.* as the friction is greater. Conversely heat and electricity may be made to produce mechanical motion, as in the steam-engine and in the various electric rotatory machines. So electricity will produce heat, and heat will generate electricity. Electricity and magnetism are not identical, as was once supposed; but each will produce the other, or may be converted into it. And, as in all these cases, the agent and the product are in a constant proportion to each other, it seems as if the same force were everywhere in action, though varied in its manifestations according to the circumstances under which it is operating.

Now, I was first led to apply these views to the Vital forces by the very close relation that exists between nervous agency and electricity. All the most recent and trustworthy experiments lead to the conclusion that the two are not identical, as some have supposed, but that they are very closely related; Electricity being able to generate Nerve-force (manifested both in muscular motion and in sensation), and Nerve-force being able to generate electricity, as in the electric fishes. Carrying out these views, I have brought together phenomena which indicate that the Nerve-force may be excited by Heat, Light, Chemical Affinity, and Mechanical Motion; and that it may in turn excite all these forces. Thus it appears that we have a right to say that Nerve-force is as completely *correlated* to Electricity and the other physical forces as they are to each other; its peculiarity being that it is only manifested through a certain peculiar material structure. But this is not sufficient to separate it, though it keeps it distinct. Until lately we thought that Magnetism could only be manifested by iron; and it is only through a peculiar combination of metals that Heat can be made to generate Electricity. So it is only through nervous structure that Electricity, etc., can generate Nerve-force.

From Nerve-force I was led to consider other Vital forces, as those of growth and development, muscular force, the chemical transformations peculiar to living bodies and others; and was able to reduce them all to one general expression, that of *cell-force;* all of these forces being, in my apprehension, but varied expressions of that which is manifested in its simplest form in the development of a *cell,* the elementary form of all organized structure; as is indicated by the circumstance that when a cell has taken on one mode or action, it seems incapable of performing any other, each peculiar vital endowment being manifested by a set of cells appropriated to it.

The question next arises whether these vital forces have any relation to the physical; and guided by the connection between *one* of them (Nerve-force) and Electricity, I was led to look at well-known facts in a new point of view, and to conclude that the Vital forces manifested by plants are really the Heat and Light which they receive, transformed, by acting through organic germs, into cell-forces; so that the Vital forces of plants are *correlated* to Heat and Light, as is further shown by the fact that certain plants can generate these by their own vital powers. The proof is of the same kind in regard to animals; but their dependence on external Heat is not so obvious, in consequence of a provision for the internal production of heat existing among many of them. But it is as true of them as of plants, that the activity of their vital operations is in direct proportion to the measure of heat which their bodies receive in one mode or the other. Thus a frog will live slow or fast, just according as the temperature of the air or water is near 32° or 80°.

All this I have developed in my "Comparative Physiology"—not as fully, however, as I could wish. But I have there avoided touching on the relation of Mental force to those commonly called Material. I have been turning the matter over in my mind, however, and have come to the conclusion that we cannot logically separate them. It is all very well to say that Mind and Matter are distinct entities; but we are talking of *forces*, not of material substances, and I cannot see any reason for shrinking from the conclusions to which the facts appear to point. These conclusions you will find in the enclosed note to a friend, whose opinion I much desired. In addition to what I have said there of the action of the mind upon the body, I might advert to the influence of emotional states in modifying the nutrition and secretion, and conversely to the marvellous influence of a slight contamination of the blood on the emotional states.

To DR. PAGET.

I have been thinking much more about Mental phenomena, and have been questioning within myself whether Mental force should not be brought into the general category of the Vital forces, on the grounds that Nervous force excites Mental force (as in sensation giving origin to Mental operations), and conversely Mental force excites Nervous force (as in emotional or volitional actions). It seems to me impossible to deny that this correlation is as complete as those existing among the physical forces; whatever we may think of the degree in which the higher phenomena of mind are dependent upon material conditions. Further, Nervous force is, in the animal body, that kind of connecting link between Mental force and the Physical forces which Electricity (as Grove has shown) often is among the Physical forces themselves, one being often convertible into another through the medium of electricity, which is not thus convertible directly. But if such a correlation really exists between Mental and Vital and Physical forces, that the one may even indirectly produce the other, may we not regard all the physical forces of the universe as the direct manifestation of the Mental force of the Deity? I believe that I could find very orthodox testimony in support of some such view. Locke argues that all notion of power is derived from our consciousness of effort (a doctrine advanced as novel by later philosophers), and that the existence of the powers of nature thus necessarily leads us back to a mental source for them. It is to me very interesting to find the two lines of argument—the one starting from the correlation of the Physical, Vital, and Mental forces, as indicated by objective facts; the other from the analysis of our own subjective consciousness—which, so far from being in any way irreverent, only gives a new argument for the existence of an Intelligent First Cause.

From this point of view I should look upon the whole Kosmos as the corporeity of the Deity, a doctrine which some may think pantheistic, but which seems to me necessarily to follow from that of his universal and immediate agency, which I cannot but regard as the highest method of viewing his *modus operandi.* Thus I should regard the mutual correlation of mental forces as enabling one mind to act on another directly or indirectly, according to the means of communication, that of the Deity upon man directly, that of man upon man indirectly. The correlation of the Mental and Vital forces is manifested on the large scale in the phenomena of life, and the direct result of the Divine agency; on a smaller and more limited scale in the mutual relations of mental and corporeal activity in man. The correlation of the Mental and Physical is manifested in the way in which man acts on external nature, and is acted upon by it, through the medium of Nervous force, but more directly in the phenomena of the material universe considered as the immediate expression of the Divine will.

In working out such speculations it will, of course, be very difficult to avoid shocking the prejudices of some good and wise people; but I do not mind this if the philosophy of them will bear a rigid examination, as I am certain that in the end they will tend to render our ideas of the Divine agency more definite, and at the same time to elevate our conceptions of it, by showing that in every way in which we feel ourselves limited, the Deity is unlimited, his mind exerting itself directly and universally in every class of phenomena.

The views indicated in the first of these letters were embodied in a memoir "On the Mutual Relations of the Vital and Physical Forces," chiefly written in 1849, and communicated in 1850 to the Royal Society. To this paper Dr. Carpenter looked back in after-years as one of his most original productions. He did not seek in it, he said, "to "increase the knowledge of existing *facts*, so much as to "develop new *relations* between those already known." Its main thesis was that what is called "vital force" really has its origin in solar light and heat, not (as generally taught up to that date) in a power inherent in the germ; that which the germ supplies, according to his views, being the directive agency by which forces derived *ab externo* are used in the building-up and maintenance of the organism. The paper was at first regarded as too abstract and hypothetical, and some doubt was expressed as to its admission into the "Philosophical Transactions." It ultimately appeared there in 1851; but it made little impression at the time. Its line of argument, however, secured more and more attention, and its conclusions were finally accepted as a part of the general doctrine of the "Conservation of Energy," which had been previously promulgated by Mayer and Helmholtz, but was not at that time known beyond Germany.*

V.

While these speculations were occupying Dr. Carpenter's thought, he was at the same time slowly elaborating a view

* See the passages from the article entitled, "The Phasis of Force," below, p. 173. In a lecture on "Present Aspects of Physiology" (Edinburgh, 1874), Professor Rutherford said, "Much of the present aspect of physiology is owing "to Ludwig, who introduced into biological study the graphic method of record- "ing movement invented by Thomas Young; to Carpenter, who applied to "physiological phenomena Grove's principle of the correlation of force, and so, "much about the same time as Mayer and independently of him, paved the way "to the application to physiology of Joule and Helmholtz's great principle of "the conservation of energy; much of it is owing to Du Bois Reymond, on "account of his researches on animal electricity."

of the nervous system and the functions of the brain which was destined to overthrow the entire fabric of his early determinism. His interest in these problems dated from his student-days at Edinburgh; and they had been discussed, though somewhat briefly, and on the lines then usually accepted, in the first editions of his treatise on "Human Physiology." But a marked advance was made in the year 1846, by the publication of an article in the *British and Foreign Medical Review*, on Mr. Noble's work on "The Brain and its Physiology." In this essay, Dr. Carpenter discussed the true methods of investigation into the physiology of the brain, with especial reference to phrenology, whose supposed scientific foundations were completely demolished. He then proceeded to extend the idea of reflex action to the centres of sensation and ideation, and, as a writer in the *Times* observed after his death, "enunciated, with a completeness which has stood the test "of time, the fundamental notions of 'consensual' and 'ideo-"motor' action." * Mr. Noble was converted, and became one of his critic's warmest friends. And Mr. J. S. Mill wrote from the India House to express his admiration and assent:—

> I should have been truly vexed not to have heard immediately of such a valuable contribution to science as your paper. I have read it once with great care, but I must read it a second time before I can have completely incorporated it with my system of thought. I have long thought that you were the person who would set to rights the pretensions of present and the possibilities of future phrenology; but I did not venture to hope that I should see, so soon, anything approaching in completeness and conclusiveness to this.

The doctrine of the will remained in the background in this essay; but it quickly forced its way into Dr. Carpenter's

* Dr. Carpenter's own summary of his conclusions at this period will be found below, p. 159.

psychology, through the study of abnormal mental conditions, and the attention which he bestowed on mesmerism, electro-biology, and other fashionable aberrations. In January, 1847, he contributed to his *Review* an article on Dr. Moreau's "Psychological Studies on Hachisch and on Mental Derangement." The book made a deep impression upon him, for it enabled him to grasp as he had never done before the significance of the control exerted by the will in a mind of healthy activity over its own trains of thought.

> One of the first appreciable effects of the hachisch (he wrote) is the gradual weakening of that power of voluntarily controlling and directing the thoughts, which is so characteristic of the vigorous mind. The individual feels himself incapable of fixing his attention upon any subject; his thoughts being continually drawn off by a succession of ideas which force themselves (as it were) into his mind, without his being able in the least to trace their origin. These speedily occupy his attention, and present themselves in strange combinations, so as to produce the most fantastic and impossible creations. By a strong effort of the will, however, the original thread of the ideas may still be recovered, and the interlopers may be driven away, their remembrance, however, being preserved, like that of a dream recalling events long since past. These lucid intervals, however, become of shorter duration, and can be less frequently procured by a voluntary effort; for the internal tempest becomes more violent, the torrents of disconnected ideas are so powerful as completely to arrest the attention, and the mind is gradually withdrawn altogether from the contemplation of external realities, being conscious only of its own internal workings.

The phenomena of hypnotism also excited Dr. Carpenter's interest, for they threw further light on the conditions of the mind's activity when its volitional control was suspended, and led him to reflect on the influence of mental states on muscular feeling and exertion in the presence of certain powerful ideas which the sensations failed to correct. The study of a number of criminal trials brought clearly before his view the forces of different passions and propensities, and the relative feebleness of the checks imposed upon them by the will. In the discussion of insanity and of responsibility for acts of violence, he found himself compelled to analyze the whole processes of the moral life, and his results were surprisingly different in 1847 from those which he had previously announced in 1845.* Starting from the frequent experience of moral conflict between (for example) the duty of a professional visit to a patient needing aid, and the desire to escape a wet ride or to avoid bringing home infection, he inquired in what lay the deciding power. Rejecting the current explanations of the autocratic nature of conscience or the moral sense, which pronounced directly on the right or wrong of any action, he expressed his sympathy with a view of its real function propounded shortly before by an "anonymous critic," in the *Prospective Review*, who affirmed that moral good was not a quality resident in actions, but that ethical judgments were always relative, and involved a preference for one spring of action over another.†

> We cannot, therefore (said Dr. Carpenter), attach a moral character to the actions of animals that are performed under the direction of a blind undesigning instinct, which operates in them as the spring which moves an automaton, leaving them no choice between one course and another; nor can we say that a human action is in itself morally wrong as regards the individual, when it directly results from a violent impulse which he has no power to restrain. . . . According to this view, then, what is termed conscience is nothing else than the idea of right

* The following quotations are from an article in the *British and Foreign Medico-Chirurgical Review*, July, 1847, entitled, "Dr. Mayo on the Relations of Crime, Insanity, and Punishment."

† The "anonymous critic" was Mr. (now Dr.) Martineau, who thus sketched in his article on Whewell's "Elements of Morality" the outlines of the ethical system now expounded in the second volume of his "Types of Ethical Theory."

or wrong character which becomes attached to an action, when we place in comparison the motives which prompted it; and this idea is entirely dependent on the relative worth or value in the moral scale which we have been accustomed to assign to the different classes of motives. The moral rule of action hence consists in the preference of a higher to a lower motive or combination of motives. But it will of course be asked how are the relative values of these motives to be determined; and the answer is, simply, by the universal consciousness of mankind, which is found to be more and more accordant in this respect, the more faithfully it is interpreted, and the more fully the general mind is expanded and enlightened. It is this tendency towards universal agreement upon this fundamental point which leads us to feel satisfied that there will in the end be as good a foundation for a science of morals in the psychical constitution of man, as there is for that of music in the pleasure which he derives from certain combinations of sounds.

Among these various springs of action, what is the function of the will?

[It is] not only concerned in carrying into effect the suggestions of the desires. In the well-regulated mind it ought to have a controlling influence over the desires themselves, so as to prevent them from exercising themselves with undue force. This is, in fact, the power known as self-control—a power which cannot be too early cultivated or too habitually exercised. Now, we believe that much may be learned by observation of infantile life of the nature of this power. When a young child gives way to a fit of passion, the nurse attempts to restore its equanimity by presenting some new object to its attention, so that the more recent and vivid pleasurable impression may efface the sense of past uneasiness. As the child grows older, the judicious mother teaches it self-control, by calling up in its mind such motives as it is capable of appreciating; the act of self-control being the result of the overpowering influence of the higher motives suggested to it over the lower or selfish emotions which we desire to bring into subjection.

The development of this power was the object of all true education; and special stress was laid on the appeal to the highest motives within the child's comprehension.

In laying down these principles, Dr. Carpenter had, in fact, been taking lessons in his own nursery. They were the principles he was himself learning to apply. The reader will perhaps forgive the triviality of an anecdote which throws light on these notions of moral discipline. Requiring one day a supply of hydrogen for purposes of lecture illustration, he called his three boys into his study to see him granulate the zinc to be employed in its preparation. The melted metal was in an iron ladle on the fire, and he began slowly to pour it into a basin of cold water, with a natural accompaniment of sputtering. The youngest of the trio, famous in the family for a peculiar roar known as the "square mouth," was frightened, and began to cry. His father bade him control himself and be quiet, but the admonition was without effect. A threat to send him out of the room proved equally vain. "But it shows you don't trust me," remonstrated his father. The boy checked his cries at once and was still.

The problem here was reduced to very simple elements. But in more complex cases, the process was, in Dr. Carpenter's view, essentially the same.

> The will (he said), by a peculiar effort, represses the vehemence of one class of motives by forcibly withdrawing the attention from them and directing it to another of a higher character. . . . The mind, thus swayed hither and thither by various motives contending for the mastery, is at last decided by those which present themselves most forcibly before it; and it is in keeping some in the background, and bringing others into clearer view, that the power of the will seems to be exerted in modifying the decision.

Here is the germ of much of his later doctrine as to the true character of volitional as distinguished from automatic action. It involved a free surrender of the earlier determinism. From this time he ceased to teach that all human actions were "the results of the operation of circumstances "upon the mental constitution of each individual according "to fixed laws." He recognized the share which each man may take in the formation of his own character. This thought grew in importance as his observation and experience extended. He studied the type of spontaneous activity presented by the musical genius of Mozart, in whom the creative energy was at its height while the will was weak and impulse strong; and he took the keenest interest in the mental action of Coleridge, whose life he regarded "as a sort of waking dream, in regard to the "deficiency of that self-determining power which is the pre-"eminent characteristic of every great mind." Convinced that the true nature of volitional action would be best understood by the examination of those states in which the will is completely in abeyance, he set himself to investigate the condition in which the courses of thought were entirely determined by the influence of suggestions upon the mind, and to compare this with the habitual control and direction exerted in the formation of a decision between various plans of action. This line of inquiry was in part physiological and in part psychological: its base lay in the nervous system, from which it was carried up into the operations of the consciousness. A few passages from an article on "The Physiology and Diseases of the Nervous System," published in his *Review* for January, 1850,* will show the progress which he was making in the interpretation of the mechanism of action and its relation to feelings and ideas; his doctrine, that the will determines the *result*, while the automatic apparatus of the body supplies the

* See below, p. 164.

means for voluntary action, having especial importance. Mr. J. S. Mill was so much impressed with the value of the principles thus indicated that he wrote to congratulate the author on an—

> additional step in advance in the most important inquiry in all physiology, viz. that most directly connected with psychology. I have long looked to you (he added) as the great living guide in this advancing speculation, both by your own speculative powers, and by the clearness and philosophical discrimination with which you conceive and judge the results arrived at by others.

The general view of the distinction between automatic and volitional action at which Dr. Carpenter had now arrived, was completed by the proof of the reflex activity of the brain, which had been first suggested by Dr. Laycock. The peculiar phenomena known under the name of Electro-Biology, which then attracted so much public attention, afforded Dr. Carpenter many opportunities of testing his conclusions; and in a lecture delivered at the Royal Institution, in March, 1852, "On the Influence of Suggestion in modifying and directing Muscular Movement, independently of Volition," he expounded the connection which he believed to subsist between the different modes of action of the nervous system.* The power of ideas to produce respondent movements through the instrumentality of the cerebrum was illustrated by the states of electro-biology and somnambulism, when the controlling power of the will was suspended. The ideo-motor principle of action being thus established at the head of the physiological scale, it was easily applied to many of the phenomena of mesmerism and spiritualism, which depended on the state of *expectant attention.* In this condition the abstraction of the mind laid the will to rest, and the anticipation of a

* See the extracts from the Report below, p. 169.

given result served as the stimulus which involuntarily prompted the muscles to produce it. An article in the *Quarterly Review* for October, 1853, enabled him to answer the question, "What are we to believe?" as to mesmerism, electro-biology, odylism, table-turning, spirit-rapping, and table-talking, on physiological principles, and led him to offer an earnest plea for the proper discipline of the automatic apparatus of man's nature by his will.

The study of human nature (he urged), physical, intellectual, moral, and spiritual, is far too much neglected in our educational arrangements. That the preservation of corporeal health is in great degree dependent upon the observance of the rules dictated by physiological science, and that a general knowledge of the structure and functions of man's *body* is really worth his possession for its own sake, is gradually coming to be generally acknowledged. We would urge, however, that an acquaintance with his *mind* is not one whit the less desirable for the right development of its powers and for the preservation of its health. We have seen in the various phenomena we have been discussing how largely the will is concerned in all those higher exercises of the reasoning powers, even upon the most commonplace subjects, by which our conduct ought to be governed; and how important it is that the automatic tendencies, of whatever nature, should be entirely subjugated by it. We are satisfied, from extensive observation, that in a large proportion of cases of insanity, the disorder is mainly attributable to the want of acquirement, in early life, of proper volitional control over the current of thought; so that the mind *cannot* free itself from the tyranny of any propensity or idea which once acquires an undue predominance. The deficiency of power to repel the fascinations of some attractive delusion that appeals to the vanity, to the love of the marvellous, or to some other respective predisposition, by employing the reason to strip off its specious disguise and expose its latent absurdities, really proceeds from a want of the same kind, the supply of which ought to be one of the prominent objects of educational culture in every grade.

Dr. Carpenter had, indeed, endeavoured himself to provide an instrument for such culture. The fourth edition of his "Human Physiology," which was completed in 1852 and issued in 1853, contained a full outline of his views on the nervous system.* It was his habit in preparing successive editions of his large treatises to expand them by the incorporation of the latest researches; but this did not generally involve any fundamental reconstruction, though sometimes three-fourths or four-fifths of the actual matter might be fresh. In this case, however, the whole division of the work was wrought anew from the beginning. He rejected at the outset the doctrine that man's character was formed for him and not (in part, at least) by him; appealed to his consciousness of possessing a self-determining power; and then proceeded to expand and enforce the conceptions to which in his previous writings he had given partial expression. Without hesitation he boldly carried the idea of automatic action into the intellectual products of the brain itself under the name of "unconscious cerebration," while he carefully discriminated from all forms of reflex operation the voluntary control which should reign supreme over all. This intelligent volition he recognized as the source of the power we determinately exert through our bodily organism upon the world around. Here he found the origin of that conception of force which he discerned behind every phenomenon of the external universe, and this supplied him with a new basis for his interpretation of the visible scene as the constant realization of Divine Thought and Will. To the development of these views he returned twenty years later; and the last decade of his life, as the essays in this volume will show, was largely occupied

* In acknowledging the receipt of a copy of this edition, his former teacher, Professor W. P. Alison, of Edinburgh, wrote: "I have found in your discussion "of the nervous system and its physiology much that was new to me, much that "is original, and nothing but what is valuable."

with the endeavour to expound them with reiterated emphasis.

Side by side with the treatise on "Human Physiology" stood the "Principles of General and Comparative Physiology," of which the third edition appeared in 1851,* and the fourth in 1854. Of the place which these books filled in the medical and scientific education of the time, and the author's share in the direction of modern thought through them, a brief estimate is offered in the words of those most qualified to speak. Dr. Carpenter used himself in earlier days to say that the greatest honour he had ever received was to be told by Von Baer that he had read one of his Physiologies on the shores of the Caspian.

> I believe (writes Sir James Paget), that among all the events which have had great influence on the teaching of physiology in our medical schools, none has been more important than the institution of separate courses of physiological lectures. The whole subject, so far as it was taught at all, used to be included in the course on anatomy, and was regarded as far less important than the applications of anatomy in the practice of surgery. The change began between forty and fifty years ago, and among many things proving its necessity, none, I think, had more influence than the publication of Dr. Carpenter's two principal works in 1839 and 1842. Their influence coincided with those exercised by Dr. Sharpey's teaching and the translation of Müller's "Physiologie des Menschen," and with the constantly increasing interest in physiology which was stirred by the teachings of Owen, Liebig, and Goodsir, by Dr. Marshall Hall's works on the reflex functions of the spinal cord, and by Kiernan's essay on the minute structure of the liver, and Bowman's on that of the kidney.
>
> It is impossible to measure the influence of each of these; but their number and importance are enough to prove that the

* The labour involved in the production of such books may be in part estimated from the fact that out of the 1080 pages of which the new volume consisted, only 151 belonged to the previous edition. The general plan, however, remained the same.

period in which Dr. Carpenter's chief works were first published was one of active research and real progress. The range of physiology was rapidly enlarging, and the need of having it much more thoroughly taught in the medical schools was constantly becoming more evident. Nothing could better both prove and supply this need than did Dr. Carpenter's books, collecting and teaching as they did all that the best and latest researches of the time was making sure or probable. They proved that physiology could not reasonably be regarded as of second-rate importance in medical education, and to many they supplied the means of teaching it. Gradually the schools adopted the plan of having the lectures on physiology and histology completely separate from those on anatomy, and coextensive with them; many of the teachers became physiologists, and did good original work, and encouraged their pupils to imitate them; and the whole subject was taught in its relations with medicine as well as surgery.

I think that no change more important than this has been made in our medical schools during the last half-century; and that no one contributed to it more than Dr. Carpenter. For many years his books were almost without a rival in the London schools; Mayo's "Physiology" soon ceased to be read; the translations of Tiedemann and Blumenbach were disused; the translation of Müller's "Physiology" was too large, and in some parts too difficult, for any but the best students. And this continued till physiology became a subject of examination for diploma, and smaller books were required with more simple recitals of admitted facts, and with less argument and reasoning.

I cannot speak from sufficient personal knowledge of Dr. Carpenter's influence as an oral teacher; but I believe it was similar, though not equal, to that which he exercised as a writer, and, especially, was marked, as were his books, by his power of clearly expounding, even while condensing, all that he could learn in even the widest study of each subject that he taught. He was always earnest and enthusiastic; he could say exactly what he knew and believed; and he used to speak as if he wished his hearers to have the same pleasure as he himself had enjoyed in learning what he had to tell.

But Dr. Carpenter's influence on the progress and teaching of physiology was not nearly limited to that of his chief books or to the time at which it began to be felt and was most potent. All through his life he was among the most active in the promotion of research, in discussions whether in public or in private, in reviewing, in exciting others to work. He constantly maintained or enlarged the wide range of physiology in which he had begun; and however definitely he might state facts already known on any subject, he never seemed to imply that they were complete or final, or that the general principles of which they were evidences did not admit of wider application. An admirable example of this was in his extension of the principle of reflex action in the nervous centres. The doctrine of the reflex action of the spinal cord, as expounded by Dr. Marshall Hall, was at the time so complete and compact that it seemed to produce in some minds a feeling of final satisfaction and repose. It did not so with him, and, as the result of his careful thinking, he showed that power like that of the spinal cord exists and does far higher work in portions of the brain.

This may, I believe, be regarded as his best contribution to physiology. It is, indeed, a rare example of accurate thinking, and the best instance of his exercise of a power by which he may always have renown among lecturers and writers on science. Its principles expanded and became clearer as they passed through his mind between the learning and the teaching of them.

My contemporaries in the medical profession (says Mr. Huxley), the old men who were young men commencing their studies forty or five and forty years ago, will, I am sure, recognize as gratefully as I do our indebtedness to Dr. Carpenter's "Human Physiology." It was the standard work on the subject in this country at that time, and it retained its high and well-deserved reputation for some thirty years.

The "forties" constituted a period of transition between the old physiology and the new, between the science of Haller and Bichat and the science of Ludwig and Claude Bernard. The microscope was opening a new world to the anatomist and the embryologist; while properly conceived and executed experimental investigations of the properties of living matter were leading by the only possible road to the explication of the complex operations known as functions.

Dr. Carpenter undertook the important office of intermediary between the rapidly accumulating masses of new knowledge and the student of physiology. Sifting, condensing, and methodically arranging the materials and embodying the results in an admirably lucid style, he produced a compendium of great excellence. And, although the greater part of the work was not enriched by any observations personal to the author, there was much that was original in the mode of treatment of the various topics. This is particularly true of the chapters on the nervous system. I conceive that in these chapters, and in subsequent independent writings, Dr. Carpenter contributed in no small degree to the foundation of a rational, that is to say, a physiological psychology.

While the "Principles of Human Physiology" not only played a leading part in the scientific education of successive generations of medical practitioners, but was widely read by the public at large, the "Principles of Comparative Physiology," of which the first edition was published in 1838, did still more important service.*

The book has the title, and in some respects resembles a well-known treatise by the eminent French *savant* Dugès. But it is a very much better piece of work, and, to my mind, contains by far the best general survey of the whole field of life and of the broad principles of Biology which had been produced up to the time of its publication. Indeed, although the fourth edition is now in many respects out of date, I do not know its equal for breadth of view, sobriety of speculation, and accuracy of detail.

I should say that Dr. Carpenter most conspicuously influenced the course of education in medicine and the progress of biological science by these two works, which have been read by thousands who knew nothing of his many valuable direct contributions to histology and zoology. In addition, his excellent and very popular work on "The Microscope," opened wide the gates of science to many people who might otherwise never have been tempted to enter therein.

* The editions to which Mr. Huxley's remarks especially refer are the third, published in 1851, and the fourth, 1854.

My copy of the "Comparative Physiology" (writes Mr. Thiselton-Dyer, F.R.S.) bears the date 1854. A good deal has been added to biological knowledge since then; but in my opinion there is no modern book which, taken as a whole, surpasses it in firm grasp of general principles and in clear and ordered exposition of details to anything like the degree that it itself did the literature contemporary with it. I suppose few of the younger men read it now. Yet I am convinced it would well repay them for the trouble. Only recently, in a paper submitted for my opinion, I found the principle of the antithesis between vegetative and reproductive activity in the organism set forth by the writer as something novel, in utter unconsciousness apparently of the fact that it is stated and enforced with extreme precision by Dr. Carpenter.

The book itself may not be read, but, as is always the case with good work, its influence, far from being spent, was never more a living force amongst English teachers of science than at the present moment. The doctrine so emphatically taught by Professor Huxley that Botany and Zoology are but branches of a common discipline—Biology, was Dr. Carpenter's cardinal idea. In so far, then, as English biological science has to-day a broad and far-seeing scope, and, above all, looks for ideas of the widest generality in the accumulation of facts and observations, to Dr. Carpenter's influence must in my judgment be undoubtedly attributed no small share in the success it has achieved.

One feature of Dr. Carpenter's writings astonishes me now, perhaps, even more than it did thirty years ago. One is accustomed nowadays to huge books which are vast receptacles of knowledge, and tell the student more than he wants to know about everything. The aggregation of such pieces of literature is, after all, little more than mechanical. The actual facts cited often seem in collision, and left to fight it out among themselves; they are rarely examined critically; still more rarely are they summed up from a single point of view. This was not Dr. Carpenter's method: in marshalling the contents of an infinite number of detached memoirs, he seems to me unsurpassed; he had the double gift of both selecting what was significant and of emphasizing its significance in connection with general principles. Whatever he took into his mind was digested and assimilated there into perfect clearness; and I suppose few scientific writers have ever so distinctly known what they meant, or expounded it with such precision, or with such a wealth of apt illustration.

One other book may be named in this connection, the treatise on "The Microscope," first produced in 1856. By this, said Professor E. Ray Lankester,* "the army of "amateur observers, who delight in the revelations of the "microscope, were trained to accurate work, and led on to "become useful auxiliaries of the professional explorers of "the organic world." This treatise Dr. Carpenter retained in his own hands, issuing the sixth edition, immensely increased in size, in 1881. Both in England and in the United States it has filled a most important place.

No one who has had any experience of the innumerable amateur scientific societies scattered throughout the country (observed a writer in the *Medical Press and Circular*) † can have any difficulty in determining to what extent this single book has influenced the love for practical microscopy among the masses. Formerly this was much more evident than now, when the pioneer of popular guides is only one out of many similar volumes, and when we are liable to forget the indebtedness of the present to the labourers in the past.

VI.

The principal physiological labours of Dr. Carpenter were now complete. He was not disposed to overrate their absolute value. A quick sense of justice sometimes made him seem tenacious of recognition of his share in the development of English biological science, as it also prompted him to accord hearty welcome to the discoveries of others. But when he compared his own work with what

* *Academy*, November 21, 1885. † November 18, 1885.

might appear much humbler toil and less conspicuous achievement in other fields, he did not exaggerate its importance.

For myself (he wrote to his mother in September, 1855), I feel that Providence points out to each of us what we are fit for, and that it is our duty to follow its pointings. I try to do my work in the world in the way and directions in which I feel best fitted to promote human progress. I often feel how very little mere intellectual enlightenment does, and wish that I had more opportunity of labouring for the moral improvement of individuals. So far from looking *down* upon such work as Philip is carrying on, I look *up* to it.* He that saves a sinner from the error of his ways, does a far higher work than he who writes any amount of scientific books, or makes any amount of scientific discoveries.

The energy of Dr. Carpenter's nature, however, was not without its own missionary outlets. With his earnest view of life, even his social pleasures must be touched with something of his favourite science. He had made the acquaintance of Lord Ashburton, and both the opening and the close of 1855 were spent under his roof at The Grange. The guests on the second occasion included Mr. and Mrs. Brookfield, with whom he afterwards became intimate (Mr. Brookfield, of all his friends, being most able to rouse what humour he possessed), and Mr. and Mrs. Carlyle. Among these he pursued a sort of apostolate of the microscope; with what success, the following passage from a letter to his wife will show:—

To-day I came upon him (Mr. Carlyle) alone in a walk, and had the boldness to tackle him, and really got on very well, by setting him to talk about Coleridge, Lamb, etc. He fired out tremendously against Coleridge's self-degradation, but

* Philip P. Carpenter was then minister of the Cairo Street Chapel, Warrington. His philanthropic labours, as well as his services to conchological science, are described in "Memoirs of the Life and Work of Philip Pearsall Carpenter, B.A., Ph.D., edited by Russell Lant Carpenter, B.A."

thought Lamb's talk a sort of diluted insanity. . . . I have opened their eyes a good deal, and interested them much, by the microscope, and I am very glad that I offered to bring it. I shall put it away now that the literary lions are coming down,* and shall keep myself in the background as an observer. I should have told you that Carlyle was very anxious to see one of his own hairs; and as it happened to be a very strong and rough one, we had some amusing jokes as to the typical character which it represented. Mrs. Carlyle then wanted one of hers to be exhibited, which was rather slenderer, but still considerably knobby.

These brief days of rest were hardly sufficient, however, for an overtasked frame, and an illness in the winter of 1856 drove him to St. Leonard's for restoration. There he seized the opportunity for reading various works for which the home-toils provided no leisure. The latest published volumes of Macaulay's History gratified his taste for political narrative, and he wrote to his mother with enthusiasm of the interest with which he traced through his pages the evolution "under the wise, firm, and imperturbable "guidance of the king, of those principles of constitutional "government on which our national prosperity has so "securely rested." Theology, as usual, claimed some of his attention:—

I have not head enough for sermon reading, but have devoted myself on Sundays to "Port Royal," † which I find far more interesting than I expected, and which comes much more home to my feelings than abstract disquisitions on religious subjects. It is remarkable, and I know not how to account for it, that with so much tendency to abstraction and generalization in my own mind, I cannot take in the abstractions and generalizations of others without thinking them out for myself.

The same holiday enabled him to study with eagerness

* Mr. Tennyson, Mr. Tom Taylor, and others, were expected.
† An abridgment of Mrs. Schimmelpenninck's History, by P. P. Carpenter.

Professor Jowett's recent treatise on the Epistles of Paul, and the results of his reading soon appeared in the Greek Testament class which he used to conduct on Sunday mornings in University Hall.

To the student-life around him there he devoted a considerable amount of thought. During the morning hours before his lectures began, he was always at hand for those who sought his guidance and advice. At dinner, and in his drawing-room in the evenings, he took a friendly lead in conversation, and won the confidence of young men by his sympathy with them in their interests and difficulties. Partly to provide them with larger social opportunities, he organized, with his wife's help, in the spacious Council Room and Library, a series of *soirées*, which became quite a feature of his tenure of office, for there the newest scientific illustrations were often to be seen, and men and women of distinction mingled in the throng. The grave and earnest habits of his own life often produced on others deep and abiding impressions. As in every other relation in which he was placed, faithfulness to duty was its most striking characteristic, so that if anything went seriously wrong among those under his care, he suffered the keenest distress. Engagements, in the same way, must be fulfilled at whatever personal cost. The wants of his pupils were his first consideration as teacher; and it was observed, as in complete accordance with the whole tone of his mind, that he lectured to one of his University College classes within an hour of hearing of his mother's death (after a long illness in 1856) with even more than his usual clear ness and accuracy.

In May, 1856, Dr. Carpenter was elected to the Registrarship of the University of London. This appointment enabled him to cease lecturing and examining in Physiology, though he continued to serve as Professor in University

College, and to reside as Principal in University Hall. Two years later, however, the new Charter of 1858 introduced changes in the constitution of the University which involved a considerable increase in the duties of the Registrar, and he then relinquished his other functions, and devoted himself with undivided zeal to his administrative labours. His tenure of office for three and twenty years coincided with a vast expansion of the operations and influence of the University, in the direction of which he took a leading share. His large knowledge of the needs and conditions of higher education, especially medical and scientific, bore rapid fruit. The arrangements for degrees in science owed their first forms chiefly to him, and in working them out practically his organizing skill and his mastery of detail were repeatedly tested and not found wanting. His business qualities enabled him to perform mere routine work with great despatch, while the history of each step of departmental development seemed to fix itself without effort in his accurate and retentive memory. Thus as years went on, he became a sort of storehouse of precedents which he could recall and apply with unusual facility; and it often happened that when administrative changes were proposed by younger men he could retrace the occasion of similar suggestions long before, and the reasons which had been urged against them, and had prevailed. The whole aim of his work was to bring the University as closely as possible into contact with the higher educational life of the country. His extensive experience and his willingness to impart information or advice made him in time a centre to which the promoters of all kinds of educational enterprises might resort; and in the rise of many of the local colleges in the great provincial towns, he took the keenest interest. His position, moreover, placed him in connection with many distinguished men associated in the work of the University, among whom his own scientific distinction gave him a just influence. The Chancellor, the successive Vice-Chancellors, were his steadfast friends; and to the last day of his life he cherished, as one of its most precious privileges, the remembrance of the intimate relations into which he was admitted with the stately and reserved historian, Mr. Grote.

On his retirement from University Hall, in 1859, Dr. Carpenter settled in a house at the foot of Primrose Hill, which became the family home for more than a quarter of a century. In the possession of a settled income, and free from the care and strain which had beset his earlier years, he was able to give fuller play to his tastes, and pursue with less difficulty his favourite scientific inquiries. In his new study was built an organ, which he designed himself, with some unusual features, to secure as much variety and richness as possible without overwhelming power. Here he found at last a place of ease though not of indolence, of satisfied desire, such as he had never before enjoyed.

> The organ looks extremely handsome (he wrote one winter's day to his brother Russell), and is as charming in its voice as in its exterior. I can sometimes scarcely realize how completely all the hopes of my life have now been accomplished. A few days ago I was very poorly with a bad cold, and I remained in bed part of the morning, reading Dickens's "Tale of Two Cities," which had so fully taken up my attention that I thought of nothing else even while I was dressing. When I went into my study, feeling rather miserable in myself, and found a bright fire, bright sunlight, and everything looking so much the opposite of what I had been reading, and of my own physical condition, I was, as people say, "struck all of a heap."

To this home Dr. Carpenter delighted to welcome his friends, and year by year, as the circle widened, his facilities also increased. What impression he produced upon the guests who came to him acquainted only with his writings, may be gathered from the following letter of the late Mr. George Ripley, for so many years the well-known literary critic of the *New York Tribune.*

I trust I do not abuse his kind hospitalities by saying that my visits at his house are among the brightest recollections of my London experience. With his eminent position in the scientific world, he has the modest simplicity of a child. His love of truth and reality, which impresses one as the staple of his character, is not incompatible with an affectionate gentleness of manner which lends a peculiar charm to his instructive conversation. Dr. Carpenter is chiefly known as a physiologist, though eminently distinguished in other branches of natural science. But I found him equally interested in the great problems of philosophic speculation, "fate, foreknowledge, and free will," which have been the delight and torment of high thinkers in every age. He has none of the flippant scorn of certain modern pretenders to science who ignore everything beyond this "visible diurnal sphere," and who would limit the study of the human soul to the manipulations of the dissecting-knife and microscope. Among other topics which he elucidated in his familiar talk was the unconscious activity of the brain in connection with the phenomena of the will. Starting with the recognition of the fact that matter is merely the vehicle of force, he sets aside the old dispute between the spiritualists and materialists as barren of fruit, and seeks to establish a sound and comprehensive psychology on the basis of the whole constitution of man, and his relations to the external world. From this point of view he regards the great centres of nervous force as the source of two classes of automatic actions, primary and secondary, of which the latter, though originally prompted by the will, and still remaining under its control, are habitually performed without any volitional agency. The power of invention, whether in the sphere of poetry, art, or mechanical combination, may be referred to this source. The same principle explains the higher operations of the mind, the creations of genius, and the intuitions of the moral sense. It is the ever-flowing current of mental activity which may be regarded as the spontaneous unconscious action of the brain, that produces the miracles of intellect which we regard as natural inspiration. Although this power is a gift, the possession of which is not at our command, partaking of the nature of an instinct, which no culture can produce any more than it can raise a crop of corn where the seed has not been sown, it may be developed and strengthened by appropriate discipline. In proportion to our love of the true, the beautiful, and the good, it gains in efficient and harmonious activity. The more intimately we commune with the highest ideals of artistic and moral excellence, the more thorough will be our appreciation of whatever is noble and elevating. The more faithfully we devote ourselves to the pursuit of truth, free from all selfish aims and conscious prejudices, the more consummate will be our mental force, and the richer in fruitful results. A foundation is thus laid in the original constitution of man for the advancement not only of the individual but of the race, until, in a higher phase of existence, the laborious and uncertain deductions of the intellect may be superseded by the clear vision of intuitive insight.

London, however, was not the only place where Dr. Carpenter was able to receive congenial visitors. In 1855, he had spent a brief September holiday in the Isle of Arran, in the Clyde, with results that had a determining influence upon his scientific inquiries. While dredging in Lamlash Bay, he came across numerous specimens of the beautiful rosy Feather-Star (*Comatula rosacea*), and its larval stages, which resemble the stalked form of *Pentacrinus.* When the British Association met that year in Glasgow, this "rediscovery" (as he called it) of the Pentacrinoid larva excited great interest among his Natural History friends. "Professor Kölliker,"* he wrote, "is "quite delighted, and seems much inclined to accompany "me to Lamlash for the purpose of working out the "matter fully." The result was that Dr. Carpenter took

* The distinguished anatomist of Würzburg.

a house on Holy Island, off the shores of which the Comatula had its home. Lying across Lamlash Bay, it formed a splendid natural breakwater, and gave security to the hundreds of vessels which sometimes sought shelter in the bay from the storms outside. The island itself was a great rocky mass, rising a thousand feet out of the sea. The solitary house stood at the northern end, two miles from the village of Lamlash, across the bay. Dr. Carpenter was a fearless boatman ; he was fond of an oar, and had a passion for sailing, which he had first practised in the West Indies ; and his boat was often seen scudding across for letters and provisions while the visitors on the other side were glad to be on shore. He was commonly known in the village as "the eccentric Englishman ;" and an old woman in the valley behind, who had never been beyond the confines of the bay in all her life, could not repress her amazement that any one should "come down "fra' London and live on an island, wi' the water a' "round it."

To this summer home came many friends, drawn by interest in common pursuits and the opportunities of dredging, which were by no means so frequent then as now. Dr. Balfour, Professor of Botany in the University of Edinburgh, who often resided at Lamlash, was a frequent visitor ; so, too, was Professor (now Sir William) Thomson, from his Brodick home. The guests, to be sure, ran risks of possible detention, if a gale cut off the communications ; and it was with mingled amusement and despair that the mistress of the establishment, in the early hours of the third day of a violent storm which had actually sunk the boat at her moorings, received a plaintive request from Professor Helmholtz for a bread poultice, when there was but half a loaf left, and the household would have to breakfast on porridge, tinned meat, oatcake, and potatoes. Such incidents as these, however, only heightened the contrast between the island-freedom and the conventions of town life. Through the quaint English of the following words of the late Professor Édouard Claparède, of Geneva, who left behind him (in 1859) the impression of a singularly gentle and lovable nature, breathes a truthful utterance of gratitude:—

> I wish to tell you and your wife my thanks for the kind reception I enjoyed in Holy Island. This fortnight on the banks of Lamlash Bay is one of the happiest I ever delighted upon. I often heard of the friendly hospitality of Englishmen, which comes not only from the lips as the French, but from the heart, and shows itself by facts more than by words. I am glad that your kindness gave me occasion of experiencing myself the truth of this reputation.

From this vacation Dr. Carpenter went home to study the book which was to give so profound an impulse to scientific thought in all directions, "The Origin of Species," by Mr. Darwin. He was well fitted to appreciate its general argument, for the subject of modification by descent, and the wide limits of species had been long in his mind. He had, indeed, rejected the theory of the author of the "Vestiges," but it had been on the grounds of deficient evidence and physiological error, not from theological prepossession. In an article on Dr. Prichard's two treatises, "The Physical History of Mankind," and "The Natural History of Man," published in 1847, he had reiterated the general doctrine—

> That amongst the different species of plants and animals there is a very wide diversity in regard to their respective *capacities for variation.* In the species which have least capacity for variation we find (as a necessary consequence) the *least* adaptiveness to external conditions; . . . on the other hand, in those which have *most* capacity for variation, that capacity manifests itself in the peculiar adaptation which their physical constitution undergoes to circumstances as they change; and

also in the spontaneous origination of peculiarities that cannot be traced to the influence of those circumstances.

He had discussed numerous cases of variation among domesticated animals, and advocated especially the descent of the dog from the wolf; replying to the objection that the wolf does not exhibit a disposition to attach itself to man, in these terms:—

> It has been proved that the wolf is much more capable of domestication than is commonly supposed; if taken young from its wild state, and brought under the influence of man; and that it then displays as much attachment to its master, and remembrance of kindness shown it, as any dog could do. So that there is no difficulty in understanding how, by a continuance of this influence through successive generations, the character of the race may become so permanently changed that the traces of former domestication may not be altogether lost, even in breeds which have returned to their wild state for centuries. There is no reason why the *psychical* character of a peculiar aptitude for domestication should not manifest itself as the special feature of a variety, like any *physical* character, such as the remarkable conformation of the otter breed of sheep; or why, to put the matter in a still more definite form, the first manifestation of the variability of the species of wolf should not be the production of a race disposed to attach itself to man, from which race, under the continued influence of domestication, an almost infinite variety of new breeds has arisen, differing in the number of the vertebræ in their tails, in that of their toes, and even in that of their molar teeth. These last departures from the ordinary type exist, not merely in particular races most remote from it, but also within the limits of single varieties or breeds, just like the occasional appearance of six-fingered races among various nations of men. They cannot, therefore, be admitted as specific differences; and they serve to show how *very* wide are the limits of variation in this species.

The researches into the Foraminifera, in which Dr. Carpenter had been subsequently engaged, had led him still further in the direction here indicated; he had had occasion again and again to point out how arbitrary were the bounds set by previous investigators, and how unsatisfactory was the old doctrine of the immutability of fixed types.*

He was ready, therefore, to give sympathetic and intelligent consideration to Mr. Darwin's main thesis, and in the correspondence which ensued, Mr. Darwin warmly expressed his pleasure at the support which was likely to be afforded to it.

> I must thank you (he wrote on November 18, 1859) for your letter on my own account, and, if I know myself, still more warmly for the subject's sake. As you seem to have understood my last chapter without reading the previous chapters, you must have maturely and most profoundly self-thought out the subject, for I have found the most extraordinary difficulty in making even able men understand at what I was driving.

The next day came a second note—

> I beg pardon for troubling you again. If, after reading my book, you are able to come to a conclusion in any degree definite, will you think me very unreasonable in asking you to let me hear from you? I do not ask for a long discussion, but merely for a brief idea of your general impression. From your widely-extended knowledge, habit of investigating truth, and abilities, I should value your opinion in the very highest rank.

After another fortnight, Mr. Darwin replied to the communication which he had thus invited: "I am perfectly "delighted at your letter. It is a great thing to have got a "great physiologist on our side." Two articles, one in the *National Review* for January, 1860, and the other in the *British and Foreign Medico-Chirurgical Review* for April, enabled Dr. Carpenter to give an outline of Mr. Darwin's

* At the meeting of the British Association in Glasgow, in 1855, Dr. Carpenter delivered one of the evening lectures, and took as his subject the "Range of Variation of Species."

views, and illustrate them with a variety of independently selected facts. Of this second, Mr. Darwin wrote as follows :—

> You must let me express my admiration at this most able essay, and I hope to God it will be largely read, for it must produce a great effect. . . . I have not a criticism to make, for I object to not a word; and I admire all, so that I cannot pick out one part as better than the rest. It is all so well balanced. But it is impossible not to be struck with your extent of knowledge in Geology, Botany, and Zoology.

Other thoughts were at the same time occupying his mind. He had lectured that winter at the Royal Institution, on "The Relation of the Vital to the Physical Forces," with especial reference to the life of plants, and had contested the doctrine of germ-force, maintaining that

> What the germ really supplies is not the force, but the directive agency, thus rather resembling the control exercised by the superintendent builder, who is charged with working out the design of the architect, than the bodily force of the workmen, who labour under his guidance in the construction of the fabric. The agency of the germ may be regarded like Magnetism, as a *static* force; and just as Magnetism requires to be combined with motion, to enable it to develop Electricity, so does the directive agency of the germ need the co-operation of a *dynamic* force for the manifestation of its organizing power. That dynamic force, as we learn from an extensive survey of the phenomena of life, is Heat.

The report of this lecture drew from the veteran Mrs. Somerville the following letter :—

> Florence, June 12, 1860.
>
> The proof of the sequence of forces by which you have connected mind with mind, and transmitted your ideas to the minds of your audience, has required a higher power of intellect than that of making electricity the bearer of thought from con-

tinent to continent, sublime as it is, inasmuch as many intellects were combined to effect the latter, while the general tendency of science seems to have been your sole guide in demonstrating that matter is merely the medium through which mind-force, like all other force, acts, and that thus mind may, and in fact does, exist independently of matter. The series which you have completed is very beautiful. First, Mr. Grove's masterly demonstration of the correlation of the physical forces, then your proof of their correlation with the vital force so happily illustrated by the zoospores, and, lastly, the remarkable correlation between the vital and mental forces. No doubt this series will mark the middle of the nineteenth century as a great scientific epoch, the discoveries arising from which who can predict, when the motion of a microscopic atom affords irresistible proof of an important fact? The paper you have kindly sent is so full of interesting matter, and contains so much new to me, that it is in vain to write all I should have wished to talk to you about. I can only heartily thank you for it.

The researches on the Foraminifera, on which Dr. Carpenter had been long engaged, were now drawing to a close. Four successive memoirs upon them had been presented to the Royal Society, and published in the "Philosophical Transactions," and on these, together with his investigations into the microscopic structure of shells, his observations on the embryonic development of *Purpura*, and his various other writings in Physiology and Comparative Anatomy, was based the award of one of the Royal medals, which he received from the President and Council of the Royal Society in 1861. He was still hard at work completing the long-delayed treatise on the entire group, designed for the Ray Society, in which he was assisted by Mr. W. K. Parker and Mr. T. Rupert Jones. With how much eagerness he toiled, even through the hot summer days in which he was detained by University examinations, may be inferred from the following letter to his wife at Holy Island:—

London, August 20, 1861.

When working on Friday evening, after my return home, upon Dactylopora, I got an entirely new light, which revolutionized my ideas of it so completely (as regards its more complex forms, at least) that I could not rest until I had gone over it with Mr. Parker. I worked at it all Saturday morning, and, finding everything confirmatory of my new ideas, I went over to him in the evening, and fortunately found him at home and disengaged. It was quite charming to see his delight at the new and more satisfactory information I was able to give him, and he seemed just as glad to be shown that he was in error as if he had made it all out originally himself. He gave me permission to do anything I wished in dismounting, breaking, and laying open his specimens, and I have found it desirable to take almost every one (several score in all) off its slide, and to examine it separately, making sections and fractures, but especially finding that removing portions by acid supplied under the microscope with a camel's-hair brush did most what I wanted. In this way I have thoroughly succeeded, have cleared up every difficulty, and have got the whole truth before me in a way quite demonstrative. I never followed up a scientific examination with such zest before, or had the same opening out of such novelty in so short a time.

The incident made a strong impression upon his mind. He recurred to it a month later in writing from Holy Island to his brother Russell.

I never saw a more beautiful instance of thorough candour. As step by step I led him from the simpler to the more complex arrangements, and showed him how the latter evolved themselves out of the former, he seemed just as much pleased in coming to the knowledge of a new and beautiful set of facts as if he had been himself the one to find them out; and was just as ready to accept them as if he had not previously, not only formed, but published a description altogether at variance with what he now saw to be the truth.

In the following year, these labours were completed by the publication, under the auspices of the Ray Society, of the large and important work entitled, "An Introduction to the Study of the Foraminifera."

Among Dr. Carpenter's favourite recreations was an occasional visit to Paris. He had many friends and correspondents among the *savans* of the French capital. With Professor Milne Edwards he was united by many ties of common work; and he was always sure of finding there a fresh sympathy in his researches and speculations. There, during the Easter vacation of 1863, he heard of the discovery of the flint implements and the human jaw at Abbeville. A day's inquiry on the spot on his way home greatly excited his interest, and led him to return in the following month, with Mr. George Busk, Dr. Falconer, and Mr. Prestwich, to take part in the investigation which ensued. The question to be decided was the antiquity of the bone. Professor Milne Edwards presided over the inquiry. "He has the great advantage," reported Dr. Carpenter, "of being able to interpret each side to the "other when there is any difficulty. The discussion has "been most friendly, and I think that each side has found "that the other had more to say than was expected."

So the fiftieth year of his life ran on; and when the family greetings poured in upon him on his birthday, he uttered his feelings with unusual copiousness and freedom in a sort of general epistle.

London, October 30, 1863.

There is great beauty in the expression which almost all of you have quoted about "the sunny side of fifty." I had quite forgotten it, if I ever heard it; but I can fancy good Dr. Tuckerman's genial utterance of it, and can heartily respond to it.

After dwelling on his home-happiness, he continued—

My social position, too, is such as when I entered upon life, sacrificing whatever prospects I might have had for the more congenial pursuits which promised no more substantial return than a bare maintenance, was altogether beyond my hopes. It is now thoroughly equal to my ambition. Anything higher would only bring with it increased cares, and involve greater temptations to worldly distraction. . . . I honestly believe that I am succeeding in carrying the University through a very important phase of its development as few other people could do, the range of knowledge required to make the various examinations go smoothly, to say nothing of habits of business, being very considerable. So that although I am not badly paid for it, I consider that, in giving up myself heartily to University work, I am really labouring efficiently for the public weal.

I have now thoroughly determined to devote what remains to me of working power to original scientific research. My two large Physiologies have been for some time out of print, and Churchill has been at me for new editions. For some time I rather clung to the idea of reproducing them with assistance; but I have now quite come to the conclusion that I must give them entirely up, and a new edition of my "Human Physiology" is now being prepared by a gentleman whom I have recommended to Churchill. It is, of course, a considerable regret to me to give up what I have worked so hard upon, and to feel that I have no right henceforth to call myself a physiologist. But, as I had to choose between imperfectly keeping up with this subject and entirely giving up original research, I could not hesitate in preferring the latter. . . .

Of my more particularly personal state I shall say less, for I have less to say. I feel deeply thankful for the many mercies I have experienced, not less for the discipline I have undergone. As I heard old Mr. Robberds say, on an anniversary of his commencement at Cross Street, "God and man have been very kind to me." And I trust that others can perceive that the discipline of life has not been without its salutary effect. I am sometimes disquieted by intellectual doubts and difficulties, and I often mourn that I cannot *feel* what others seem to experience of their personal relation to the Deity. But I believe that these difficulties are a necessary result of the habits of thought which have been growing up with me; and as they never obscure my view of duty, I find it better not to trouble myself too much about them, but to apply myself to the business of the time, and find their practical solution in the doing it. Still, it is when prevented by bodily indisposition from so escaping them that these sources of uneasiness make themselves felt; and, as it would be too much to expect all sunshine, I must regard these as the clouds. I am now and then comforted by the knowledge of the large toleration which men of great religious experience have for difficulties like mine. Both Mr. Martineau and Dr. Sadler (to whom I have most freely opened myself) have assured me that I ought not to make myself unhappy about them, and that they would rather be in my position than in that of many who believe themselves much safer.

Through the difficulties here indicated, Dr. Carpenter, after no long interval, worked his way. The strong religious needs of his nature found their satisfaction in the view of the world depicted in the later essays in this volume. His intellectual fidelity was far too steadfast for him to be contented with anything short of real intelligible conviction. And partly under the stimulus of the preaching and the writings of his friend, the Rev. James Martineau, and partly through the natural development of his own philosophical principles, he laid firmly in his thought the bases of the Theistic interpretation of the world. Moreover, he was peculiarly susceptible to sympathy, though the subjects on which he was exercised did not admit of frequent speech; and the presence by his side of a most tender and discerning companion who (as one who knew her well, said) "leaned "on him, but in whose very leaning there was persuasion," brought to him a helpful influence more easily understood than described. He did not dwell on special theological points; but his doubts and difficulties were of the kind to be met by evidence of the reality of religion in man's nature and experience. Had he been shut up to the alternative of the Calvinistic scheme of redemption or agnosticism, he would doubtless have joined the ranks of those who declared a theology impossible. But he returned to the manifestation of religion which he saw in the character and teachings of Jesus, from whose figure he now began to detach the supernatural vestments in which it had been robed. There he found nothing inconsistent with the strictest demands of his science, while a moral image of supreme beauty was presented to his affections; and he accepted Christianity in the sense in which he believed it to have existed in "the mind of Christ." This attitude of thought is portrayed in the conclusion of one of the first Sunday lectures for the people on scientific subjects which were ever delivered in London, in the winter of 1866.* The topic of the evening had been the "Antiquity of Man." After stating some of the scientific and moral difficulties besetting the ordinary Evangelical view of the Bible, Dr. Carpenter (who had warmly befriended Dr. Colenso three years before) continued in these terms:—

> But to the honest inquirer, who brings to the religious history of the world the same modes of investigation that he applies to the secular—who takes nothing for granted, but endeavours fairly to estimate every fact at its true value—who appreciates at their full worth those noblest instincts of man with which all true progress has been in relation, by action and reaction, both as cause and as effect—and who looks to the religion of the future as destined to exalt and refine these, and to bring them to bear with augmented strength on the great problems of human welfare, what but good can come from the freest search into scientific truth? What part does science play that is not in fullest harmony with the highest truths of religion? Do the Divine words of our dying Master, "Father forgive them for "they know not what they do," appeal less strongly to our deepest sympathies, because astronomy teaches that the earth moves

* These lectures at St. Martin's Hall were under the auspices of the National Sunday League. Dr. Carpenter took great interest in these and similar efforts to extend the range of Sunday teaching. He was President of the Sunday Lecture Society from its first formation, in 1869, until his death.

round the sun? Or does his prayer for his disciples, "that they "may be one even as we are one," less earnestly move us to seek to realize that unity which he came to promote, because geology shows that the present surface of the globe is the resultant of a vast series of changes, of which we have no trace in the Biblical record, but which are yet more surely revealed to the eye of science than they could have been by the most veracious contemporary narrator? So far from being in opposition, I affirm that science is in the fullest harmony with all that is essential and true in Christianity; for whilst it is every day contributing to the *material* welfare of man, it is even more certainly benefiting him by the enlargement of his intellect, the elevation of his morale, and the strengthening of his power of spiritual discernment—all which contribute their respective shares to the development of his religious nature; and, last, but by no means least, it is undermining, one by one, those props on which have rested those unsightly and repulsive additions built up by the perverted ingenuity of theologians around the original edifice: so that, when the time is at last come, the blast of common sense, the flood of public opinion, shall overthrow all that has its foundation in the sand, and leave in its majestic simplicity and beauty that temple, founded upon a rock, in which all mankind shall one day gather themselves for the worship of their common Father and the recognition of their mutual brotherhood as His children.

VII.

In the vacation of 1863, Dr. Carpenter visited his friend, Professor (afterwards Sir Wyville) Thomson, at Belfast. He, too, was engaged in the study of the Crinoid group, and in the waters of the Belfast Lough he had successfully employed the dredge. The visit was repeated in the following year, but it was interrupted by the beginning of a very serious illness, through which Dr. Carpenter was nursed with the greatest care by his kind host and Mrs. Thomson. But when he was at length able to return to London, he was quite unfit to resume his University duties. The long strain which he had put upon his energies seemed to have exhausted his natural powers of recovery. The eminent medical men who met in consultation at his house, and detected the presence of permanent disease, said to themselves beneath their breath outside the door of the patient's room, "He has one foot in the grave already." Music ceased to charm; his scientific investigations were laid aside; his Foraminifera and his Comatulæ remained undisturbed. It seemed as though he had become prematurely old; torpor crept over him and numbed his activities; the weeks passed by listlessly and mounted into months, and he gained no strength. The fears of his friends appeared on their way to verification, when one day Sir William Logan, the head of the Geological Survey of Canada, called upon him, bringing with him some specimens from the great beds of the Canadian limestones, on which he asked his opinion. Dr. Carpenter's quick eye at once detected in them a remarkable affinity to the foraminiferal structure with which he was so familiar. His interest was again powerfully awakened; the "will to live" revived; he began to make microscopic preparations, and entered with much of his former zest on a new path of inquiry, with the result that he regained some of his old vigour, and became the ardent champion of the truly organic character of the rock in question. Here, as he believed, was the earliest known form of animal existence; it was the *Eozoön*, "the dawn of life."

The spring of 1865 found Dr. Carpenter again at his post. But his strength was not yet adequate to the full labours which the summer series of examinations entailed. Threatened with another collapse, he was suddenly ordered off to the Engadine. He passed slowly up the Rhine with his wife, being directed to proceed as little as possible by rail, and the travellers rested for a while at Heidelberg. There his scientific imagination was kindled by the wonders of the spectroscope in the laboratory of Professors Kirchhoff and Bunsen; and a supper-party in the Castle grounds, given by them in his honour, stamped itself in his memory as one of the happiest evenings of his life. At St. Moritz he found the stimulus which his constitution so much needed. His vitality reasserted itself; the specific malady was subdued and kept at bay, though it tended occasionally to break out again in after-years; and when, to avoid the advancing cold of the latter part of August, he moved down to Bellaggio, he drank in deep draughts of beauty from the mountains and the lake which completed the refreshment of mind and heart.

In June of this year Dr. Carpenter had presented to the Royal Society the first portion of a memoir on the Rosy Feather-star, which embodied the results of his vacation studies at Arran for many years previously. These had been carried on in conjunction with Professor Wyville Thomson, who had already published an account of his observations on the earliest larval stages of the Feather-star. Dr. Carpenter's memoir took up the subject at the point to which it had been carried by Professor Thomson, and made known two important discoveries, one of which found immediate acceptance. But the other, respecting the nervous system of the Crinoid type, remained without notice for many years; and when, in 1875, he stated his views more fully, they were strongly opposed by the principal continental students of Crinoidea. They gradually found acceptance, however, and were publicly adopted by his chief opponent, but a few weeks after his death, in 1885.

But the joint work of the two friends on the Rosy Feather-star was destined to bear yet more important fruit. For it led them to take a very special interest in the discovery, by Professor Sars, the Superintendent of the Fisheries to the Swedish Government, of a stalked Crinoid living at a depth of three hundred fathoms, near the Lofoden Islands. This little form, which had received the name *Rhizocrinus*, was recognized as the living representative of a family of stalked Crinoids, which was abundantly represented in the Oolitic rocks, and less so in the chalk, but had apparently become extinct in later geological times. The discovery of a member of this group, living in European seas, was therefore of the highest significance to the two English students of the Crinoidea ; and it suggested to Professor Thomson, in 1868, the idea that the British Government might be induced to promote the scientific exploration of the deep sea between the Shetlands and the Färoe Islands. This proposition was promptly laid by Dr. Carpenter before the Council of the Royal Society, who in their turn made application to the Government. The season was already advanced, but a vessel was allotted for the purpose ; Dr. Carpenter was entrusted by the Admiralty with the scientific direction of the expedition, and he was accompanied by Professor Thomson and one of his own sons.

This was the beginning of the series of deep-sea researches, in which for four years Dr. Carpenter bore so conspicuous a part, until they culminated in the despatch of the *Challenger* on its voyage round the world. These expeditions involved no small amount of work. Special apparatus was necessary for dredging and for temperature-soundings, which was only perfected after various preliminary trials. The plan of operations had to be carefully designed in consultation with the authorities of the Admiralty ; and their results in due course begot reports, which grew both in bulk and in importance with successive years. Nor were the cruises themselves an unalloyed pleasure, though they brought with them hours of rapturous scientific bliss. Again and again, when Dr. Carpenter joined his vessel, he was worn and jaded with protracted work through the hottest days of the year, when, unfortunately, the severest pressure of University duty coincided with his least physical capacity to bear it. He knew that he would pass days together, perhaps a week, in his berth at the outset, and again with every gale; and that the liability to sickness and discomfort would haunt him through the entire voyage. But for the brilliant success of the first expedition, he would hardly, perhaps, have had courage to attempt another.

The ship first assigned to the investigators was the *Lightning;* it had passed the days of its youth, for it had been built in 1824; nor was it constructed in accordance with modern ideas of speed, as it was the earliest steam-vessel in her Majesty's service. "Our old tub," wrote Dr. Carpenter, somewhat disconsolately, "cannot, at the best, "make more than seven miles an hour!" The weather was abominable; even the officers and men were sick; and it was often too rough to attempt to dredge. The kindness of the Danish Governor and his lady, while the ship was at Thorshavn, the chief harbour of the Färoe Islands, and agreeable intercourse with the Dean of the Islands, and the Rector of the High School, relieved the tedium of confinement to the little cabin. Once more at sea, they encountered fresh resistance from wind and wave, as though the waters resented their inquisitorial activity, and were determined to baffle all efforts to probe the secrets of their depths. But at length the day of compensation dawned.

To MRS. CARPENTER.

On board the *Lightning*, September 6, 1868.

This morning, after two days' interdiction, we had our most interesting result. At 530 fathoms the temperature was 47° (probably on account of the Gulf Stream), and we have brought up in a muddy ooze a most remarkable set of new and large forms of siliceous sponges, with which Thomson is especially delighted, together with others previously discovered and recently described by Lovén, as well as small specimens of the *Hyalonema* (Japanese flint-rope) and its encrusting Polype; the whole giving materials for completely settling the questions lately discussed between Gray and Bowerbank, in which Thomson has intervened, and (as at present appears) entirely in favour of Thomson's views. He is, of course, greatly delighted, and now says that it was quite worth a week's misery to get these.

September 7.

After I wrote yesterday afternoon, we had the intense satisfaction of meeting with two specimens of *Rhizocrinus*, not very good ones, but serving to prove the existence of this type in the open ocean, and therefore (presumably) in considerable quantities, if we can only hit upon the spots where it abounds, as we have fortunately done with the sponges. This completes the success of our expedition in everything that we hoped to do, except that the zoology of the Färoe fjords proved much less interesting than we had anticipated. We have proved that dredging at 500 or 550 fathoms involves no more difficulty, where there is adequate power, than dredging at 100 fathoms. We have found out the best form of dredge and the best material for the bag. We have got all the Norwegian forms to which we alluded in our letters as carrying us back to older types. We have added a great deal to our knowledge of geographical distribution, and have shown how much more it depends on the temperature than on the pressure of the deep sea; and we have a set of observations on this subject which are of first-rate importance. As complete novelties from 500 fathoms and more, we have not only the series of siliceous sponges, but also some very curious Rhizopods, with sandy envelopes. And what was of special interest as marking the tropical source of the warm band, was the presence of two large forms of shelly Foraminifera, of types precisely corresponding to those of warm waters, and living. If they had been dead, they might have been regarded as mere drifts.

A week later the ship found shelter again in Stornoway. From this haven of rest, in the light of their recent successes, the memory of their first troubles faded away.

> Nothing but the strong motive which induced me to make the original application (wrote Dr. Carpenter) would have kept me up through its early miseries and discouragements. If we had had to come home with our tails between our legs, instead of with the flying colours with which our ship was literally decked when we came into port, my present feelings would have been very different.

The results of these investigations were summed up in two important generalizations. In the first place, the phenomena of temperature led Dr. Carpenter to conjecture that besides what is properly called the Gulf Stream, *i.e.* "the current of heated water which issues from the Gulf "of Mexico," there was a "continual interchange between "the *oceanic* waters of equatorial and polar regions." The water cooled in the polar seas, he argued, must sink, and displace the water that is warmer than itself, pushing it away towards the equator. In the deepest parts of the ocean, therefore, there would be a progressive movement in the equatorial direction; whilst, conversely, the warm water of the tropical seas, being the lighter, would spread itself north and south over the surface of the ocean, and would thus move towards the polar regions, losing its heat as it approached them, till, under the influence of polar cold, it again sank to the bottom, and the same round was retraced anew. This view of ocean-circulation had been, in fact, already offered by the French physicist, Pouillet, and also by the Russian physicist, Lenz, with whose expositions of it Dr. Carpenter afterwards became acquainted, though they had not given any precise indication of the forces which would keep up the movement. It had failed to win acceptance, and the current doctrine on the subject was that of Sir John Herschel.

With indefatigable industry, Dr. Carpenter set himself to establish his own conception, as he hoped, beyond refutation. In papers before scientific societies, in private discussions, in popular lectures, in magazine articles, he reasoned and expounded; he urged fresh illustrations; he met and overcame unexpected difficulties. The facts accumulated in subsequent expeditions, and the masterly combinations in which he arranged them, at length began to produce the desired effect. In a letter, written only a month before his death, in 1871, Sir John Herschel accepted the new teaching, which also won the sanction of such distinguished authorities as Sir William Thomson and the Astronomer Royal.

The second suggestion was due to Professor Wyville Thomson. The animals brought up alive from the chalk-like deposit then in progress over what the temperature-soundings proved to be a relatively warm area, distinguished from a cold area at no great distance, presented many points of most interesting relationship to the Fauna of the Cretaceous period. Was it not possible, then, surmised Professor Thomson, that the deposit of Globigerina-mud had been going on, over some part or other of the North-Atlantic sea-bed, from the Cretaceous epoch to the present time? Might we not, indeed, be said to be, in one sense, still living in the Cretaceous epoch?

To the solution of these and other problems generated by the first cruise, successive expeditions were devoted.

Her Majesty's surveying-vessel *Porcupine*, under the command of Captain Calver, was assigned for the service, and proceeded, in 1869, to work over the ground traversed by the *Lightning*, as well as to investigate new fields; while in 1870 it was sent to the Mediterranean. The following passages from Dr. Carpenter's letters home will show his interest in the scientific work and in the new scenes to which he was introduced.

Thorshavn, August 22, 1869.

I have now to tell you of a most remarkable and unexpected revelation. Our dredgings last year brought in so little from the bottom of the cold area except stones and sand, that we concluded that animal life is very scanty under that low temperature. Captain Calver, however, having bethought him of attaching swabs to the dredge, so as to sweep the bottom as well as to scrape it, these swabs have come up teeming with life, when there was next to nothing in the dredge but sand and stones. And though a great deal of this consists of common things, yet we have obtained in this way some specimens of extraordinary interest. Thus in one place we brought up several specimens of the large *Comatula Eschrichtii*, a well-known Greenland and Icelandic type, obtained there in shallow waters. But our great catch has been an extraordinary sponge, with a thick and dense branching axis like that of a Gorgonia, entirely disconnected from the flesh which clothes it, and of a bright-green colour. This came up in abundance on Friday morning, the dredge having been down for several hours of the night, and pulled in at four in the morning. W. T. and I were on deck by five, though the morning was decidedly uncomfortable, cold, with a drizzling rain; and we forgot all about the weather in our interest in this and the abundance of other things brought up by the swabs. They were perfectly gay with bright-coloured Echinoderms, purple, red, and orange; and when I detached several of these and put them in a basin with some of the green stems of the sponges, and bright-yellow Comatulæ, I thought I had never seen a more beautiful display of animal colour. Yet this came from a bottom of sand

and stones, at a depth of about 600 fathoms, presumably in utter darkness, at a temperature of 30°, and with 40 per cent. of carbonic acid in the atmosphere of dissolved gases. I can scarcely conceive a more complete *bouleversement* of our ordinary biological notions than is given by this remarkable disclosure of the condition of this bottom.

Stornoway, September 9, 1869.

On Tuesday we brought up a great prize, an Echinoderm, which (Thomson is sure) is "brand-new, but intensely old," *i.e.* a form which belongs to the Chalk, but was supposed to be quite extinct. It is something like an Echinus which has been sat upon, so as to be flattened out into a round cake; its peculiarity being that whilst it has the same general plan of structure, the plates are disconnected from each other, and some of the meridional bands are wanting, so that there is a general looseness about the frame, which gives it a most curious feel when laid living on the hand. The discovery of this living type at once gives the clue to the interpretation of the fossil *Echinothuria*, which had previously been accounted very problematical, and supplies an instance equally interesting with *Rhizocrinus*, of the persistence of Cretaceous types, thus adding strong support to Thomson's hypothesis. In the evening the dredge was put over, and allowed to trail all night with the swabs attached. Hearing the heaving-in a little before five a.m., I got up and went on deck, where Thomson already was, and there we saw a sight we shall not easily forget: the swabs loaded with *Holtenias*, of which there were at least two buckets full, besides multitudes of other things, nearly all of them specially interesting, as a new species of *Cidaris*, nearer to the Chalk forms than the common one, numerous specimens of star-fish, of which we had previously only two or three, and of which there are probably no specimens in any other than Scandinavian museums, two very fine specimens of *Hyalonema*, many small siliceous sponges, and last (but by no means least) a second specimen of the *Echinothuria*. This I was greatly rejoiced at for Thomson's sake, as he can now work out the anatomy of the animal without mutilating his first and best specimen. This brought our work to a most triumphant conclusion, this haul being as much beyond any previous one in interest as was our corresponding haul last year.

In the next summer, when the *Porcupine* was anchored off Goletta, the little harbour of Tunis, science gave way to sight-seeing. The Mediterranean had, in fact, yielded less zoological results than were expected; but even this negative issue was not without its consolations. "After all," reflected Dr. Carpenter, "it was something to have found out "that there was nothing to find."

Malta, September 13, 1870.

On Monday morning we got up very early, breakfasting at five o'clock, to go up to Tunis, for which the little steamer that runs up and down the lake ordinarily leaves at six. But when we got on shore we learned that there was not enough water in the lake, and had to take a carriage to drive round it. This was tiresome, as the drive was very uninteresting, the country being quite level for miles round, and very arid, the only green at this season being that of the olive tree. The only feature of interest was a fine group of mountains at some distance, about the scale of Goatfell and Ben Huish,* and not unlike them in outline. The appearance of Tunis itself did not improve as we approached it. Excepting a few villas, which are chiefly occupied as consular residences, it is entirely included within a wall; and when we passed the gates we found ourselves in very narrow roads, with continuous dead walls on either side, occasionally pierced by doorways, which led to the interior of the houses.

We at last came into the principal open space of the town, where what were formerly the palaces of the Bey and his principal ministers are now the consular and other public offices, the palaces being outside the walls. Having learned that the Bey sits on Monday mornings at his palace to hear causes, we at once went on to it, and found it a by no means imposing-looking building, with numerous courtyards, at some distance outside the town. We were shown into a room, from which we had a view of one of these courtyards, in which the guard was relieved, with the usual European ceremonial and the performance of the military band. There was something in the whole affair which

* Mountains in Arran, which constantly served as a family standard for comparison.

impressed all of us with the feeling of its being very like a scene in a theatre, the marching and costumes of the men being very like that of the *supers* on the stage. The music was simply hideous, the different instruments playing in unison or octave without the slightest idea of harmony, and leaving off on the most unexpected notes. Two or three times we were told that the Bey was coming; but, after waiting an hour, we found that he had gone over to another place. We followed thither, and learned to our mortification that he had just finished his sitting. We were shown the hall in which it had taken place, which was more like a long corridor; and we were told that the suitor has to stand at one end of this, and to 'make his statement'* to an officer near him, who repeats it to another a little way off, and at last it reaches the Bey, with such modifications and variations as it may have sustained in its transit. Of course, any questions from the Bey's end have to go through the reverse process; while the replies will again find their way to him as at first. Fancy the proceedings of an English court of justice being carried on on such a system!

The new palace has, built into it, several relics from the remains of Carthage; entirely, as I should judge, of the Christian times, when Carthage was an important Roman city and a bishop's see; among these was a pair of columns, ten or twelve feet high, of brass.

We then returned to town and went to the bazaar, which is the place of all buying and selling, except what is carried on in some little shops of the meanest kind elsewhere. This is a most curious place. It is a series of narrow and tortuous arcades, completely arched over, except in one central spot, where they all meet. This, at the frequented time (eleven a.m.) at which we chanced to be there, was full of people, some buyers, but many sellers: people who have got no shops, but carry their goods on their heads, screaming and shouting what they have to announce. In these arcades the only light is from a hole left here and there in the arched roof; yet this is sufficient in the middle of the day to give as much as is needful. The shops

* Another home phrase, derived from the habit of certain members of the family, whose conversation on subjects in which they were interested, was apt to become monologue.

are the queerest little dens imaginable, just about the same size and arrangement as those of the beasts at the Zoo. You stand in front of them, and the dealer sits cross-legged on the raised floor, rising to get any of the goods on shelves disposed round his den. All those of one trade congregate in the same arcade, and the stocks of the several dealers are very small. Of the larger articles, it often happens that each man has only one of a kind, and if you do not like it, you either go on to another dealer, or the shop-keeper will collect other specimens from his neighbours. There does not seem to be any rivalry among them, but each deals for his neighbours as well as for himself. In many of these dens the manufacture is going on. This is especially the case with the red Fez, which is now gradually taking the place of the turbans, etc., among the various races along the Mediterranean, and of which all the best that are sold come from Tunis. . . .

The next morning we again got up early to pay a visit to the Consul, who had arrived from England the day before, and to see the remains of Carthage, which lie near the entrance of the bay of Tunis. There is now nothing of a port, and it is difficult to see how there ever can have been a harbour of any importance; but there is a massive ruined wall extending far into the interior, notwithstanding that a great deal of the stone has been taken to build houses in the neighbourhood. But that which was especially worth seeing was a great series of very large underground cisterns, like dry docks, lined with brick, and arched over, for the storing of water brought by an aqueduct from mountains at many miles distance. There were two rows of these, of which seventeen have been uncovered in each, and there may be many more still buried and filled up. I never saw so gigantic a public work.

I find Malta a very interesting place, and the harbour and fortifications are wonderful. We went a long drive yesterday to see some places of interest in the interior of the island, and more especially St. Paul's Bay. This was very much what I expected from Mr. James Smith's plan of it,* and I seemed able

* Mr. James Smith, of Jordan Hill, near Glasgow, an old fellow-student of Dr. Lant Carpenter, had devoted special attention to the record of St. Paul's voyage, which he had investigated in his own yacht. His results were published in a book entitled "The Voyage and Shipwreck of St. Paul."

to fix almost precisely on the spot where the ship grounded: the point on which he is said to have landed has a small chapel to commemorate the event. The interest of the association is somewhat marred by the erection of a new set of villas near the shore, as the locality is thought to be suitable for a bathing-place!

Nothing can exceed the aridity of the country, the surface of which is, at this season, almost entirely bare of vegetation, except the cotton-plant, which is extensively cultivated, and is now just ripening. The land is everywhere divided up by stone walls into enclosures of varying size, but scarcely any trees are to be seen anywhere. These will all be sown at the beginning of the rainy season, and in a few weeks everything will be verdant. The population of the island is enormous, more than 120,000, in an area much smaller than that of the Isle of Wight. How they all live is a mystery I have not yet been able to solve, as all the food grown in the island will not keep them three months in the year, and I cannot learn how they find means to purchase the deficit. The lower class are chiefly sailors, and go about all parts of the Mediterranean. The *patois* they speak is based on Arabic, with a mixture of Italian words, and they can make themselves understood all along the African coast, from Egypt to Tangier, though the people of Egypt, Tripoli, Tunis, Algiers, and Morocco, speak very differently among themselves. They seldom, however, go beyond the Mediterranean, and come back to Malta as their home whenever anything goes wrong with them elsewhere.

Gibraltar, September 29, 1870.

We learn here of the fall of Strasburg, the surrender of Metz, and the investment of Paris. I have had a long talk with Sir F. Williams this morning, and find him strongly anti-Gallican. He has been a good deal in France during the last two years, and has seen how the people and the Emperor have been egging each other on, in their desire to pick a quarrel with Prussia, with a view to obtain further territorial extension. He says, very truly, Europe stood by without interfering when France acquired Savoy and Nice; why should France interfere with the consolidation of Germany? Paris complains now of being besieged by

> Prussia, when at the beginning of the war the universal cry of the French army was "à Berlin." This was even chalked on the baggage and ammunition waggons. . . . It is Sir F. Williams's opinion that of all men now living, Thiers is the man who most contributed to the present state of things, both by helping to make the exaltation of France the one idea of the French people, and also by inducing Louis Philippe to fortify Paris, which now makes it the special point of attack by the Prussians.

The attention excited by the deep-sea researches, and the value of the discoveries already made, led Dr. Carpenter to project a plan for investigations on a still wider scale. Mr. Lowe, then member for the University of London, and Chancellor of the Exchequer in Mr. Gladstone's first administration, took a warm interest in the work. "Though time is a scarce commodity just now," he had written from Downing Street in March, 1870, "I have "not been able to deny myself the pleasure of reading your "lecture. It fills me with interest and admiration. You may "rely on my support for further experiments of a like "nature." This support was cordially given to the larger proposals which Dr. Carpenter now ventured to lay before Mr. Goschen, who at that time presided over the Admiralty, for the scientific circumnavigation of the globe. In the summer of 1871 these proposals received the practical sanction of the Cabinet, and Dr. Carpenter felt that a heavy responsibility rested upon himself to do all in his power to render such an expedition successful. Many considerations seemed to point to his own assumption of its scientific direction. He possessed an unusual range of knowledge, a very varied experience of affairs, an eminent position, and he had given special proof of his ability to conduct investigations alike in the physics, the zoology, and the geology of the deep sea. There were, of course, considerations of another kind arising out of the peculiar risks to his own health, his home, his University duties; but he felt himself ready to make any sacrifice for his love of knowledge for its own sake. These thoughts, blended with what may be called his family-consciousness, were in the background of his mind when he wrote from the *Shearwater* * to his sister, Mary Carpenter, who, earlier in the year, had been contemplating a fourth visit to India.

To MARY CARPENTER.

Gibraltar, August 25, 1871.

Your going out to India seems now little more than my going out for a vacation cruise; and it seems as clearly your mission to carry on the work of female education in India, as it is mine to prosecute the science of the deep sea. You have found your work, as Carlyle says, and I have found mine. I have been reading again, on this voyage, Carlyle's "Life of John Sterling." Poor Sterling, from a combination of circumstances, never found his work, though having all the will to do it. On the other hand, Coleridge had with his vast powers and influence on the thought of the time, no end of work to do, but had no will to do it. When Sterling had made up his mind to leave the Church, Carlyle says, "What is to be done? Something must be done and soon, under penalties. Whoever has received, on him there is an inexorable behest to give! *Fais ton fait.* Do thy little stroke of work! This is Nature's voice, and the sum of all the commandments to each man." The more I see of human life and experience, the more I see how true this is; and how all individual considerations should be kept in subservience to great ends, when we have a right to feel assured that they are truly great and good. You, my dear sister, have the happiness of feeling that your ends are in the most eminent degree both great and good, as bearing

* The *Shearwater*, under command of Captain (now Sir George) Nares, was on its way to the Red Sea for surveying work. It had been arranged that Dr. Carpenter should carry out some investigations in the Mediterranean on the way.

immediately on the moral as well as on the intellectual elevation of great masses of our fellow-men and women. My work (I mean my scientific work) is of a very different character, and has not, apparently, a direct moral bearing, however high its intellectual value. But I feel sure that the single-minded pursuit of truth for its own sake, without a thought of selfish aims, has its effect not only in raising the character of the individual, but in elevating the moral standard of the educated community; and I am sure that I can trace this in the greater earnestness, sincerity, and thoroughness of the leading scientific men of my own standing, as compared with many of those of the generation now passing away. I do not think the same of mere intellectual acquirement; though even here the thoroughness on which our dear father used to lay so much stress, is a valuable moral discipline. So, my dear sister, let us, the eldest daughter and the eldest son, bearing the name which we so much venerate, go on our several ways; carrying out each in her and his own way the objects in which our dear parents would have felt so much interest.

It was highly characteristic of Dr. Carpenter at this crisis that he placed the decision as to his scientific duty in other hands. He felt that the fascination of the prospect of devoting the rest of his life to original investigations for which he believed himself specially qualified, might become one of those "dominant ideas," the presence of which he could so often detect in the conduct and dispositions of others. He consulted those in whose wise judgment he felt the fullest confidence, and he returned from the Mediterranean that autumn perfectly content to tread the accustomed round. He never looked back. In all the preparations for the *Challenger* Expedition he took an active share, and he saw it depart without a pang. There were still fresh interests to occupy his mind, and more work for him to do at home.

VIII.

The conclusion of this chapter of Dr. Carpenter's active labour may fitly be followed by a semi-autobiographical summary of his views on "Darwinism in England," drawn up during his second Mediterranean cruise, and published in a little Valetta journal named *Il Barth*,* in December, 1881.

I have been so frequently asked by Continental *savans* what English naturalists think of Mr. Darwin's views, that it may not be an unprofitable use of a short interval of leisure which my detention in Malta forces upon me, if I attempt briefly to answer the question.

To do this, I must say something of the state of opinion among British naturalists previous to the appearance of Mr. Darwin's "Origin of Species." I can myself remember the time when the "fixity of species" was the generally accepted doctrine among zoologists and botanists; when much greater stress was laid upon points of *difference* than upon points of *agreement;* and when far more credit was attached to the *multiplication* of species by attention to minute differences than to the *reduction* of their number by such a careful comparison of numerous individuals as proved these differences to be inconstant and gradational. So, again, it was the general creed of the older palæontologists that each geological period had a fauna and a flora of its own, every member of which must be specifically distinct from that which preceded and followed it; a *complete extinction* of all the types of life then existing having taken place at the end of every such period, and an *entirely new creation* having ushered in the next. This school has been represented among Continental naturalists to a recent period by men of such eminence as M. D'Orbigny and Professor Agassiz; but it has long since died out in Britain. All our most esteemed zoologists and botanists have latterly studied

* A large part of this was afterwards embodied in a paper entitled, "Charles Darwin: his Life and Work," *Modern Review*, July, 1882. A few verbal changes made in this paper are here introduced.

the *range of variation* of each reputed species, as one of the most essential features of its character; whilst our ablest Palæontologists have laboured with success in tracing the identity of numerous species whose remains occur in formations stratigraphically distinct. It was, indeed, a favourite doctrine of the late Professor Edward Forbes, that there was a constant relation between the range of any species in *space* and its range in *time; i.e.* that in proportion as the constitution of any species adapted it to diversities in climate, food, etc., so as to permit its extension over a wide geographical area, in that proportion would it have been able to accommodate itself to changes in the same condition, so as to hold its ground through successive geological periods. Further, it had come to be perceived that where the stratigraphical continuity is the closest, there is the greatest resemblance between the successive faunæ, as in the case of the different members of the Cretaceous series; and further, that where there is an interruption to such continuity in one locality, the gap is often bridged over elsewhere. And even as regards those great separations which were reputed to mark the terminations of the Palæozoic and of the Mesozoic series respectively, it was generally believed by geologists of the newer school that the interruption was more apparent than real; depending merely on the want of intermediate beds in that small portion of the globe which has been hitherto explored. A geologist who has formed his notions of stratigraphical succession from a country where Tertiary strata immediately overlie Silurian, would find that tremendous *hiatus* in great degree filled up by the intermediate series presented in England alone; and, in like manner, if the British geologist could carry his researches into areas which were submerged when Palæozoic and Cretaceous Europe were above the sea, he could doubtless find abundant evidence of gradational passage to the Mesozoic and Eocene. Such gradations, it is now well known, are not wanting within the limits of Europe, and are very obvious elsewhere.

Even in the pre-Darwinian epoch, then, many of our most thoughtful naturalists were disposed to admit (1) that no definite limits can be assigned to the variation of any species without the careful collection and comparison of examples of the type throughout the entire extent of its geographical and geological range, and (2) that a very considerable amount of *generic continuity* existed between the fauna and flora of successive strata, extending in all probability to what are known as *representative species;* as well as to types between which the gradational passage could be shown to be complete. These doctrines I myself strongly advocated in the first of the memoirs on Foraminifera (entirely devoted to the genus *Orbitolites*), which I have presented at various times to the Royal Society; and I therein cited, in support of them, the experience of several of my most esteemed brother-naturalists, whose views on this question were altogether in accordance with my own. And if these doctrines be admitted, it becomes obvious that the range of any true species in geological time would be determined only by the degree of its capacity to accommodate itself to changes in the conditions of its existence; and that there is no *à priori* reason why marine types having a large capacity of this kind should not maintain their existence through a long succession of epochs. That existing species of mollusca are met with even in the earliest Tertiary strata, and in increasing proportion in the later, had been demonstrated by M. Deshayes, and made by Sir C. Lyell the foundation of his classification of the Tertiary series. That numerous types of Foraminifera and Diatomaceæ characteristic of the Cretaceous period are existing at the present time, had been shown by Professor Ehrenberg. And Messrs. Parker and Rupert Jones had shown the identity of even Triassic Foraminifera with types still inhabiting the Mediterranean.

However limited in scope were these pre-Darwinian views, as compared with those developed in the "Origin of Species," they had taken the same direction, and in some degree prepared the way for their reception; as had also an application of Von Baer's great doctrine of *Development from the General to the Special*, which was first (I believe) put forward by Professor Broun, and which I myself worked out (in ignorance of his having already done so) in the third edition of my "General and Comparative Physiology." For I there dwelt upon several cases in which the earlier forms of certain great types presented *generalized* combinations of characters, which subsequently became more and more distinctly *specialized* in the progress of geological time. But I put forth this merely as an expression of the *plan* according to which the succession of animal and vegetable forms had been created, not as indicating any genetic continuity between the earlier and the later. Some years before, indeed, while criticizing the "Vestiges of the Natural History of Creation," and exposing the unsoundness of the author's data and the fallacy of his reasonings, I had taken occasion to say that I had not the least objection, either philosophical or theological, to the doctrine of Progressive Development, if only it could be shown to have a really scientific basis: since the development of the very highest type of animal life from the very lowest, during the long succession of geological ages, did not seem to me more strange than the actual development of that same type during a nine months' gestation. And I had further argued that it really involves a far higher idea of Creative Design to believe that a small number of types of organic life originally introduced were continuously evolved in the course of geological ages, according to a definite and unchanging plan, into a countless variety of forms suitable to the "conditions of existence" at each period, and finally into the flora and fauna of the present epoch,—than to suppose that the changes which successively took place in those conditions necessitated interferences from time to time on the part of the Creator, in compensating, by the creation of new species, for the extinction of the old. For, to compare great things with small, we regard the production of a chronometer whose pendulum or balance-spring is furnished with a self-acting compensation for changes of temperature, as a higher effort of constructive skill than the production of an ordinary clock or watch, in which the needful compensations have to be made, as occasion requires by the interposition of an external power.

By those who had been following the line of thought I have just indicated, the publication of Mr. Darwin's "Origin of Species" was felt, as by myself, to be the inauguration of a new era in a biological science. It gave a distinct shape to ideas on which many of us had been pondering as vague speculative possibilities. It showed that the doctrine of Progressive Development might be put into the form of a definite scientific hypothesis; in favour of which a vast mass of evidence could be adduced, whilst the objections to its acceptance were shown to arise chiefly out of that "imperfection of the geological record" which we were all prepared to admit. It showed that on general grounds the probability of a genetic continuity of organic life throughout the geological series—the fauna and flora of any epoch being the product of "descent with modification" from that which preceded it,—is far greater than that of successive new creations. And to such as admitted this, it was plain that the conclusion can scarcely be evaded, that as the tendency throughout has been clearly one of *progressive differentiation* or *specialization*, the number of original types might have been very small—perhaps even a single primordial "jelly-speck" being the common ancestor of all.

But we could not attach the importance which Mr. Darwin seemed to do, to the doctrine of Natural Selection, or the "survival of the fittest," as *in itself* an adequate explanation of the progressive modifications that have produced the long and diversified succession of animal and vegetable forms which have peopled our globe from the first appearance of life on its surface to the present time. The instances adduced by Mr. Darwin as results of *artificial* selection were cases of *varietal* modification only; and he was unable to prove that the character which most strongly marks what the naturalist had been accustomed to accept as a true *species*—viz. its incapacity for producing with any congener an intermediate self-sustaining race—is otherwise than fixed and permanent. All that he could show is that *varieties* placed under artificial conditions may come to be so far differentiated constitutionally as to breed together with difficulty. But of the actual origination of what a philosophical botanist or zoologist would accept as a true species, incapable of breeding except with its own type, I do not recollect that he was able to produce any instance whatever. If, then, Natural Selection could not be shown to have produced a new species, still less could it be looked to as a *vera causa*, for the establishment of still greater differences.

But it is further obvious that Natural Selection can only operate where a *capacity for variation* is inherent in the type. There are some types of which the range of variation is so restricted that they can only exist at all under certain combinations of conditions; their distribution, therefore, being limited alike in space and in time. There are others which have a much wider range, being able to adapt themselves to great diversities in external conditions; but it cannot be justly said that the variations which these present are "spontaneous." Every effect requires a cause. Natural Selection is assuredly not that cause, since its effect is only to perpetuate, among varietal forms, that one which best suits the conditions of existence. Consequently we must look to *forces* acting either *within* or *without* the organism, as the real agents in producing whatever developmental variations it may take on. Of the action of such forces, we at present know scarcely anything; and Mr. Darwin has not given us much help towards the solution of the problem.* But this much seems to me clear: that just as there is at the present time a determinate capacity for a certain fixed kind of development in each germ, in virtue of which one evolves itself into a zoophyte, and another (though not originally distinguishable from it) into a man, so must the primordial germs have been endowed each with its determinate capacity for a particular course of development; in virtue of which it has evolved the whole succession of forms that has ultimately proceeded from it. That the "accidents" of Natural Selection should have *produced* that orderly succession, is to my own mind inconceivable; I cannot but believe that its evolution was part of the original Creative Design; and that the operation of Natural Selection has been simply to limit the survivorship, among the entire range of forms that have thus successively come into existence, to those which were suited to maintain that existence at each period.

* In 1882 this last clause ran thus:—"But Mr. Darwin has himself most "fully recognized the need of them. His latest utterance on the subject is that "'at the present time there is hardly any question in biology of more import- "'ance than that of the nature and causes of variability.' I cannot, then, be "accused of undervaluing Darwin's work, in pointing out that what I originally "felt to be its weakest part, still remains incomplete."

That something of this kind is felt by most of those British naturalists who, like myself, accept the doctrine of continuity by "descent with modification," is more than I can possibly affirm; but I believe that such as have thought most deeply on the subject are quite satisfied that the doctrine of Natural Selection *does not of itself* afford an adequate explanation of the phenomena that have to be accounted for. Of that genetic continuity, however, every extension of palæontological knowledge affords additional evidence. A most striking example is afforded by the gradual divarication of the Ruminant and Pachyderm orders, and of the family subdivisions of the latter, which can be now traced through the Tertiary and Quaternary series. Every naturalist knows that the Anoplotherium and other mammals whose fossil remains occur in the Eocene Tertiaries of Paris, presented most remarkable combinations of pachyderm and ruminant characters, which are completely separated and specialized in Pliocene and post-Pliocene genera. A few years ago a remarkable collection of mammalian fossils was discovered at Pikermi in Greece; and the study of these, most carefully prosecuted by M. Gaudry, of the Jardin des Plantes, has shown that they supplied such a number of "missing links," that the genetic derivation of the latter more specialized types from the earlier more generalized could scarcely remain a matter of doubt to any naturalist not previously wedded to the doctrine of special creations. On the basis of a very careful examination of the whole series as completed by recent American discoveries, Professor Huxley has been able to construct a "Pedigree of the Horse," so complete that nothing is now wanting to its entire continuity from the Eocene period to the present.

Again, the Deep-Sea researches in which it has been my privilege to bear a part, have shown that a large number of Cretaceous Echinoderms, Corals, Sponges, and Foraminifera, as well as of Tertiary Mollusca, supposed to be extinct, survive in the depth of the ocean at the present time; these types being in some cases *specifically identical*, whilst in others the modification they have undergone is so limited as to justify their being accounted *representative species*. This has been the result, not merely of the dredging expeditions conducted by my colleagues (Professor Wyville Thomson and Mr. J. Gwyn Jeffreys) and myself, but also of the like exploration carried on by the United States Coast Survey in the Gulf of Mexico and elsewhere. [One of the most characteristic examples of it is presented by the little *Rhizocrinus Lofotensis;* the discovery of which by G. Sars, off the coast of Norway, in 1866, gave the start to our own work. For this is clearly a dwarfed and deformed representative of the highly-developed *Apiocrinus* (Pear encrinite) of the Bradford clay (Wiltshire Oolite); which, as my friend Wyville Thomson said, "seems to have been going to the bad "for millions of years," under the influence of a reduced temperature.]

To most English naturalists it seems premature at present to attempt to construct a pedigree of the animal kingdom generally, as has been done by Professor Haeckel and other naturalists in Germany. It appears that the palæontological as well as the developmental history of each group must be much more completely ascertained before any but tentative arrangements of this kind can be formed. Thus, while some of us have found no difficulty in believing that all existing birds have arisen from one common stock, the derivation of that stock from a common *stirps* with the reptilian at first appeared almost inconceivable; birds and reptiles being *physiologically* almost the antithesis of each other. But the discovery of the Archæopteryx has shown that a true bird may have a prolonged and distinctly jointed tail. The careful comparison made by Mr. Seeley of the skull of the Pterodactyl with that of the Fowl, led him to conclude that the former must have had a development of brain scarcely inferior to the latter, and was likely, therefore, to have had a circulation as vigorous and complete as that of birds. [And the researches of Professor Marsh in the Cretaceous strata of North America, have brought together a vast number of "missing links" in the form of Pterodactyls which resemble birds in the want of teeth, and of birds which correspond with reptiles in the possession of them.] Further, the development of the Struthious birds, which were formerly supposed to have the closest mammalian affinities, is now found to be much more reptilian than mammalian; while certain Dinosaurian reptiles present distinct indications of progress towards birds. And thus it does not seem at all unlikely that evidence may hereafter be obtained, which may adequately support the idea of the descent even of birds and reptiles from a common ancestor.*

In the mean time I think I may say with confidence that all British naturalists who are not dominated by the prejudices of a bygone age, accept the general doctrine of Continuity as—to say the least—a good working hypothesis, under the guidance of which their inquiries may be advantageously prosecuted; and that they feel the great *desideratum* to be the acquirement of such a knowledge of extinct types, as may give to the entire pedigree of the animal and vegetable kingdoms a completeness approaching that of the pedigrees already constructed for particular families; and such an elucidation of the causes of variation as may show under what circumstances those marked divergences of type took place, whereby distinct classes, orders, families, and genera successively came into existence.

IX.

The cessation of the summer cruises in which Dr. Carpenter took so active a share, and the completion of the new building of the University of London, which had involved him in much additional and anxious labour beyond his ordinary duties, set him free for other tasks. He had become the secretary to the Gilchrist Educational Trust on its first establishment in 1865, and was thus brought into connection with a large number of educational movements all over the country. This was especially the case with the courses of popular scientific lectures for the working classes in various large towns, the organization of which fell chiefly upon him. He resumed his place himself upon

* In 1882: "And thus the evidence now in course of accumulation "already affords adequate support to the idea, etc."

the platform, with the prestige of diversified experience and eminent scientific authority. Winter after winter he made a rapid tour, lecturing four or five nights a week, to vast assemblies rising from twelve to eighteen hundred people. His subjects often lay far apart; sometimes they were suggested by the physical or biological conditions of the deep sea; sometimes they dealt with popular applications of important physiological and psychological principles, as when he discoursed of human automatism or epidemic delusions; or, again, they were fetched from his experiences of travel, it might be in the Nile valley, or (subsequently) at Niagara, when any chance listener who had trodden the same ground would often find that he had nearly as much to learn as those who had stayed at home. In such discourses (and this was also characteristic of some of his writing in later years), Dr. Carpenter often fell instinctively into a sort of autobiographical vein. He had been mixed up with so many important movements, and had seen so much of their working, that it seemed the most natural thing to him to illustrate almost every fresh topic by his own personal experiences, or his own contribution of action, knowledge, or thought, to the matter under discussion. Such references were not inconsistent with a real modesty, though they did not always convey that impression. They poured out from his lips, or his pen, simply because they appeared to him the most suitable to his purpose; and they often stood side by side with an original teaching of far higher value. In a lecture on Niagara, he once related what Oersted had said to him about it in a way which excited some amusement for its evidently unconscious egotism; "but Oersted's remarks," it was observed, "which were the substance of "the story, were commonplace compared to Dr. Car- "penter's own comments, which were thrown in incident-

"ally and apparently with no sense of their greatly "superior importance." To great popular audiences this practice only seemed like taking them into a familiar intimacy, and it made them feel immediately at ease. In each new town which he visited, he was always interested in the leading industries and manufactures; and some apt illustration, borrowed perhaps from a local process which he had that morning witnessed, caught the attention of his hearers, which never flagged to the close. Nothing, indeed, was more striking than the breathless suspense with which a complicated argument would be followed, the gathering excitement as the conclusion to which it pointed first came distantly into view, and the burst of applause attending its final demonstration. But Dr. Carpenter was never dependent on the stimulus afforded by these popular manifestations. He was very generous of his time and thought even for small causes. He would take as much pains to speak to a little band assembled in the school-room at Hampstead,* or to the poor and uncultivated at an East-end Mission, as to his equals and critics at the Royal Institution, or the huge and eager gatherings of a northern town.

Such lecture-tours, however, were the recreation of Dr. Carpenter's spare time, rather than the occupation of the working hours saved from his University duty. These were devoted with unflagging vigour to the various branches of research in which he was continuously engaged. One little stream of notes and papers communicated to the scientific periodicals dealt with his former clients, Comatula and Eozöon. Another was concerned with the theory of oceanic circulation, currents, tempera-

* Only last summer a gardener at Hampstead referred to a lecture on mildew, delivered many years before, as having been of great practical use to him.

ture, and the physical geography both of the deep and inland seas. And a third, growing in bulk and importance, related to the old questions of psychology and religious philosophy, on which he had been silently pondering since 1854. He entered the field once more with papers on the "Physiology of the Will" (1871), and "Common Sense" (February, 1872). In the summer of 1872 he presided over the meeting of the British Association for the Advancement of Science at Brighton, and took as the theme of his address the interpretation of nature by man.* A succession of articles on kindred topics followed in the next three years, while he devoted himself to the project which he had long entertained, of enlarging the outline of his chapters on the nervous system in the fourth edition of his "Human Physiology." This was completed in 1874, under the title of "Principles of Mental Physiology, with their Applications to the Training and Discipline of the Mind, and the Study of its Morbid Conditions." Into this book he poured much of his most earnest thought, his observations on human character, his meditations on the conduct of life. Starting from the functions of the different portions of the nervous system,† he sketched the natural history of thought and feeling, and discriminated with the added precision of twenty years' consideration, between the two spheres of automatic action and volitional control. Reflection had only confirmed him in the views which his physiological inquiries had originally generated; and he had accumulated a large store of illustrations, which threw new and suggestive lights on the meaning of many of the commonest experiences. The attention which he had bestowed on many abnormal mental phenomena, and

* See below, p. 185.

† Subsequent investigations have thrown doubt on some of his positions, but it is not perhaps too much to say that in the present state of knowledge the view which he offers still remains more coherent than any other.

the openness of mind with which he surveyed them, gave especial value to his treatment of difficult questions on the border-land of the marvellous. Students of philosophy who found that he approached their problems from the scientific rather than the metaphysical side, sometimes discovered gaps in his reasoning, even while they shared his conclusions. This was especially the case in his discussions of speculative themes such as the nature of the external world, or the presence of Mind and Will in the Universe, to which the argument of the whole book was one long prelude. He had not had a metaphysician's training; and could not think in his language, or dwell at ease with his abstractions. When he read the treatises of Principal Caird or Professor Edward Caird, and attempted to master the principles of Kant or Hegel, he felt himself in a strange land, among men of other tongues which he could not learn. But he believed that what was on one side a limitation, might be on another a source of strength. He managed to combine with the idealism of Berkeley and Mill a robust realism which was intelligible to the ordinary reader; and he hoped that he might act as the interpreter of important scientific truths to a growing number of religious minds whose faith could not live in the attenuated air of the new agnosticism.

One great desire I have (he wrote to his brother Russell in the birthday letter, this time on the right date, of December, 1874), to be of some use as a mediator in the conflict which has now distinctly begun between science and theology. I see quite clearly that it is of no use to try to grapple with the subject unless one thoroughly masters the question on both sides. On the scientific side I find it taking a development such as I never dreamed of, as in Professor Clifford's Sunday Lecture published in the last *Fortnightly*, in which it is asserted that there is no room for a God within the solar system; while his and H.'s doctrine of human automatism pure and simple, seems to me to strike at the root of all moral responsibility. I am going to reply to this in the *Contemporary Review* for February. I know that there are a number of thoughtful people, especially among the clergy, who look to me for guidance on these matters, and I am anxious not to fail in giving it. I have the greatest confidence in the ultimate prevalence of truth; and the surging up of the depths only makes me feel that the bottom is reached more nearly than on previous occasions.

The interest excited by these varied labours was indicated in the letters which Dr. Carpenter often received from those who were eminent in philosophy, in public affairs, and literature, of which the following criticisms and acknowledgments may serve as specimens:—

From the REV. DR. MARTINEAU.

Dolgelly, September 8, 1872.

I was presuming enough to hope for an authorized copy of your Address,* and so refrained from looking at the imperfect newspaper reports which fell in my way. Your kind remembrance of me in your presentations has enabled me to read it with the careful attention it requires and repays. It is full of interest from beginning to end; and I need not say that its main drift and purpose appear to me at once philosophical and seasonable. The distinction on which you insist between the "law" and the "cause" of phenomena is assuredly real and of the utmost moment: and no survey of the ultimate logic of science can be long regarded as adequate which does not provide for it. If I had taken in hand to enforce it, I should have expressed myself (doubtless to the great disgust of my hearers) in terms more metaphysical than you have deemed it needful to employ, being convinced—possibly through over-estimate of my habitual pursuits—that there is no firm basis for the distinction, unless we resort to the *à priori* postulates of thought. For science, in its researches into Nature, I do not see how we can

* The Address delivered at the Brighton meeting of the British Association in the previous August. See p. 185.

claim more than access to the *laws* of phenomena, in their grouping and succession; nor can I hesitate to accept the positivist dictum that *causes* lie entirely beyond scientific cognizance. *Our own* causality, as you justly say, we do directly know; but causality *other than our own* we do *not* know by either observation or consciousness; we observe only *movements;* we feel only certain *sensations* of our own; both of which are phenomena and not their causes; and our reference of such things to an *objective causality* which is not in our experience is, I take it, an *intuitive intellectual act*, planting outside of us the counterpart and antithesis of the power which we put forth from within. If the authority of this intellectual act as a prior condition of our thinking of phenomena at all is denied, no ground whatever appears to me to remain for "dynamical laws;" and either Mill or Büchner would easily throw back your second class into the first. They would ask what more you find in the "conditions of the action of a force" than the concurrence or sequence of phenomena; and would protest that the "direct consciousness" to which you appeal is still nothing but an order of feelings, *i.e.* of internal "phenomena;" and on the ground of scientific experience and method, I really do not see how an answer could be given to this. Besides Mill's reduction of all mathematical and physical axioms to inductions on observed uniformities, we have now Continental *physiciens* calling in question Newton's first law of motion; so that, among those who decline all obligations to metaphysical assumptions, the distinction which you would draw between Kepler's laws and Newton's is being broken down. As to Büchner, since he contends, as you do, for our scientific knowledge of "force" (as well as "matter"), and therefore does not stop short with your first class of "laws," but proceeds to the second, I do not see why he may not, with you, speak of such laws as "governing" or "explaining" phenomena.

So much for my old client, Metaphysics *versus* Physics. He is always bothering you, if you try to dispense with him. The only other point that I should like to remark upon is a use (which seems to me the source of misapprehension) of the word *intuition*. It is certainly common to speak of any apprehension at a glance, though it may be a shorthand compend of many steps, as "intuitive;" and in this sense, Bidder's calculations, the visual interpretation of distance, etc., may be called "intuitive;" and you may speak of "the tendency to form intuitions," etc. But in accurate metaphysical speech "intuition" denotes—like the phrase "*à priori* cognition"—*a primary condition of thought at all*, a belief or cognition presupposed in experience, and constitutive of it. Such cognitions (*e.g.* space, time, cause) must seem to us immediate and irresolvable (being really so); but it is not *this seeming* (which may be simulated by acquired states) which earns the name: if they can be resolved, they do not deserve it, and it must be handed back to their primary elements till you get to that which you must bring into experience if you are to think it at all. Hence the explanation of intuitions by ancestral inheritance is necessarily without result. The primary *conditions* of thought cannot be the *effect* of converging or accumulating lines of thought. All that habit, personal or transmitted, can do, is to facilitate and condense mental actions once difficult and consciously successive; so as to conceal the steps and prevent detection of the *elementary intuitions*. But those elementary intuitions must be there, though we may have got hold of the wrong things for them. Thus by denying that my (seeming) intuitions were intuitions to my hundredth grandfather, you only evade the question by pushing it back. Of course, in one sense, no one denies the *genesis* of intuitions, more than of any other function of a human being who, from end to end, *has to be born*. The question is not of the physiological building up of the conditions of life, but of *intellectual derivation;* and the intuition doctrine simply maintains that intellectual action cannot take place at all, without certain cognitive elements being supplied from within.

I was interested in your new case of recovered vision. It adds a valuable fact. I fancy, however, that the theory to which we have been accustomed requires a good deal of qualification. Even in this case, why should the patient accuse herself of "stupidity" in not recognizing the scissors, if the means of recognition were not there? The co-ordination of the visual and tactual experiences is already within reach by the muscular traversing of the eye; and the lesson is easier in proportion to the command over the needful movements.

I shall look with much interest to your further treatment of such topics in the *Contemporary*, and especially for your elucidation of the "sense of effort," an obscure point on which light would be most welcome. As at present informed, I think too much is attributed to the "muscular sense," notwithstanding its value as a *measure* of force.

From the RIGHT HON. W. E. GLADSTONE, M.P.

10, Downing Street, January 13, 1873.

I have read, though only quite recently, the paper you were so good as to send on the "Physical Condition of Inland Seas;" and I am very glad it has been in the power of the Government to meet your wishes in this important and most attractive branch of inquiry.

I have also read your paper on "Hereditary Transmission" in the *Contemporary Review*,* and I venture to offer two remarks.

First, with regard to handwriting. I could name two most conspicuous instances of eldest sons who presented in the main a strong contrast to their fathers in character, but who in handwriting strongly, and in their autographs most closely, resembled them.

Secondly, with regard to colour. I should say that my observations on hereditary transmission have been human only, and in their very limited ranges have turned on the comparison of ancient and modern men; as to whom generally it has appeared to me that there had been probably in simultaneous operation opposite processes, on the one side of growth and development, on the other of dilapidation. What I would now mention relates to the former of the two. Examination of the text of Homer, with respect to colours, convinced me that the ready perception of them, which our children generally display, was an acquired aptitude, standing in marked contrast with the perceptions of three thousand years ago, as they are represented

* "On the Hereditary Transmission of Acquired Psychical Habits," in the *Contemporary Review* for January, 1873; the subject was continued in the April and May numbers.

by the poet, whose views of specific colour appear to show much defect and confusion, while his sense of light was most vivid, and his sense of form alike strong and refined.

From DR. OLIVER WENDELL HOLMES.*

Boston, Mass., U.S., May 9, 1874.

I have been for such a long series of years your debtor, having been familiar with your writings since the first essay which brought you into notice, having always almost within arm's length your Physiologies, Human and Comparative, and your book on the Microscope, that you are a kind of classic to me; and to see my name in a treatise of yours is like receiving an unexpected honorary degree from some institution of note and name. I have always been greatly interested in the subject of unconscious cerebration, to use the expression which you, I think, first employed long ago in your Physiology. Every man is more or less a metaphysician, and I think we often feel, in reading the acutest or even the profoundest analysis of mental actions, that we too are experts, and hold in transparent solution the same ideas to which another has given the crystalline solidity and definiteness of language. In this way I have often felt when reading your own subtle and searching observations, and very likely with this feeling have borrowed more from your suggestions than I was aware of. If I have done so in the little book from which you quote, or helped myself from others without giving them credit, you will, I know, set it all down to unconscious cerebration and automatic manipulation. But as we all handle the same tools in the same cerebral workshop, it is no more wonderful that we should often work after the same pattern, than that two gloves made in two different countries, should each have four fingers and a thumb.

From the REV. DR. MARTINEAU.

London, March 9, 1874.

I am much gratified by your kind remembrance of me in drawing up your list of presentations for your "Mental Physi-

* On receiving a copy of the "Principles of Mental Physiology," in which Dr. Carpenter had quoted Dr. Holmes's "Mechanism in Thought and Morals."

ology." I need not say that the original groundwork of the volume has long been familiar to me. Indeed, I owe to it a large part of my small store of knowledge with regard to the nervous system and its functions in man. The new elements in the volume are most inviting; it is impossible to cut open the sheets without alighting, by merely indulging a cursory glance, on a rich vein of instruction or suggestion. To me, also, it is always a comfort when I take up your books to know that in surveying the belt of borderland between the domains of physiology and of psychology, you will treat the rights of both with due respect, and will not turn a professed scientific exploration into an expedition of aggression and conquest. If anything is absolutely and ultimately certain, it is that neither of these provinces can ever merge by annexation into the other; and that therefore the true method of prosecuting both requires the creation and observance of a separate nomenclature and descriptive vocabulary for each. Yet among our English writers on these subjects, nine out of ten conceal their real distinctness, and thrust them into artificial approximation by carrying over the language of the one into their reports of the phenomena of the other.

Within two years of its publication, the "Mental Physiology" ran through four editions, and in 1876 Dr. Carpenter drew up a final statement of his views on the limits of human automatism in the shape of a preface to the fourth edition, which dealt with recent utterances of some of his scientific friends, notably Professor Huxley and Professor Clifford.* The days were still full of eager labour, but the longing for rest rose more and more frequently in his mind. In the spring of 1875 he was greatly interested in the project of University Extension, and joined a deputation to the Lord Mayor on behalf of a scheme "originated by Cambridge, but here taken up at my in-"stance in a more comprehensive spirit. Our object is to "induce the City Companies to co-operate in a People's

* See below, p. 284

"College for thorough high-class teaching." The Council which was formed to carry on the work, represented the three Universities of Cambridge, Oxford, and London, and he remained a member of it till the last. But the active conduct of such new enterprises he felt that he must leave to younger men.

> I assure you (he wrote to his brother Russell, as the year 1875 ran out) that even when most rejoicing in the continuance of my own energy, I often long for the time when I may cease to feel it a duty to be always *doing* something, and may be able to rest on my oars with an easy conscience, and let the world go on without my participation.

Partly under the influence of this feeling, and partly for the completion of some investigations into the anatomy and development of the Feather-Star (*Comatula*), he obtained leave of absence from the University for three months in the beginning of 1876. When all the arrangements for the winter courses of Gilchrist lectures were completed, he hurried off to Naples to carry on his studies in the great aquarium maintained there by international scientific co-operation. Through a long spell of cold and cheerless weather, the southern city failed to reveal her charms; and its sanitary and social conditions somewhat disgusted him.* His interest rose high, however, over Pompeii, which he did not visit till his wife could join him in the spring; and when they passed to Rome, to Florence, to Bologna, on their way home, he found so keen a pleasure in great historic memories, and so unexpected a susceptibility to the glories of classic and mediæval art, that

* He used to tell afterwards, with much amusement, how when he was one day walking alone at no great distance from the town, a stalwart beggar suddenly came up behind him, flung his arms over his shoulders, and snatched away the contents of his breast-pocket. The prize proved to be no pocket-book with its roll of notes inside, only a little paper-covered guide, which had cost a *lira*. Dr. Carpenter walked on with an amused pity for his assailant's disappointment.

he regretted that he had not snatched a few more days from the laboratory to bestow on the opportunity he might never have again. To see Italy once more became one of his cherished dreams. Meanwhile the usual labours were begun again; the University claimed him as the spring advanced; a new phase of the Eozöon controversy turned up, in which he gave a temporary triumph to "the Anti-Eozöonists;" the fresh materials collected at Naples called loudly for arrangement; and the fourth edition of the "Mental Physiology" only awaited the new preface.

> My time (he wrote in the middle of May) has been much taken up by foreigners, who have come over to the Exhibition of Scientific Apparatus, which seems to have excited much more attention abroad than here. The Queen came to pay it a visit on Saturday morning, and the Empress of Germany. I followed in the train, and had a general look at what the collection contains, which is very wonderful and interesting, but what time I shall get to examine even a small part of it, I cannot divine. Just now I have to digest a new alternative scheme for the B.Sc. examination, and to ascertain the opinion of from twelve to twenty people upon it, and to go into questions between the University and the Medical Corporations, which, after everything had been settled, the latter have reopened. And as to home work, I am only gradually preparing (by getting my things into some kind of order) for what I shall take up when my time comes. I have not yet been able to concentrate my thoughts sufficiently to write the preface to my "Mental Physiology."

At length the time arrived. After twenty-three years of service, coinciding with the period of the most rapid development of the University, Dr. Carpenter resigned the office of Registrar, his retirement taking effect in the spring of 1879. Honours at home and abroad had flowed in upon him abundantly. In 1871, his own University of Edinburgh had conferred on him the degree of LL.D. He had more than once served as Vice-President of the Royal Society.

In 1872, he had filled the Presidential chair of the British Association for the Advancement of Science. The next year he was made a Corresponding Member of the Institute of France, the name which was submitted as an alternative to the choice of the electors being that of Charles Darwin. And Mr. Disraeli, soon after coming into power in 1874, conceiving that his services to education and science deserved recognition, recommended him to the Queen, without political or official prompting, for the order of Companion of the Bath. To these distinctions the Senate of the University had it not in their power to add; but they recorded their sense, not only of the ability, judgment, and fidelity with which he had uniformly discharged the duties of his post, but also of the zeal and efficiency with which he had on all occasions exerted himself, both within and beyond the limits of his official obligation, for the promotion of the best interests of the University; and they expressed their conviction of the advantage conferred upon it by the services of a Registrar who, besides being an excellent administrator of its affairs, had attained, by his scientific labours, a position which gave him a just weight and influence over those with whom he was officially brought into contact. When the next vacancy occurred, his name was placed upon the list of the Senate, and he continued to take an active share in its deliberations.*

The sense of occasional strain now passed out of Dr. Carpenter's life; but his days were no less fully occupied than before. He had more leisure to write, though writing became more irksome, and from the vantage ground of experience, and detachment from professional interests, he addressed himself with fresh energy to questions new and old. He had published two years before a little volume on

* His portrait was painted by subscription among the graduates, and now hangs in the Senate-room.

"Mesmerism and Spiritualism," and had devoted a large amount of time and thought to the investigation of "spiritualistic" phenomena, both at his own house and at the houses of other friends, such as Mr. Robert Chambers and Mr. A. R. Wallace. Then came vaccination, vivisection, the germ theory of disease, on all of which he entered with a certain eagerness which showed an unabated activity for thought, an unwearied zeal for what he believed to be the public good. It was his earnestness for this cause which sometimes lent a touch of asperity or intellectual scorn towards forms of error (as he regarded them) which had no legitimate ground, and might, in his judgment, be noxious to physical or mental health. If ever he yielded to the temptation to speak *ex cathedrâ* in the name of science—a habit which he deplored when he observed it in others—it was in dealing with doctrines and practices which appeared to him rooted in incurable prepossession, and maintained against overwhelming evidence. Here his intellectual tolerance found its limits. He was ardent, and hence sometimes unguarded in controversy; but none could enter into dispute with him, and not feel that he sought no personal triumph, but only desired the establishment of the truth. This quality of his mind revealed itself especially in the essays on religious philosophy, which he contributed to the *Modern Review* in the years 1880 and onwards. They bear the impress of a calm and weighty judgment, which has faced all issues without fear; they are the deliberate outcome of long and patient thought, lifted above passion or prejudice, and anxious only to know things as they are, to "see life steadily, and see it whole."

In August, 1882, Dr. Carpenter was able to realize a long-cherished wish to visit Canada and the United States. Accompanied by his wife, he passed from Quebec through Montreal, the home of the last years of his brother, Dr. P.

P. Carpenter, to Niagara, stopping on his way at the great beds in which Eozöon had been discovered. The week's rest which the travellers sought at the Falls was diversified by attendance at the meeting of the American Pharmaceutical Conference, where he was called on for an address. It was a foretaste of what befell him afterwards. Congresses and conferences seemed to occur in town after town as he arrived. On one occasion, the discovery of his name in the hotel book suggested to some leading pastor an urgent request that he would give a discourse from the pulpit of his church. The most important of these speeches, some of which were quite *impromptu*, was delivered before the National Congress of Unitarian and other Christian Churches, at Saratoga, on "The Influence of Science on the Progress of Religious Thought." The autumn weeks were chiefly spent in Boston, where Dr. Carpenter poured out the results of many years of labour and thought in two courses of lectures, under the auspices of the Lowell Institute, on the "Physical Conditions of the Deep Sea," and on "Human Automatism." The boundless hospitality of his Boston friends, and the contact with so many men eminent in science and literature, with whom he had been acquainted only through books and correspondence, rendered this visit a time of keen intellectual excitement, and filled him with affectionate memories.* From his earliest years he had been trained to interest in New England Unitarianism, and he was familiar with the writings of its leading representatives. When the centenary of Dr. Chan-

* The impression which he left behind him was of the same warm-hearted kind. He was ready to be pleased and to give pleasure everywhere. "There, "at my house," afterwards wrote his old English friend, the Rev. Brooke Herford, "the big-wigs having met him elsewhere, I gathered a crowd of "young students and our poorer ministers, to have a chance to see him, and "they have spoken to me many a time since of his beautiful cordiality, kind-"ness, and simplicity, as he talked with them at first individually, and then "all sitting round and holding a general cross-fire of questioning."

ning's birth had been celebrated in London, in 1880, he had attended, at some personal risk, for he was suffering from a return of the malady of 1864, to show his "thorough "accordance as a man of science with his general views of "human nature and its responsibilities." The great Civil War had kindled in him an absorbing interest; he had followed its progress with almost personal anxiety; his recollection of its incidents was vivid, and in a long letter written in 1878, to Dr. O. W. Holmes, who had sent him a copy of his life of the historian and diplomatist Motley, he had retraced, in full detail, the causes which had for a while somewhat alienated his own sympathies, and those of many of his London friends, from the side of the North, partly through what he felt to be the unwise advocacy of Mr. Motley, with whom he was at one time in intimate intercourse. For the character of Lincoln he had conceived warm admiration; he had studied the details of his career; in the President's devotion to duty, his single-mindedness, his strength, he found the elements of nobility which he regarded as of highest worth, and his sense of humour was especially gratified by the manifold stories which he gathered of the insight and pungency of Lincoln's retorts. Under these influences his judgment of the issue became far tenderer to the North; and when, after his return home in December, he recalled some of his impressions, strongest and deepest was his admiration for the readiness with which it had met the call to sacrifice.

To the REV. R. L. CARPENTER.

London, December 31, 1882.

A very fine memorial of the graduates who lost their lives in the war has been erected by subscription at enormous cost [at Harvard College, Cambridge, Mass.]; including a hall for dining, a good deal in the style of one of the Oxford or Cambridge College Halls, but much larger, and a theatre for public celebrations (in which the Greek play was performed not long ago), with a sort of transept between the two, giving entrance to each, the walls of which are covered with memorial tablets containing the lists of the graduates of the several faculties, with a number of appropriate mottoes. It was the going over these lists and recognizing so many names of the old New England families, that impressed me more than anything else with a feeling how completely the war had penetrated every circle of Northern society. O. W. Holmes's son, who has been Professor of Law at Harvard, and has been just made a judge (at the age of forty), went to the war before he graduated, and was wounded three times. Theodore Lyman, brother-in-law of Alexander Agassiz, whom I only knew as a naturalist (he has just brought out an admirable monograph in the Challenger Series), served on the staff of one of the Generals, and now holds the rank of Colonel. He has just been elected to Congress. In every cemetery the graves of those who fell are specially distinguished by small flags; and there are generally little societies for keeping them decorated with flowers. I asked Dr. Morison what he considered to have been the principal motive that impelled the Northern volunteers; and he said without hesitation that it was "country." The anti-slavery feeling doubtless helped, but it was not the moving power. The more I come to know of what they went through, the less I have been surprised at their complaint of want of sympathy on our parts, and their interpretation of our coldness as resulting from a desire for a split that should destroy the union which they felt bound by all the ties of patriotism to uphold. . . .

A great sensation was produced while we were in Boston by a paper read at the Unitarian Club by Dr. George Ellis, as to the proper mode of now dealing with orthodoxy. He expressed the conviction that in the old controversies in which the discussion was upon the meaning of texts, both sides accepting the Scriptural authority, the orthodox had the best of it; and that the way now to deal with the questions at issue is to throw over this authority altogether. I think he is quite right in his conclusion, though I do not accord with his premises, as I do not think that the Trinity or the Deity of Christ find any support in the Bible. But I think that much of the Calvinistic system and the doctrine of eternal punishment are clearly formularized, and can only be set aside by an appeal to general principles involving an abandonment of doctrinal inspiration.

On his return to London, Dr. Carpenter resumed his usual occupations. But it was not without an effort. The excitement of his American tour had involved a great drain on his strength, though it had given him acceptable change of thought, and a really invaluable mental refreshment. Composition became more and more difficult; he shrank from taking pen in hand; the labour of revising the shorthand-writers' reports of his lectures on "Human Automatism" loomed portentously before him so that he could hardly face it, and in fact it was never completed. He felt age creeping upon him, though he struggled against it. When the seventieth birthday came round in the autumn of 1883, he wrote to his brother Russell:—

It was very pleasant to me to receive on Monday morning such a chorus of affectionate greetings on the attainment of my three score and ten years. Your remark about David's lamentation having special reference to the want of spectacles and dentistry was very apposite, these being now great aids in making life worth living. But I suppose that there were no small-print books or newspapers in those days that now specially need the artificial help. I wonder whether David was subject to rheumatism; he ought not to have been, in the dry, warm climate of Palestine; but it is this that just now makes me most uneasy respecting my future, as the damp weather we are at present experiencing has made me more painfully conscious of creaking joints.

Yet no one who witnessed his burst of energy the next spring would have thought his strength declining. On the

4th of April, 1884, he records that he has been "on circuit" the previous week, lecturing for the Gilchrist Trust at Gloucester, Stafford, Northampton, Peterborough, and York! In the next week he is to discourse to the Microscopical Society, and at the approaching Easter to attend the Ter-centenary festival of the University of Edinburgh, as representative of the University of London. Degrees were to be conferred in the metropolis of Knox's Calvinism on Dr. Martineau and M. Renan. "Verily," said Dr. Carpenter, recalling his earlier experiences, "*tempora mutantur*." Nor did this complete the list of his engagements. "On the following week I am to go down to "Plymouth to help to launch a local Fisheries Exhibition "they are getting up there. Our zoological station is as "yet *in nubibus*." Ever since his visit to Naples, Dr. Carpenter had been impressed with the desirability of promoting marine zoological research at home, and he had made proposals for the thorough exploration and study of Milford Haven. This plan was not adopted. But a Marine Biological Association was formed, of which he became vice-president, and this has since carried out, by means of its laboratory on Plymouth Sound, a design traceable to his own suggestion. It was the last public movement which he helped to initiate and guide.

In the same spring he presented to the Royal Society a short paper on the Nervous System of the Crinoidea. Here he summarized the evidence in favour of his views, which had been made known since his second statement of them in 1876, partly by the researches of one of his sons, and partly by those of other naturalists in England, France, and Germany. This was his last communication on a scientific subject to a learned society. Eighteen months later, but a few weeks after his death, a text-book of zoology was published by his former chief opponent in

Germany, in which his views were unreservedly adopted; and they are now taught in every zoological laboratory, though their importance as regards the general evolution of the Echinoderm type is not yet fully recognized.

Thus, his interests were still keen and clear; and though the times were long past when he could punctually turn out the same amount of "copy" day after day with the utmost precision, and he would sit for a whole morning pen in hand gazing at the paper, unable to put down a word, every now and then some public or private event roused the old force. In the summer of 1884 he had given an address to a meeting of Unitarian ministers on the "Relation of the Argument from Design in the Organic World to the Doctrine of Evolution," and this was (with some difficulty) enlarged from the reporter's notes, and published in the October number of the *Modern Review.** It was the final utterance of his reasoned faith. A few weeks later he shared the universal regret at the death of Mr. Fawcett, as well as the universal curiosity and expectation as to the probable attitude of the Opposition and the House of Lords on the Franchise and Redistribution Bills. References to politics were very rare in his correspondence, though his conversation often dealt largely with them. The following letter contains a characteristic illustration from Bristol memories:—

To the Rev. R. L. Carpenter.

London, November 9, 1884.

Although I did not often come across him (Mr. Fawcett), we were very good friends when we met; and I greatly admired the pluck with which he had made so good a position in the House, notwithstanding his blindness. My own impression, indeed, is that his accident was really the making of him,

* See below, p. 409.

by giving him a power of concentrating his energies so as to overcome the obstacles his blindness created. I shall always have a pleasant recollection of him for the kindly way in which he moved a vote of thanks to me as President of the British Association at the closing meeting at Brighton, for which he was then M.P. He said that he was quite unable to judge for himself what I had done for science, but that all he had heard of me led him to recognize the love of truth as the guiding motive of my scientific career.*

The next week will, I suppose, show whether the Opposition are going to be wise in time, or to evoke the hostility of the mass of the people, of which they have had the fullest warning. If they adopt the suggestions of Gladstone and Lord Hartington, and put forth their own programme of a redistribution scheme, which the Government will most gladly take into consideration, so as to make (as Gladstone said) the Bill the work of the House, they will have a much better case on which to go before the country at the next election, than if they persist in opposing the passage of the Franchise Bill. And I cannot but hope that the attitude of Mr. Gorst may have a sufficient number of imitators among the Peers to make Lord Salisbury doubtful of his majority. If they force the country to question the right of fifty country gentlemen—responsible to nobody—to resist its will, I think there is no doubt what the *ultimate* result will be. It is rather curious that Lord Salisbury, who is so anxious to preserve the minority vote for the *Commons*, should oppose any change in the mode of electing the Scotch and Irish *Peers*, which makes the majority the sole electors, and gives no representation whatever to the minority, which (as in the election of aldermen by the *first* Bristol Town Council) may be numerically less by only a single vote. I have the fullest confidence that a great result will be gained in the end, in whatsoever way it is worked out. But it will be a great

* Mr. Fawcett said that long before he had the honour of Dr. Carpenter's personal acquaintance, he had always heard him spoken of by scientific men, whose authority he valued and whose opinion he could trust, as one of the most conscientious, laborious, and single-minded workers in the great world of science. No one, he had always been told, had ever worked with a purer desire to promote scientific truth, with less idea of personal distinction, than Dr. Carpenter.—*Brighton Daily News*, August 22, 1872.

pity for the agitation to be prolonged, to the suspension of other legislation.

Dr. Carpenter's recollection of Mr. Fawcett's words touched indeed the central energy of his whole thought and life. To realize Schiller's description of the philosopher, to love truth better than his system, had been his constant endeavour.

> In the pursuit of truth (he wrote in a fragment found among his private memoranda), the more faithfully, strictly, and perseveringly *we fix our attention on the goal*, not allowing ourselves to be distracted by the temptations of self-interest, or by the timid apprehensions of those who fear the risks more than they value the reward, the more shall we find ourselves progressively emancipated from those unconscious prejudices which cling around us as results of early misdirection and erroneous habits of thought, and which are more dangerous to our consistency than those against which we knowingly put ourselves on our guard. And so in the path of life, if we begin by *turning to the right*, and determinately keep straight on, we find the way become more and more clear before us; the suggestions of a temporary expediency lose their force when we have formed the fixed habit of trying everything by the test of fundamental principles; the temptations which arise out of the lower parts of our nature lose their hold upon us in proportion as we keep our attention fixed upon the highest class of motives; and the determination to act upon those motives becomes more and more easy to carry out with every victory it has already gained.

Here was his whole philosophy of conduct; it guided him alike in scientific and social effort, and was the spring of his untiring toil. What influences he had felt most stimulating and helpful from the personalities whom he had known, may be inferred from the concluding words of a lecture on the "Principles of the System of Reformatory and Preventive Discipline as worked out in Theory and Practice by Mary Carpenter," delivered before the Sunday

Lecture Society, of which he was President, on November 4, 1877, in the autumn following his sister's death.

> The world has been most benefited by the labours of those who have had the greatest desire to employ their powers for the good of others, the greatest knowledge of the best mode of doing so, and the greatest faith in the ultimate success of their work. And I wish no better for myself than that I should hereafter be remembered as one who has endeavoured, in however humble a degree, to transmit to those who may come after me the earnest love of scientific truth which was the pre-eminent characteristic of John Frederick Herschel, the unswerving love of what was just and right and kind which animated the course of George Grote, and the large-hearted and self-sacrificing love of her fellow-creatures which gave to Mary Carpenter a foremost place among the philanthropists of this or any other time.

To his friends, also, as to the public men who only saw him at a distance, singleness of aim seemed the most striking quality of Dr. Carpenter's life. This had, indeed, its severe and unsympathetic side to some who approached him only for the first time, especially in any post of official duty. He was charged to carry out certain rules, and they must be fulfilled, whatever might be the cost to personal convenience or pride. His life-long habit of acting on fixed principles made him impatient of anything that seemed to contravene them; the strenuous effort of his earlier years had partly deprived him of the elasticity of nature which renders it easy for others to enter into fresh relations; and he had a difficulty in spontaneously adapting himself to varieties of character not formed after his own model. As his circle of friendships widened, however, and a larger and more diverse experience gave him a fuller insight into the perplexities of life, his judgments towards his closing years became far gentler. He was not, indeed, without his share of the combative impulse; but even when he headed an assault upon what seemed to him injurious error, or absolute folly, or defended on his own side some cherished position, he sought to distinguish between the opinions which he condemned and the persons who held them, for whom he even sometimes came to feel an unexpected tenderness. In his pursuit of truth there were no reserves; honesty of purpose was stamped upon all he wrote. Thoroughness marked all his performance, whether in scientific investigation, in the discharge of official duty, or the administration of private or public trusts; he could be content with nothing but his best, and he could endure no slovenliness in others born of weakness or indolence. This very thoroughness made him often slow in forming opinions, till all available evidence should be before him; and though his convictions when once formed were exceedingly tenacious, he strove earnestly to guard himself against allowing them to become mere prejudices, and he was not betrayed into quitting the attitude of the teacher, with its open outlook towards all possibilities, for that of the partisan. Hence in his treatment of religious questions he could reason without dogmatism. There was in his mind what one of his friends described as an "abiding and apparently inde-"structible instinct of reverence;" but it was united with perfect intellectual freedom. This quality commanded the sympathy of many who had become more or less detached from the traditional forms of belief; they read what he wrote on the deeper issues of faith "without the kind of "mental protest which is elicited both by orthodox denun-"ciations of scientific agnosticism, and not less so by the "pert and aggressive attitude of many modern agnostics."

At the same time there was nothing visionary about Dr. Carpenter's modes of thought. Of the two great seers with whom he was acquainted, he probably derived from

Carlyle the more vivid intellectual stimulus; but Emerson had for him by far the stronger moral charm, and awakened in him the more enthusiastic admiration. When he visited Concord, he eagerly gathered up the memories of the beauty and nobility of Emerson's life, though he had often failed to follow him with assent or even with comprehension along the dizzy heights of his discourse. Emerson's flashing glances into the manifold relations of things were, indeed, as different as possible from the slow and cautious steps with which Dr. Carpenter felt his way through facts to principles. He would go no further than the most careful reasoning allowed him; but he admitted into the elements on which his reasoning was to be based certain primary powers, affections, and sentiments, which he found in his own heart, and saw in various forms in the consciousness of the race. Nor was he disturbed in his estimate of their value, because it might be possible to show their origin and trace the history of their growth. The obligations of conscience were not, in his view, stripped of their Divine authority, even though the contents of its specific decisions depended on the long evolution of experience. So he seemed to many to balance and harmonize different aspects of scientific, moral, and religious truth with a well-tempered wisdom; giving to reason its fullest play over the widest range of outward and inward facts, he rose to be a kind of sage in the intellectual and theological world around him. Teachers and students, men of thought and feeling, and men of the world and affairs, discerned in him an unusual breadth of sympathy, and a rare combination of gifts, each of which was cultivated to its fullest capacity. The simplicity of his aims flowed forth from a rich and sound humanity.

"He was one of my oldest friends," said Sir James Paget, after his death, "a friend of more than forty years;

"and in all that time I could think of him as a model of "gentleness and fairness, and of unbounded desire for the "attainment and diffusion of knowledge." This sense of justice was stamped on all his intellectual work. He sought anxiously to manifest it towards others; he desired it to be displayed towards himself. It made him eager to recognize to the full the value of the investigations of fellow-labourers, and he expected a similar recognition of his own.

I gratefully remember (wrote one of his old friends to him in 1883) that you were among the earliest to welcome me among the workers in biology, and to encourage me by commendation both privately and publicly expressed.

Of his generous kindness to young men, and his faithfulness as a friend (Mr. Huxley says), I can speak from knowledge. I was a very young man, almost friendless in the scientific world, when I returned to England in the end of 1850. I made Dr. Carpenter's acquaintance early in 1851, and it so happened that I was able to give him some odds and ends of information, which he found useful in bringing out the third edition of the "Principles of Comparative Physiology." In the preface, Dr. Carpenter has referred to my small services in a manner which I thought then, and think now, disproportionate to my deserts; and, from that time until his lamented death, he remained a friend who did me many a good turn, and upon whose steadfastness I could always rely. More than once I had the misfortune to come into scientific conflict with him; and on one occasion, certainly, I was in the right. Yet not even that provocation disturbed his unvarying goodness.

Some other aspects of Dr. Carpenter's work are described in the following communication from Mr. Thiselton-Dyer, F.R.S.*

In later years, when it was my privilege to be counted by Dr. Carpenter among his personal friends, I saw, with delight,

* See a quotation previously given, p. 68.

another side of his scientific character. Up to the very end, his intense interest in new knowledge might put to the blush many a younger man. It seemed extraordinary that it should never flag. I well remember his ardent excitement on the return of the *Challenger*, laden with the spoils of four years' deep-sea exploration. It was just the same at the British Association at Southport, when he sat for hours at a time in the Biological section, eager to hear the papers read by the younger men, and delighted, when called upon, to speak words of approval and encouragement.

And not merely had he this vast appetite for knowledge, but it was an appetite governed by perfect mastery. He remembered all about everything which he had ever learnt. It was a hazardous matter, therefore, to differ with him on a point of historical detail, and on the one occasion when I ever found myself in that predicament, I executed a very speedy strategic retreat. I append a copy of a letter which he wrote me on that occasion. It is in its way an interesting chapter of scientific history, and illustrates in a manner which is still marvellous to me in re-reading it, the perfect discipline in which he preserved the detailed knowledge stored up in his mind. The letter is the more important as it states, and I think with perfect accuracy, what he claimed to have effected in some points of botanical theory.*

* *To* W. T. THISELTON-DYER, ESQ.

56, Regent's Park Road, July 7, 1875.

Dear Mr. Thiselton-Dyer.—Glancing over your article in the new number of the *Microscopical Journal* I see with some surprise that you credit De Bary with being the first to point out that conjugation is the primitive phase of sexual reproduction. For this was distinctly indicated by Thwaites in his paper in the *Annals* for March, 1848 ; and I myself more fully developed this view in the *British and Foreign Medico-Chirurgical Review* for October, 1848, pp. 370, 371, and October, 1849, pp. 341–347, also p. 437, where I bring into contrast the *subdivision* of cells as the type of *growth*, and "*the mixture or* "*reunion of the contents of two cells*," as the type of *generation*.

This, again, was explicitly set forth in my "General and Comparative Physiology," 3rd edition, 1851, p. 881.

The whole subject was at that date in a state of complete muddle ; and I think I could easily show that I was one of the first to indicate the mode in which the clearing-up would take place. In fact, I do not see that any essential correction has been made in the views I expressed in pp. 346, 347 of the *Review* of October, 1849, which no other vegetable physiologist, so far as I know, had then reached, Thwaites having most nearly approached them.

I feel that there is perfect justice in the complaint he makes in the conclusion of the letter. The position is pathetic, but inevitable, and can only be redressed, if at all, by the testimony of men like myself, who do actually, in some degree, apprehend what the position of a man like Dr. Carpenter really has been in scientific history, and have the opportunity of stating it.

Dr. Carpenter, in fact, was a member of a group of men who lived through a half-century of biological discovery, the like of which, from the nature of things, can never be repeated. The rapid development of the use of the microscope revealed a profusion of cardinal facts in biology in a comparatively short time. The actual quantity of biological investigation will, year by year, no doubt, progressively increase. But the veil of ignorance can never again be lifted in the same interval from such an aggregation of fundamental additions to knowledge, for the simple reason that science can never again be occupied, as it was then, at one and the same moment with the fundamental facts of every branch of biological investigation. It was in this exciting atmosphere that Dr. Carpenter passed the early part of his life. The facts of the life-history of a fern are taught in every class of elementary biology in the three kingdoms. Yet I remember Dr. Carpenter telling me how he one day met a friend in the street who asked him to go to the lodgings (somewhere in

Owen's book on "Parthenogenesis" shows what a confusion he was in; as Steenstrup's "Alternation of Generations," and Edward Forbes's "Naked-Eyed Medusa" had shown in regard to the reproduction of animals. In the first volume of the *Review* (then edited by me) I had shown that the so-called "alternation" is really the *budding* of *generative* zooids from the *nutritive* zooid; and this, though contested at the time by Edward Forbes and Owen, is now universally recognized. At the Oxford meeting of the British Association, in 1847, at which I advanced this heresy, I was pooh-poohed; and at the Council of the Ray Society, at which I advocated the reproduction of Suminski's book on the "Ferns," I was assured that the close resemblance of the Antherozoids to Spermatozoa was quite sufficient proof that they could have nothing to do with *vegetable* reproduction.

I do not think that the men of the present generation, who have been brought up in the *light*, quite apprehend (in this as in other matters) the utter *darkness* in which we were then groping, or fully recognize the deserts of those who helped them to what they now enjoy.

I am not given to reclamations, and should not have troubled you with this on my own account; but Thwaites having been a special "child" of mine (as he always avowed), I do not like that *he* should not get full credit for his work,

Yours faithfully,

WILLIAM B. CARPENTER.

Bloomsbury) of a Pole who had come to London, and who had made a remarkable discovery about the reproduction of ferns. This was Suminski, whose research holds an ever-memorable place in the history of botanical discovery. The elementary facts of biology seem a somewhat hackneyed drama to us now. But Dr. Carpenter had, as it were, seen the whole *mise en scène.* The entire story was fresher to him than it could be to us, paradox as this may seem. But the new knowledge of his later days was equally absorbing to him. It often seemed to me amazing to reflect that here was a man who had practically seen the whole thing grow up, and yet was as enthusiastic about the future development of biological science as its youngest votary.

Certainly, as I have said, the progress of discovery which Dr. Carpenter saw, was an exciting one, and it was a fortunate thing that the task fell to him to be in some sort its historian, or, at any rate, expositor. For, as he in effect tells us, he at least never lost his head about it. The great work of his life was, after all, that he gathered up the new knowledge, digested it and put it before the world in a coherent and logical form. Stated in this way, the task accomplished may not seem much. In effect it was of the deepest importance. In my judgment he laid the foundations of that breadth and comprehensiveness of the English biological school, which will, I hope, be its lasting heritage. In some ways his method of orderly exposition reminds me of the logical lucidity of the best French work of the same kind. But in grip, depth, and even a sort of fervour, I venture to think that its good qualities were peculiarly English.

In full accord with the single-mindedness of Dr. Carpenter's scientific character was the simplicity of his personal and home life. A certain frugality of habit, the fruit of Puritan ancestry and early struggle. marked him almost to the last; but it imposed no restraints on his domestic intercourse. There all the wealth of his affection manifested itself in his never-ceasing solicitude for the welfare of his sons, and the strength of his principles in the patience with which he took up the family burdens that sometimes fell upon him. In his later years he delighted to gather his grandchildren about him; the playfulness which had been repressed under the strain of early days, found vent; and the ways and wants of an infant went straight to his heart. On one of his Scotch rambles, in the autumn of 1878, he wrote to his wife (of whose travelling companionship he was that season deprived) from the Bridge of Allan:—

> Yesterday, after a morning shower, the day was very bright and beautiful, and I greatly enjoyed the journey, not the less for there being in the carriage a fifteen-months-old baby, the brightest, most good-tempered, and one of the prettiest I ever saw. Though the journey was more than six hours, she did nothing but laugh, sing, and play the whole time, except when she was sucking her bottle, and made great friends with me. I also amused myself with watching my aneroid, which went down an inch and a quarter in going over the highest watershed, that above Killiecrankie, and then rose visibly as we descended the steep incline.

The sympathy which he felt for children readily extended itself also to animals. The proximity of his house to the Zoological Gardens made him a frequent visitor on Sunday afternoons. There he was often to be found in the monkey-house, especially in the private room of the first chimpanzee, in whom he took a lively interest. He was always pleased to relate its educational progress, and would constantly take friends to see a display of its accomplishments. This grew almost into the pride of ownership; and when the poor animal succumbed under its second teething, he genuinely regretted its decease.

No less marked was the force of his feeling at the other end of the scale. In all that related to the conduct and character of those with whom he was most nearly connected, or even of those with whom he was brought only into official relations, his sensitiveness was extreme. Anything that seemed like moral wrong caused him the most stinging pain; and to the imputations which he had occasionally to meet in controversy he was acutely susceptible. Again and again he would occupy the hours of a sleepless night by writing letters, which the calmer judgment of the morning (sometimes under the influence of his wife) withheld; the energy of protest had expended itself, and reason suggested the modifying considerations which agitated sensibility had ignored. The same warmth manifested itself in his friendships, and prompted continual acts of kindness, which sometimes surprised the receiver, until he learned that he might rely on his faithfulness with implicit trust. The inevitable severance of old family ties, especially the death of his brother Philip and his sister Mary within a few weeks of each other, in the summer of 1877, deeply affected him; and in the loss of friends whom he revered or loved, like Mr. Grote and Sir William Siemens, he felt that something passed out of his life beyond recall. It was with no less vigour of heart that he joined in public worship. He well understood the strain involved in the preacher's office: "My work," he said once, "is for the most part merely in-"tellectual; but when I do anything that deeply interests "my feelings, I find how much it takes out of me." The more the preacher was himself touched by what he was saying, the more sure was he of Dr. Carpenter's sympathy, and sometimes he would utter that sympathy with earnest emphasis. In music, above all other forms of art, he found for such modes of emotion the fullest expression; yet his favourite passages in the masses of Haydn and Mozart, the oratorios of Handel, Mendelssohn, and Spohr, or the symphonies of Beethoven, were hardly dearer to him than some of the simplest strains of congregational psalmody, associated as they were with the memories of a life.*

* He had himself compiled a book of tunes, for the use of the Rosslyn Hill congregation; it contained several compositions of his own.

This readiness of sympathy, combined with his vast range of knowledge, gave a special geniality and charm to his companionship, and enabled him as a teacher the better to enter into the difficulties of his pupils. Looking back on the precious half-hour before breakfast, which he always devoted, even in his busiest days, to his sons' lessons, they could recall the evident interest which he took in their Latin and Greek, their Algebra and Geometry, for the sake of the studies and the problems themselves. He seemed as much at home in them as the masters who gave their lives to them; and the lad to whom it appeared only natural that a grown-up person should deal easily with a schoolboy's work, found reason afterwards to marvel that the mind, absorbed in other pursuits, could so readily unlock the secrets of a different lore. He had the same intellectual curiosity in manufactures, inventions, machinery, processes of every sort. The newest scientific toy, the zoetrope, the chameleon top, the radiometer, was sure to appear upon his table. And his studies of things were always supplemented by the studies of men. He read the political memoirs of his own time with avidity, and could turn on rills and streams of discourse on the most unexpected subject. The conversation once alighted, in some party chiefly composed of young men, on the constitutional history of Switzerland in the last century; he was immediately ready with a large store of facts, and kept up the talk for three quarters of an hour. His lectures in the same way seemed to proceed from an inexhaustible source. "When I look at that man's head," said a Bristol organ-builder, "I cannot help wondering at "the amount of knowledge it contains." He possessed a power of mental classification, so he once told a friend, by which, whenever he became acquainted with a new fact, it arranged itself under its proper head, and was there ready for reproduction and application. He was thus able to do mentally what most others can only accomplish by an elaborate machinery of labelled papers. Nor did he concern himself only with facts. Like other eminent men of science, he was a great novel-reader. In hours of weariness he always turned to his favourite, Scott. Though he could not originate humour, he enjoyed it greatly in others. To Lamb he was drawn with a positive affection; he was familiar with Hood and Dickens; the sayings of Mrs. Poyser were sometimes on his lips, though he found Daniel Deronda "rather tough;" and he had a warm appreciation of Thackeray, with whom, through his kinship to Mrs. Carpenter, he was brought into occasional contact, the character he loved best in all fiction being Colonel Newcome.

These resources made Dr. Carpenter a welcome guest among a large circle of friends; but it was in his own home that his personality was most amply revealed. There it became clear how large was the circle of his interests. The study was equally open to the tried scientific investigator, or the young man in the first flush of enthusiasm over some new work; there the stores of his collections, accumulated for future memoirs, some of which were never written, were displayed; there the bearings of one element or another of doubtful interpretation were discussed; there his delight in beauty, whether in a new form of animal life or in the order and coherence of a chain of reasoning, kindled the zeal of fellow-workers and friends. For those to whom the microscope had less charm, there were remembrances of travel, photographs and stereographs gathered from other lands; politics, literature, antiquities, music, all supplied in turn themes for his eager and discursive talk And he would always take the same pains (or even greater) for the undistinguished, as for the brilliant and famous

He felt for young men, especially, an almost fatherly interest; the friends of his sons could always rely on him for counsel and help; for those who were passing through struggles such as he had himself endured, he had an untiring sympathy; whenever it was possible he exerted himself to promote their welfare or professional advancement; and even if that lay beyond the reach of any effort of his, the influence of his example and encouragement proved a strength and support. Writing of "that beautiful "presence, full of benevolence and kindly dignity, of intel-"lectual vivacity and moral earnestness, of wisdom and "love which pervaded the whole atmosphere of the house, "and lent a charm to the most trivial interests and a "brightness to the most serious employments," an American visitor recalled her memories of a brief stay in the summer of 1884:—

> I think of him in every phase of that short intercourse, of his friendly morning greeting, of his table-talk, so easy, so entertaining, of the long walks in the gardens, through the park, down in the city, of the expedition to Kew, of all those excursions lighted up, illustrated, by a constant flow of anecdote or personal reminiscences, poured out without stint, without reserve, as freely as if he were talking to his equals, instead of to insignificant persons who could give him nothing in return. Especially I think of the Sunday morning when he and I alone went to the Temple Church, and, finding it closed, wandered about the gardens, sat down in the Fountain Court, and then penetrated through Lincoln's Inn Fields, into the crowded ways by Drury Lane, and out again into the decorous Strand. I wish I could have made notes of all his talk that day, especially as we sat half an hour by the fountain in the stillness of the Sunday morning and of the ancient buildings round. And most of all I think of him as he sat on Sunday evenings playing the sweet old music that he loved, his face full of light, and his voice of sweetness.

A similar impression was recorded after his death by another pen, that of a cultivated Norwegian scholar, the friend of one of his sons.

> Well do I remember the kindness he showed me, the obscure stranger, when I was privileged to be together with him, his noble face, his eager instructive talk, more interesting than any I ever listened to, the genial sympathy and light in which he moved as in his atmosphere. You felt him immediately to be not only a great but a good man. I like to think of him as I remember him one night at Christmas in his house, with his sons assembled round him in the library, your mother at his side, giving out a hymn at the organ, his fine face upturned in beaming gratitude towards his Eternal Maker.

Genuineness, reality, in thought, feeling, and conduct, these were the things which he asked from those around him; these were the standards of worth for which he cared.

> When I preached a sermon in reference to Mr. Darwin (reported his friend, Dr. Sadler, shortly after his death), Dr. Carpenter came to me afterwards with tears in his eyes, and told me of what had been said to him by a leading scientific friend, to the effect that great as Mr. Darwin was as a scientific discoverer, he was still greater as a man. And he spoke as if he felt this testimony to character to be not only true, but also more to be desired than any testimony to intellectual ability could be. I think what was said is no less true of himself than it was of Mr. Darwin. The work of his life was great for its quality and for its extent; but pervading it all one sees the man of highest moral principle, and of a deeply religious nature.

In the spring of 1885, Dr. Carpenter's strength, which had for some time been impaired, especially by repeated attacks of rheumatism, seemed suddenly to give way. For many weeks he remained in a condition of physical and mental torpor which made his family apprehend the possibility of some obscure brain-disease. Change of air and scene failed at first to restore him; but the vigour of his constitution slowly reasserted itself; and the customary visit to Scotland, with the gentle stimulus of varied society and the pleasure of meeting old friends, partly revived his energy. He even insisted on attending the meeting of the British Association at Aberdeen, and took some share in its labours.

> He looked somewhat ill (wrote Professor W. C. McIntosh, of St. Andrews, a few weeks later), but his great kindness and interest in the proceedings triumphed over physical weakness, so that he was one of the pillars and heads of the meeting. I shall never forget his generous action and kindly words in proposing thanks for my address in Section D.

He had especial satisfaction in breaking his journey home so as to avail himself of the hospitality of the Bishop of Ripon. His visit to the Palace happened to coincide with an ordination; he studied the details of the examination (in one department of which his own "Mental Physiology" was prescribed), and showed the same bright and sympathetic interest in intercourse with some of the clergy and candidates which had struck his Boston friends. He had always noted with care the signs of the growth of Liberal opinions both within and without the Established Church. He had gladly embraced occasional opportunities of addressing the London clergy at Sion College on subjects such as prayer, or evolution, connected with the theory and practice of religion. He was accordingly quite willing to accept an invitation from Canon Fremantle to read a paper before the Christian Conference at its November meeting, on the subject of Miracles. The suggestion harmonized with the direction which his own thoughts had been recently taking. Biblical study had never lost its charm for him. But a short time before he had read through Dr. A. B. Davidson's Commentary on Job; and during his Scotch sojourn he had devoted much attention to Dr. Temple's Bampton Lecture. So, when once more at home, he took up some of his former occupations. He attended a few meetings, and when questions of difficulty arose, his judgment showed its wonted clearness, and was felt to have lost none of its grave wisdom. On the 7th of November, he met a number of old friends at the house of Mr. George Busk, where the animated talk of a group including his host, Mr. Huxley, Dr. Allman, and himself, made the party peculiarly memorable. The next day he dined after morning chapel with one of his sons, and spoke much of the Resurrection, in connection with his forthcoming paper, dwelling with especial force on the testimony of Paul, and expressing a characteristic suspense of judgment among the various theories offered in explanation. The whole topic occupied his mind so fully that it naturally came uppermost when, on the following afternoon, he met Dr. Martineau at the Athenæum. The subjoined record of their talk was afterwards communicated by Dr. Martineau to the *Christian Reformer* of January, 1886.

About 4.30 p.m. on Monday, November 9, I met my late friend, Dr. Carpenter, at the Athenæum, for the first time since his illness in the early summer. Though he bore some slight traces of rheumatism still, he was full of life and energy in his conversation; which, passing quickly from subject to subject, soon settled upon the paper on miracles, which he was about to prepare for the Christian Conference on the following Monday.

He did not propose, he said, to undertake a substantive treatment of the topic as a whole, but to content himself with a criticism of Bishop Temple's argument in his recent volume of Bampton Lectures. In that work, the credibility of miracles was vindicated in the method suggested to Babbage by his calculating-machine, and expounded in the so-called "Ninth

Bridgewater Treatise;" consisting chiefly in resolving a phenomenon, which was exceptional within the little span of human experience, into an incident of some more slowly circulating series. Dr. Carpenter remarked that this explanation, by merely throwing the event out of the category of miracle into that of law, stripped off all its supposed religious significance, as a special act of Divine witness and authentication. Instead of an isolated "interposition," it was the recurring term of a periodicity, admitting of prediction. There was neither more nor less sacredness in a change due to a law of giant strides taking a millennium at a step, than in one which recurred at a moment's beat, like the steps of a little child. If the common conception is true, and all the order of Nature is delivered over to *Second Causes, immediate volition of the First Cause* is removed alike from the frequent and the rare. If, on the other hand, the enumerated energies of nature are but constant varieties of form in the Divine activity, the contents of every cycle, swift or slow, are alike immediate. The supposed argument from miracles rests upon an assumed antithesis between Nature and God, which the Babbage solution destroys.

Dr. Carpenter added that, to him, the whole class of arguments to which that of Bishop Temple belongs, on the abstract possibility, probability, credibility, of miracles, appeared a futile waste of ingenuity. The problem was not philosophical, but historical; and must be determined by critical methods applied to the records of concrete cases; fair account being taken, on the one hand, of the value and extent of assured first-hand evidence; and, on the other, of the sources of subjective illusion and the fluid state of all popular tradition.

Under these conditions, the reported miracles were, to him, evidence chiefly of the intense and profound impression left by the personality of Jesus. In *that*, and in the spiritual relations which it implied, lay the real secret, and the permanent power, of Christianity. These the records suffice to preserve; and with these it is wiser for the present age to be content.

More than this passed between us; and I believe that I was tempted to say more in my recital to the Christian Conference. But further I cannot securely go, without making my lamented friend responsible rather for my part of the conversation than for his own. The foregoing sentences contain, at least, the outline of the scheme of thought which he sketched.

To this meeting Dr. Carpenter recurred several times in the home-talk that evening, over the tea-table, the microscope, and the familiar game of backgammon. On retiring to rest he took a hot-air bath to ease the stiffness and rheumatic pains which the damp weather rendered unusually severe, when the accidental overturning of the lamp inflicted such injuries that after a few hours—which closed in tranquil sleep—he passed quietly away.

Four days later, on Friday, November 13, his remains were laid near those of a venerated relative to whom he had been deeply attached, in the Highgate Cemetery. Ere the last office was complete, Dr. Sadler spoke of him as teacher and investigator, as companion and helper, and added the following words on that aspect of his life which it is especially the object of this volume to illustrate :—

> At a time when religion and science have appeared too often unhappily divided, it is hardly possible to overestimate the significance of their union in him, of his steadfast avowal of his own faith, and his personal sympathy with and participation in Christian worship. It is hardly possible to overrate the value of the contributions from his pen on religious subjects. To none, indeed, of those who have given up all religious profession, was a narrow and unspiritual theology, such as has been too often preached, more repellent than to him. But in the home of his childhood he breathed an atmosphere both of religious freedom and of religious feeling, and was led by precept and example to think freely and earnestly on religious subjects, and the result was that his large intellectual culture did not repress in him a most devotional spirit, but gave it a wider range, and enabled it to soar up higher, foreshadowing, I trust, the way in which
>
> "That in us which thinks and that which feels
> Shall everlastingly be reconciled,
> And that which questioneth with that which kneels."

ESSAYS.

I.

THE METHOD AND AIM OF THE STUDY OF PHYSIOLOGY.

[From the conclusion of an article entitled, "Physiology an Inductive Science," in the *British and Foreign Medical Review*, April, 1838.]

It is quite evident that no one can advantageously commence the study of physiology without a tolerably complete knowledge of human anatomy, both general and special. Those details, however, which are peculiarly connected with physiological inference may, perhaps, be not improperly deferred until the time when their application tends to implant them on the memory. Either conjointly with, or subsequently to, the study of the human organism, we recommend that a general knowledge of comparative anatomy be acquired; and though the magnitude of the task may alarm the student, he will find that if he avoids devoting much attention to details of external form, and endeavours to make himself acquainted with the general development of each system, the pursuit will be easy as well as delightful. It will not be amiss to acquire at the same time a knowledge of the structure of vegetables, not only because we find there expressed in another and frequently a simpler form, the anatomical facts which it is difficult to trace in animals, but because the attainment of the laws of morphology in flowering plants, and their progressive extension in the cryptogamia, may advantageously serve as our guide in the more intricate pursuit of similar generalizations in the animal kingdom. We have already stated our belief that a knowledge of the principles of general physics is essential to the successful cultivation of physiological science; and when all these preparatory steps have been taken, the student will enter upon its study with no small advantages.

Whatever may be thought of the expediency of commencing the study of anatomy by investigating the structure of the simplest organisms, a plan which has many advocates, we are decidedly of opinion that this course is essential in physiology; and that the student who adopts it will be saved the necessity of unlearning many erroneous notions which he would unavoidably imbibe from the premature study of the human functions. In the pursuit of general physiology he will learn what are the essential conditions of life; he will see the changes indispensable to its support manifested in their simplest circumstances; and he will be able to ascertain what structures are necessary to their performance, and what additions and modifications these may undergo to suit the various purposes of their existence. He will acquire, also, the great advantage of making observation a substitute for experiment; the former means, wherever it can be employed in physiology being decidedly preferable (as we hope we have successfully demonstrated), both in the certainty and satisfactory nature of the conclusions which may be drawn from it; and in its freedom from those objections which every humane mind must feel to the infliction of unnecessary tortures upon beings endowed with sensations as acute as our own.

We have alluded, in the early part of this article, to the difficulty of distinguishing the operation of vital and physical laws; and this we cannot but regard as a question to be completely determined before the laws of purely vital phenomena can be satisfactorily established. To analyze the phenomena in which physical laws are acting under conditions supplied by vital processes, and to trace the diversities from their usual mode of action occasioned by the existence of these conditions, appears to us, therefore, to be at present the most obvious method of advancing the science. We cannot but believe that the inquiry would ultimately terminate in referring all vital actions to properties as essentially connected with that form of matter which we call organized, as are the ordinary physical properties with inorganic matter.

One more question would then remain: is it possible that these physical and vital properties of matter, which are at present our ultimate facts or axioms, may be hereafter included within a more general expression common to both? On this subject we can only speculate; but the probability appears decidedly in the affirmative. We have already remarked upon the rapid progress of generalization in the physical sciences, rendering it probable that before long one simple formula shall comprehend all the phenomena of the inorganic world; and it is not, perhaps, too much to hope for a corresponding simplification in the laws of the organized creation, although this is necessarily retarded by the many obstacles which the nature of the subject presents to the philosophical inquirer. In proportion to our attainment of such generalizations, we rise from the domain of our ignorance to that of our knowledge; for, at every successive step, we are able to comprehend new relations between facts that previously seemed confused and insulated; new objects for what formerly appeared destitute of utility.

Every step, then, which we take in the path of generalization must increase our admiration of the beauty of the adaptation, and the harmony of the action of the laws we discover; a beauty and harmony in which the contemplative mind delights to recognize the wisdom and beneficence of the Divine Author of the universe, If we can conceive that the Almighty *fiat* which created matter out of nothing, impressed upon it one simple law, which should regulate the association of its masses into systems of almost illimitable extent, controlling their movements, fixing the times of the commencement and the cessation of each world, and balancing against each other the perturbing influences to which its own actions give rise,—should be the cause, not only of the general uniformity, but of the particular variety of their conditions, governing the changes in the form and structure of each individual globe protracted through an existence of countless centuries, and adjusting the alternation of "seasons and times and months and years,"—should people all these worlds with living beings of endless diversity of nature, providing for their support, their happiness, their mutual reliance, ordaining their constant decay of succession, not merely as individuals, but as races, and adapting them in every minute particular to the conditions of their dwelling,—and should harmonize and blend together all the innumerable multitude of these actions, making their very perturbations sources of new powers;—when our knowledge is sufficiently advanced to comprehend these things, then shall we be led to a far higher and nobler conception of the Divine mind than we have at present the means of forming.

II.

THE BRAIN AND ITS PHYSIOLOGY.

[From an article in the *British and Foreign Medical Review*, October, 1846.]

It may be desirable to recapitulate briefly the positions on which we have now dwelt.

1. That the sensory ganglia supply all the conditions requisite for the reception of sensations in the higher animals as in the lower; and that there is a class of actions excitable through them by the direct influence of sensations; to these we give the name of consensual.

2. That the sensations which excite these actions, also excite the feelings of pleasure and pain, which have their seat in the same ganglia. These feelings may receive different designations, according to the nature of the objects towards which they are displayed. Thus, attachment and dislike, affection and rage, joy and sorrow, and many other simple and elementary feelings, are but modifications or phases of pleasure and pain, which receive their different designations according to the character of the objects which excite them, the ideas which they arouse, and the mode in which they are manifested.

3. That sensations, the simple feelings connected with them, and the consensual movements to which they prompt, make up the sum-total of those operations to which the term *instinctive* is properly applicable; that these take place through the instrumentality of the *sensory ganglia*, and that none of those higher operations which involve the formation of ideas, reasoning processes, and volitional determinations, can take place without a cerebrum.

4. That the cerebrum is the seat of the formation of *ideas*, or elementary notions originating from sensations, and of all those higher *intellectual operations*, of which those ideas form (as it were) the pabulum.

5. That the occurrence of *ideas* in the cerebrum may produce feelings of pleasure or pain in the sensory ganglia, analogous to those which are produced by sensations.

6. That the tendency to the recurrence of a certain class of ideas, constantly connected with feelings of pleasure or pain, constitutes what is known as an emotion, desire, or propensity; and that this is composite in its nature, involving the cerebrum for the formation of ideas, and the sensory ganglia for the feelings with which they are associated.

7. That certain ideas, which thus strongly excite the feelings, may also produce motions through the instrumentality of the sensory ganglia and their nerves; that these movements are involuntary in their character, and are excited by emotional states in the same manner as they are by direct sensations; and that they consequently belong to the consensual group.

8. That intellectual operations *may* take place, in which the feelings do not participate (as, for example, in mathematical or scientific ratiocination); but that the motives which regulate our personal conduct are, in great part, derived from the feelings attached to particular ideas or classes of ideas. When the emotional states thus act, in affecting the further course of the mental operations, they have no immediate agency upon the body, their influence being exerted through the will.

9. That the exertion of the reasoning powers, and the final determination which, in its action on the body or the mind, we call volition or will, operates solely through the instrumentality of the cerebrum.

10. That the cerebrum has probably no direct connection, however, either with the sensory organs or with the muscular system; but that it depends upon the sensorial ganglia for the reception of sensations, and for the execution of voluntary movements; this execution being still guided by the sensations received through these ganglia, and the act of muscular contraction being dependent upon their continuance.

. . . .

We conclude, as we commenced, by disclaiming any hostility whatever to the phrenological system in the abstract, and by freely admitting the *general* coincidence between the indications of human character, which are afforded by cranioscopical examination, and those derived from a direct acquaintance. But we consider that, in building up their system, the followers of Gall have been too disregardful of evidence supplied from other sources than observation of man; and that they have been misled, as to the fundamental connection of the cerebrum with the purely instinctive actions, by their inattention to comparative anatomy, which proves that the cerebrum *cannot* be the instrument of those actions; and have glossed over the important objection which the non-development of the posterior lobes in the lower mammalia and in all the oviparous vertebrata interposes to the location of the animal propensities in them. So far, however, from availing ourselves of these errors, as conclusive arguments against the whole system, we have endeavoured, by a new analysis of the propensities and emotions, to show that the facts supplied by comparative anatomy may be brought into conformity with the physiology of Gall; and that the phrenological system may be planted upon a much more secure and extended basis than it has yet possessed; a new and more exact series of observations, however, being required to build it up with anything like firmness and consistency. We cannot regard the question of the functions of the cerebellum as at all fundamental in its character; and can easily understand how a candid phrenologist like Dr. Gowan, may, on this point, embrace the views held (we believe) by all the leading physiologists of the day.

Finally, we commend our review of the subject to the candid consideration of those who think with us that the determination of the *general* functions of the *encephalon* is the *first* question for the physiologist; that the determination of the share of these performed by the *cerebrum*, to be effected by attention to comparative anatomy and by experiment, is the *second;* and that the determination of the *special* functions of *different parts of the cerebrum*, to be effected (for the reasons we have stated) by the comparison of the varieties of cerebral (not cranial) conformation in man, with some assistance from that of the lower animals, is the *third.* Upon those who blindly uphold the method of Gall, in disregard of all the improvements which have taken place in our knowledge of neurology since his time, and who regard the present phrenological system as so perfect as to be incapable of improvement, we certainly despair of making any impression. We would not be supposed to assert our conviction that our own views, as now expressed, are so complete as to be incapable of further improvement. Considering, as we do, that the whole science of encephalic phrenology is in its infancy—that a large amount of information as to the fundamental data on which it must be built up is yet wanting—that the progress of comparative anatomy, of embryology, and of microscopy may make many additions to our knowledge of the connections of different parts of the nervous centres, which may tend to modify previously received doctrines—and that, on the other hand, an entirely new system of psychological observation must be carried out, in order to bring psychology and physiology into their proper relation; it would be absurd in us to attempt to lay down dogmatic conclusions, by which to stand or fall. We would be understood as attempting nothing in this article, but to test the relative validity of two rival *methods* of philosophizing on this subject. Our conviction of the uniformity of Nature is such, that we are thoroughly persuaded that there can be no real contradiction between her various indications, when these are properly brought together and compared; and our attempt has been to point out the application of the method, which has elsewhere been pursued with complete success, to neurological investigation. We deem it particularly incumbent upon us to point out that even if our views should be proved to be erroneous as to a few minor points—such, for example, as the offices of the thalami and corpora striata—our main argument is not affected. The points for which we contend are simply these: the independent character of the sensory ganglia as the instruments of sensation and of consensual actions; the superadded character of the cerebrum, as the organ by whose instrumentality ideas are formed, and reasoning processes are carried on; and the mixed character of the emotions and propensities, as compounded of *ideas* and *simple feelings* of pleasure and pain. On this last point we venture to think that we have made a real advance in psychology, which will prove to be important; and we happen to know that several intelligent psychologists are well prepared to receive it, as fixing and defining views which had been previously floating in their own minds. It seems, indeed, to have been glimpsed at by the late Mr. James Mill, in his valuable "Analysis of the Human Mind;" his deficiency consisting in connecting the feeling too much with the sensation, rather than with the intellectual idea. We should be doing injustice to that very painstaking anatomist, Mr. Swan, were we not to state that, on referring to his general summary of his views of the offices of the nervous centres, we find a very near coincidence with the leading features of our own doctrines regarding the relative offices of the sensory ganglia and the cerebrum—doctrines, indeed, to which it would be easy to point out approaches in the writings of many previous physiologists, to whose authority we might refer in support of our own.

III.

THE AUTOMATIC EXECUTION OF VOLUNTARY MOVEMENTS.

[From an article on Todd's "Physiology of the Nervous System," in the *British and Foreign Medico-Chirurgical Review*, January, 1850.]

Every one who has attentively considered the nature of what we are accustomed to call *voluntary* action has been struck with the fact that the will simply determines the *result*, not the special movements by which it is brought about. If it were otherwise, we should be dependent upon our anatomical knowledge for our power of performing the simplest movements of the body. Again, there are very few cases in which we can single out any individual muscle, and put it into action independently of others; the cases in which we *can* do so are those in which a single muscle is concerned in producing the result, as in the elevation of the eyelids, and we then really single out the muscle and cause it to contract, by "willing" the result. Thus, then, however startling the position may at first appear, we have a right to affirm that the will cannot exert any direct or immediate power over the muscles; but that its determinations are carried into effect through the intermediation of some mechanism, which, without any further effort on our own parts, selects and combines the particular muscles whose contractions are requisite to produce the desired movement. This conclusion, at which we arrive by an analysis of our own consciousness is in perfect harmony with the influences which we should draw from the anatomical relations of the cerebrum; for we have found strong reason to believe that the cerebrum does not directly transmit any fibres to the muscular system; but that its operations are exerted through those fibres which pass between the surface of the hemispheres and the chain of ganglionic centres at the base of the cranium that constitutes the summit of the automatic apparatus. And thus, as the sensorium *plays* (so to speak) upon the cerebrum, sending to it sensations in order to call forth its activity as the instrument of the purely mental operations, so does the cerebrum, in its turn, *play* downwards upon the motor portion of the automatic apparatus, sending it volitional impulses, which excite its motorial activity. Thus, even what we are accustomed to consider our *voluntary* movements, are in their immediate and essential nature *automatic;* their peculiar character being, that whereas the ordinary automatic movements are excited by *external* stimuli, impressional or sensational, conveyed by the afferent nerves, the volitional movements are excited by a stimulus proceeding from the cerebrum, and conveyed along what Reil, with great sagacity, termed the nerves of the *internal* senses.

The views which we have advanced as to the really automatic character of voluntary movements, and the inclusion of the sensorial centres in the automatic, rather than in the cerebral, division of the apparatus, appear to us to be in most singular harmony with the phenomena of those movements which were not unaptly designated by Hartley as "secondarily automatic," having been voluntary in the first instance, but having been brought by habit into more or less complete independence of the will. Such actions, in fact, take the place in man of those which are primarily and purely automatic in many of the lower animals. Take, for example, the movements of progression. In the first instance they are performed in sole respondence to the will. Whilst the child is learning to walk, every single effort has a voluntary source; but still its immediate dependence on the automatic mechanism is evident in the necessity for attention to the guiding sensations as the regulators of the voluntary effort. As the habit of movement becomes more and more established, however, we are able to withdraw both the attention and the voluntary effort, to such a degree that at last it is only necessary for the will to start or commence the actions, and to *permit* their continuance. We think that no one can doubt this, who can analyze his own consciousness as to those states of "reverie" in which the mind is completely withdrawn from the contemplation of external objects, and is concentrated, as it were, upon itself. A person who is subject to such fits of "absence of mind," may fall into one of them whilst walking the streets; his whole attention shall be absorbed in his train of thought, so that he is conscious of no more interruption in its continuity than if his body were perfectly at rest, and his reverie was taking place in the quietude of his own study; and yet, during the whole of that time, his limbs shall have been in motion, carrying him along the accustomed path; and his vision shall have given the direction to these movements which is requisite to guide him along a particular line, or to move him out of it for the avoidance of obstacles. In such a case it would seem as if the contact of the foot with the ground, in making each step, was the stimulus to the next movement; and as if the visual organs exerted just the same automatic guidance over the direction of the progression as they appear to do in animals which do not possess a distinct organ of intelligence and will. The complete occupation of the mind in other ways, as in close conversation or argument, is equally favourable to this independent action of the automatic apparatus in progression; and many other cases might be cited, in which an habitual train of actions, such as reading aloud, or playing on a musical instrument, is not interrupted by the complete withdrawal of the attention, and consequent suspension of voluntary effort.

It would be difficult to explain such phenomena on the hypothesis of the "distinct system;" because we cannot conceive how a set of movements originally performed by the sensori-volitional or cerebral fibres can ever be *transferred* to the excito-motor or spinal; and every one allows that in man these movements are in the first instance prompted by the will and performed under the guidance of sensations. On our hypothesis, on the other hand, the solution is easy and natural. Even when voluntary, as they are in the first instance, these movements are performed by the instrumentality of the automatic apparatus; and the influence of habit gradually links on the actions to the sensations which at first guided them, in such a manner that the latter at last come to be in themselves adequate excitors of the movement, when the series has once been commenced by an exertion of the will. It has been thought by some a sufficient proof of the voluntary nature of these movements, that we can check them at any time by an effort of the will; but this we do only when the attention has been recalled to them, so that the cerebrum, liberated, as it were, from its previous self-occupation, resumes its usual play upon the automatic centres. It has been asked, moreover, why, if these sensations are adequate to call forth automatic movements when the perceptive and voluntary operation of the cerebrum is suspended, they do not exert the same influence when it is in its ordinary condition of functional activity. This inquiry, however, is equally applicable to the most undoubted cases of automatic movement; thus we do not find that tickling the soles of the feet in man ordinarily produces the same semi-convulsive agitation of the lower extremities, that such irritation will call forth when the spinal cord has been divided or seriously injured in the dorsal region. And when the cerebral influence is withdrawn by the absorption of the mind in reverie, slight stimuli will often call forth unaccustomed and sometimes powerful automatic movements. So, again, during sleep, when both the cerebrum and the sensory ganglia are in a state of torpor, reflex actions may be excited through the spinal cord, such as could not be called forth by the same stimuli in the waking state. The fact appears to be that, when the cerebrum is in its usual state of activity, any irritation which would dispose to reflex action, if its effect were limited to the automatic centres, is expended (as it were) by being propagated onwards to the cerebrum; and the mind thus rendered conscious of it, controls, if necessary, any tendency to automatic action which it may have excited. But when this onward propagation of the polar state is checked, either by interruption of the structural continuity, or by the want of a recipient condition of the cerebrum, it must then react in the automatic apparatus itself. The case, in fact, appears to us to be analogous to that of the emotional impulses, which are not so prone to act upon the *mind* when they can discharge themselves through the *body* by muscular movement. The immediate seat of these impulses, Dr. Todd agrees with us in locating in the sensory ganglia; but he does not seem to us sufficiently to recognize the participation of the cerebrum in emotional states. A simple *feeling* of pleasure or pain excited by a sensation, and tending to react directly upon the muscular system, cannot be correctly termed an emotion; for this last involves an *idea*, which, though originally springing from a sensation, at last comes to be quite independent of external stimuli. But the idea is not emotional so long as it is a state of simple consciousness: it must be associated with a pleasurable or painful feeling, in order that it may become so; and then, if strongly excited, it may act at once through the automatic centres, without any effort of the will. In an emotional action, then, we believe the impulse to be formed in the sensorial centres, so that it so far resembles an instinctive movement; but this impulse derives its force rather from a cerebral idea than from an external sensation; and its influence, if not exerted downwards through the motor apparatus, is transmitted back again to the cerebrum, so as to modify the course of the intellectual operations, and to supply motives to the will.

IV.

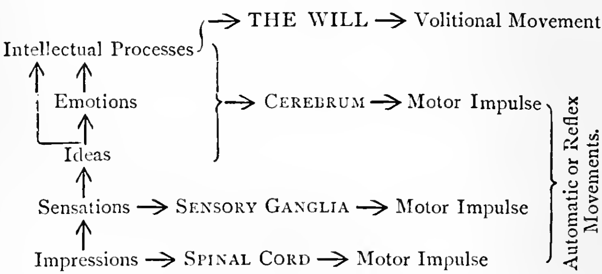
ON THE INFLUENCE OF SUGGESTION IN MODIFYING AND DIRECTING MUSCULAR MOVEMENT, INDEPENDENTLY OF VOLITION.

[From a report of a Lecture at the Royal Institution, March 12, 1852.]

It now remains to inquire whether any such physiological account can be given of the "biological" state, as shall enable us to refer it to any of the admitted laws of action of the nervous system. This, the lecturer stated, was the point which he was the most desirous of elucidating; and in order to prepare his auditors for the reception of his views, he gave a brief explanation of those phenomena of "reflex" action (now universally recognized by physiologists), in which impressions made upon the nervous system are followed by respondent automatic movements. Such movements have hitherto been distinguished into the *excito-motor*, which are performed, without the exciting impression being necessarily felt, through the instrumentality of the spinal cord and the nerves connected with it; and the *sensori-motor*, in which sensation necessarily participates, the respondent motions not being executed unless the impressions are felt, and their instrument being the chain of sensory ganglia (collectively constituting the "sensorium") which lies between the spinal cord and the cerebrum, and is intimately connected with both. The automatic movements of breathing and swallowing, which continue during a state of profound insensibility, are examples of the former group; whilst the start upon a loud sound, the closure of the lids to a flash of light, or the sneezing induced by the dazzling of the eyes, as well as by the irritation of the nasal passages, are instances of the latter. The whole class of purely *emotional* movements may be likened to these; for in so far as they are involuntary, and depend upon the excitation of certain states of mind by external impressions, they must be considered as "reflex" in the general sense of that term.

Now the usual *modus operandi* of sensations is to call forth *ideas* to the mind; and these ideas, associated or not with emotional states, become the subjects of intellectual processes, which result at last in a determination of the will. The movements we term *voluntary* or *volitional* differ from the emotional and automatic, in being guided by a distinct conception of the object to be attained, and by a rational choice of the means employed. And so long as the voluntary power asserts its due predominance, so long can it keep in check all tendency to any other kind of action, save such as ministers directly to the bodily wants, as the automatic movements of breathing and swallowing.

The cerebrum is universally admitted to be the portion of the nervous system which is instrumentally concerned in the formation of ideas, the excitement of the emotions, and the operations of the intellect; and there seems no reason why it should be exempted from the law of "reflex action," which applies to every other part of the nervous system.* And as we have seen that the *emotions* may act directly upon the muscular system through the motor nerves, there is no *à priori* difficulty in believing that *ideas* may become the sources of muscular movement, independently either of volitions or of emotions.—The relations of these different modes of action of the nervous system, and the place which this ideo-motor form of "reflex" operation will hold in regard to the rest, will be made more apparent by the following tabular arrangement:—



* To Dr. Laycock is due the credit of first extending the doctrine of reflex action to the brain.

Now if that ordinary *upward* course of external impressions—whereby they successively produce sensations, ideas, emotions, and intellectual processes, the will giving the final decision upon the action to which they prompt—be anywhere interrupted, the impression will then exert its power in a *transverse* direction, and a "reflex" action will be the result. This is well seen in cases of injury to the spinal cord, which disconnects its lower portion from the sensorium without destroying its own power: for impressions made upon the lower extremities then excite violent reflex actions, to which there would have been no tendency if the current of nervous force could have passed upwards to the cerebrum. So, if sensations be prevented by the state of the cerebrum from calling forth ideas through its instrumentality, they may react upon the motor apparatus in a manner in which they would never do in its state of complete functional activity. This the Lecturer maintained to be the true account of the mode in which the locomotive movements are maintained and guided in states of profound abstraction, when the whole attention of the individual is so completely concentrated upon his own train of thought that he does not *perceive* the objects around him, although his movements are obviously guided by the impressions which they make upon his sensorium. And he adverted to a very remarkable case, in which the functional activity of the cerebrum seemed to have been almost entirely suspended for nearly a twelvemonth, and all the actions of the individual presented the automatic characters of consensual and reflex movements.

On the same grounds, it seems reasonable to suppose that when *ideas* do not go on to be developed into emotions, or to excite intellectual operations, they, too, may act (so to speak) in the transverse direction, and may produce respondent movements through the instrumentality of the cerebrum; and this will of course be most likely to happen when the power of the will is in abeyance, as has been shown to be the case in regard to the direction of the thoughts, in the states of electro-biology, somnambulism, and all forms of dreaming and reverie. Here the movements express the ideas that may possess the mind at the time; with these ideas, emotional states may be mixed up, and even intellectual operations may be (as it were) automatically performed under their suggestive influence. But so long as these processes are carried on without the control and direction of the will, and the course of thought is entirely determined by suggestions from without (the effects of which, however, are diversified by the mental constitution and habits of thought of the individual), such movements are as truly automatic as are those more directly prompted by sensations and impressions, although originating in a more truly *psychical* source. But the automatic nature of the purely emotional actions can scarcely be denied; and as it is in those individuals in whom the intellectual powers are the least exercised, and the controlling power of the will is the weakest, that the emotions exert the strongest influence on the bodily frame, so may we expect ideas to act most powerfully when the dominance of the will is for the time completely suspended.

Thus the *ideo-motor* principle of action finds its appropriate place in the physiological scale, which would, indeed, be incomplete without it. And, when it is once recognized, it may be applied to the explanation of numerous phenomena which have been a source of perplexity to many who have been convinced of their genuineness, and who could not see any mode of reconciling them with the known laws of nervous action. The phenomena in question are those which have been recently set down to the action of an "Od-force," such, for example, as the movements of the "divining-rod," and the vibration of bodies suspended from the finger; both which have been clearly proved to depend on the state of *expectant attention* on the part of the performer, his will being temporarily withdrawn from control over his muscles by the state of abstraction to which his mind is given up, and the *anticipation* of a given result being the stimulus which directly and involuntarily prompts the muscular movements that produce it.

V.

THE PHASIS OF FORCE.*

[In the earlier part of the article, Dr. Carpenter referred to "a few of the "more striking and typical examples of the *phasis of matter*, for the purpose of "introducing a kindred topic, the *phasis of force*." After illustrating the mutual correlation of mechanical force, heat, chemical affinity, and electricity, he dealt with light, passing from its relation to the preceding modes of force, to describe its effects in influencing vital processes, and thus advancing to the phenomena of life.]

In by far the larger number of cases in which Light is evolved, its manifestation can be directly traced to chemical combination; whilst, conversely, light is often a most powerful agent in bringing about chemical change. In fact, it may be doubted whether light does not alter the structure or composition of all matter through which it passes, or on which it falls. Upon such an alteration depend, not only all the phenomena of photography, and numerous chemical changes of a most important character, but also the sustentation of all organic life, and our own sensibility to visual phenomena. For it is by the extraordinary influence of light upon the surface of the growing plant, that it is able to separate the inorganic elements of water, carbonic acid, and ammonia, and to unite them into those new and peculiar compounds—starch, oil, albumen, and their derivatives—which serve, not only for the extension of the vegetable fabric, but also for the nutrition of the animal body; so that without light, as Lavoisier truly said, nature were without life and without soul. So, again, there can be no doubt that it is by directly producing some change in the nervous tissue of the retina, of which change the result is transmitted to

* *National Review*, April, 1857.

the sensorium, that luminous impressions are communicated to our consciousness; and this change is essential to the continued nutrition of the tissue; for it is well known to the physiologist, that if an opacity on the front of the eye completely prevent the access of light to the interior, the retina and the optic nerve gradually waste away, just as muscles do when long disused. What the precise nature of this change may be, is yet beyond our ken; but of the immediate and direct relation of light to the peculiar properties of animal bodies, a very remarkable proof has been recently given by the researches of one of the best experimental physiologists of our time, M. Brown-Séquard; for he has found that the contraction of the fibres of the iris, which diminishes the diameter of the pupil, is capable of being called forth, not only by the stimulus of light upon the retina, which affects the iris through the nervous circle of reflex action, but also by the impact of Light upon the iris itself, which directly excites the contraction of its muscular fibres, in the same way as electrical or mechanical stimulation excites muscular contraction elsewhere.

By these most important links of connection, we are conducted to another division of the inquiry—that which relates to the powers of Life. There have not been wanting, at any period in the history of physiology, men who have attempted to identify all the forces acting in the living body with those operating in the inorganic universe. Because muscular force, when brought to bear on the bones, puts them in motion according to the laws of mechanics—and because the propulsive power of the heart drives the blood through the vessels on strictly hydraulic rules, it has been imagined that the movements of living bodies may be fully explained on physical principles; no account being taken of the most important consideration of all, namely, the source of that power which the living muscle possesses, but which the dead muscle is utterly incapable of exerting. So, again, because the digestive process, whereby food is reduced to a fit state for absorption, and the formation of various products of the decomposition that is continually taking place in the living body, may be imitated in the laboratory, it has been supposed that the appropriation of the nutriment to the production of living tissue, and the various metamorphoses which this undergoes, are to be regarded as chemical phenomena; here, again, those most essential peculiarities of the living body, which involve the temporary subjection of ordinary chemical affinities to some other agency, being entirely passed by. A scarcely less unphilosophical method, however, has been pursued by another class of reasoners, who have cut the Gordian knot by attributing all the actions of living bodies which physics and chemistry cannot account for, to a hypothetical "vital principle;" an agency which they suppose to exert an autocratic rule in each organism, and whose laws they think it vain to seek.

By various intelligent physiologists of modern times, however, the dynamical ideas introduced from physics and chemistry have been carried into the domain of life; and it has been felt that the only mode of placing physiology on a truly scientific basis is, to regard those phenomena which, being altogether peculiar to living bodies, are designated "vital," as the manifestations of a special force or power, and to seek to determine the laws of its operation by the study of its actions. Of all these actions, there is none so universal, and therefore so characteristic, as that by which the organism is built up, or rather builds itself up, from the germ, by the appropriation of materials derived from external sources, and subsequently maintains itself in its characteristic form during its term of life; hence the hypothetical power which is the supposed source of it, has been designated as the *nisus formativus*, the *bildungstrieb*, or the *organizing force*. This power is usually considered as inherent in the organic structure, and as quite independent of heat or other agencies external to this, although they are admitted to exert an exciting or modifying influence on its operation; and it is supposed to be imparted to each individual, like the substance of the germ from which it sprang, by the parental organisms which preceded it. In this point of view, therefore, the germ being potentially the entire organism, all the organizing force required to build up an oak or a palm, an elephant or a whale, must be concentrated in a minute particle only discernible by microscopic aid. But the hypothesis may be disproved by even a more complete *reductio ad absurdum* than this; for if we suppose the whole organizing force to be inherent in the organism itself, and to have been at first derived from its parents, the aggregate of the forces possessed by the several individuals, how numerous so-ever, of any one species, must have been concentrated in their first progenitors—a doctrine scarcely less monstrous than that of the *emboitement* of the germs themselves, which were once supposed to lie packed one within the other, like nests of pill-boxes.

Now, as the process of physiological inquiry has been recently bringing more and more clearly into view the dependence of all Vital activity upon certain antecedent conditions, it has especially established such a definite relation between the degree of this activity and the amount of Heat supplied to the organism, either from external or internal sources, as to make it clear that this agent is much more than a mere stimulus or provocative to the exercise of the vital force, and really furnishes the power that does the work. It has been, in fact, from the narrow limitation of the area over which physiological research has been commonly prosecuted, that this great truth has not sooner become apparent. Whilst the vital phenomena of warm-blooded animals, which possess within themselves the means of maintaining a constant temperature, were made the sole, or at any rate the chief objects of study, it was not likely that the inquirer would recognize the influence of external heat in accelerating, or of cold in retarding their functional activity. It is only when the survey is extended to cold-blooded animals and to plants, that the immediate and direct relation between heat and vital energy—as manifested in the rate of growth and development, or of other changes peculiar to the living body—is unmistakably evinced.

All the facts and generalizations of Botanical Geography point to the uninterrupted supply of a large measure of light and heat as the source of the rich luxuriance and perennial activity of tropical vegetation; whilst the periodical declension of vegetative activity which we observe in the trees and plants of the temperate zone, is no less obviously due to the seasonal diminution in the supply of these agents. So, again, the entire cessation of all manifestations of vegetative life during the protracted intensity of an arctic winter, is in striking contrast with the almost incredible rapidity of development, which is observable under the unintermitted beams of the summer sun. Now, there are certain annual plants, such as the corn-grains, which will flourish under a considerable variety of climatic conditions, and whose term of life is definitely marked out; and of such it has been ascertained by Boussingault, that the same aggregate amount of light and heat is required by each kind for the sustentation of its whole term of activity from germination to the maturation of its seed, under whatever latitude it be grown; that term being so uniformly abbreviated by an exaltation, and protracted by a depression, in the intensity of these forces, as to show that its rate of life must stand in a direct ratio to them.

We have already seen that the influence of light is exerted in providing the material for vegetable growth by a quasi-chemical action; and it is capable of proof by direct experiment, that, *ceteris paribus*, the quantity of carbonic acid decomposed by a plant in a given time is proportional to the amount of light that has fallen upon it. There is no reason to suppose that light acts upon more than the surface, or that it has any direct concern with the internal operations of growth and development. On the contrary, we find that at one most important epoch, that of germination, these processes are most actively carried on in the dark; it being only when all the store of nutriment laid up in the seed has been exhausted, and when the young plant is beginning to be dependent upon that which it obtains for itself, that the influence of light becomes requisite. On the other hand, the rate of germination is so closely dependent, as every maltster knows, upon the degree of heat to which the seed is exposed, that it is capable of being exactly regulated by an increase or a diminution of the temperature; and thus we are led to regard heat as the force by which the vegetable germ is enabled to appropriate the nutriment prepared for it, and to organize this into living tissue. Such a view, however, is by no means equivalent to the assertion that heat is itself the "vital principle," or the organizing force. We do not say that heat is electricity, because the heating of a certain combination of metals produces an electric current through them; nor do we say that heat is mechanical force, because by boiling water we generate an elastic vapour. In each of these instances the character of the force is changed; and so it is here. The living organism is the medium of transmutation, like the bismuth and antimony in the first case, or like the water in the second; and its special peculiarity is, that it converts the heat, not only into vital force generally, but into that peculiar form of it which exerts itself in building up and maintaining a certain structural type. Thus each species puts to a use of its own the heat that is supplied to it; just as, if we may use so rough a simile, each of the machines in a large manufactory may turn out a particular kind of work, although the same motor force is supplied to all; and each generation transmits to its successor, not the force, but the capacity, for making a particular use of the force; just as a machine would do, that could apply its motor power to the construction of another machine similar to itself.

The study of the life-history of cold-blooded animals—those, namely, whose temperature closely follows that of the medium they inhabit—leads to precisely the same conclusions; as is especially apparent in those cases in which the ratio of life can be most accurately estimated. The earliest developmental changes in the fertilized egg of the frog, for example, consist in the cleavage, or segmentation of the yolk-mass, first into two parts, then into four, then into eight, and so on; and it was found by Mr. Newport that the periods at which the successive cleavages took place were so precisely determined by the temperature to which the eggs were exposed, that he could predicate the former from the latter with great precision. So it has long been known that the production of larvæ from the eggs of insects could be accelerated or retarded, like the germination of plants, by increase or diminution of temperature; and that the same holds good also regarding the production of the perfect chrysalis in the last metamorphosis. In the adult animal, the rate of life may be in some degree estimated by the amount of carbonic acid thrown off in respiration; and it has been shown by the experiments of Dr. W. F. Edwards, that this increases in a direct ratio to the temperature to which the body is exposed; whilst the duration of life, when respiration is prevented, is much greater at low temperatures than at high, showing that the animals then live much more slowly.

The case is different, however, with warm-blooded animals; for they are rendered in a great degree independent of external variations, by the power which they possess of generating such an amount of heat within themselves, as shall keep the temperature of their bodies up to a certain fixed standard. Hence it is that *their* rate of life varies very little, and that their developmental functions are performed with a remarkable conformity to fixed periods of time. Thus, in the incubated egg of the bird, which is not left to casual supplies of warmth, but is constantly subjected to the high temperature of the maternal body, the chick is matured after a definite term of days; and if the requisite heat were not thus constantly supplied, not merely would the developmental process be suspended, but the reduction of temperature would annihilate the organizing power. For it is the peculiarity of warm-blooded animals, that whilst this power is more energetic in its action than in that of the lower tribes, it requires for its maintenance a higher measure of heat; so that a reduction of the temperature of the body to such a degree as would favour the energetic activity of the fish or reptile, would be fatal to the bird or mammal.

Although there is still some obscurity respecting certain phenomena of "animal heat," yet there is no question amongst either chemists or physiologists in regard to the general fact, that the main source of this heat is the oxygenation (by a kind of combustive process) of the hydrocarbons contained in the food. Now, we have seen that all these hydrocarbons, such as starch, sugar, oil, etc., are either directly or indirectly derived from the vegetable kingdom; and not only a direct amount of oxygen, hydrogen, and carbon have been consumed in their production, but also a certain amount of solar light and heat, which they may thus be said to embody. The combustive process is not so carried on in the living body as to give forth light, save in a few exceptional cases, but it reproduces in the form of heat all that was embodied in the respiratory food, and thus the warm-blooded animal may be said to be continually restoring to the universe that force which the growing plant had appropriated to itself. And, carrying the same principle a little further, we may say, that in utilizing the stores of coal which have been prepared by the luxuriant vegetation of past ages, man is not only restoring to the atmosphere the carbonic acid and water of the carboniferous epoch, but is actually reproducing and applying to his own use the light and heat which its vegetation drew from the solar beams, as if for the very purpose of fixing them until he should find the means of turning them to account. Looking at this matter from the standpoint afforded by the "correlation" doctrine, we are led to question whether the project of the Laputan sage to extract sunbeams from cucumbers was so very chimerical after all, while we cannot but feel an increased admiration of the intuitive sagacity of that remarkable man George Stephenson, who was often laughed at for propounding in a somewhat crude form the very idea which we have just been endeavouring to present under a more philosophical aspect.

There are other modes, however, in which the living animal restores to the universe the forces which the plant took from it. Its most distinguishing attribute is motion; and this motion being another expression of force, the question arises, What is the source of that force? There, again, we fall back on the plant, both for the force, and for the material of the structure which exerts it. All the higher forms of animal motion are the result of Muscular contraction; and physiologists are now generally agreed in the truth of the statement first formally enunciated by Liebig, that every act of muscular contraction involves the death and oxidation of an amount of muscular substance proportional to the force exerted. Hence we are justified in regarding the motion produced by this contraction as an expression of the vital force which is superseded by chemical action, and as holding the same relation to that chemical action which the voltaic current bears to the oxidation of the zinc in the battery. Going further back, we find that the peculiar nitrogenous material of which muscle is composed, though organized by the animal under the agency already explained, is really generated by the plant; and that its production in large amount may be regarded as the highest effort of plant-life, taking place as it does only under the most favourable concurrence of conditions, among which a copious supply of light and heat are especially required. And thus we may say that the nitrogenous constituents of plants embody a high degree of force, which is destined ultimately to manifest itself in the sensible motions of animals. And it is a curious confirmation of this view, that if these substances pass into decomposition without being organized into muscle, they set free a large amount of chemical force; all those "ferments" which have so remarkable a power of exciting chemical changes in other organic compounds, being members of this group.

The highest manifestation of animal life, however, is unquestionably that Nerve-force, by the instrumentality of which our consciousness receives its impressions of phenomena external to it, and our will exerts its power in producing motion through the instrumentality of the muscular apparatus. Regarding the nature of this force there is still some obscurity, but its very close relation to electricity cannot be doubted. Though many most eminent physicists hold that they are identical, we regard the "correlation" doctrine as equally accounting for all those facts which support such a view, whilst it also accords with others which seem opposed to it; and we, therefore, prefer to consider nervous force as belonging to a distinct category. As its source lies, like that of muscular power, in the chemical changes involved in the death and decomposition of the peculiar tissue which manifests it, we trace it back ultimately to the plant which generated the material of the tissue, and thence to the light and heat which that plant received from the sun. Although the most obvious exertion of this force in the living body is that by which it calls forth muscular contraction, yet it can also influence in a very marked manner the processes of nutrition and secretion; so that its correlation with the general organizing force is exhibited (as in the case of electricity and chemical action) on both sides, the nervous substance giving up its characteristic organization whilst developing nerve-force, and that nerve-force being transmitted to a distant part, to be applied there in producing or modifying organization. It is now well known that in the common experiment of exciting muscular contraction by galvanizing a motor nerve, the galvanism does not act directly through the nerve upon the muscle, but excites the nerve-force in that part of the trunk which intervenes between the point irritated and the muscle to which the nerve is distributed; and in like manner, when sensation is called forth by the application of the electric stimulus to the sensory nerve, the effect is produced, not by the transmission of the electric current to the sensorium, but by the excitement of the nerve-force of the part of the trunk which proceeds towards it from the point irritated. And as the converse action to this excitement of nerve-force by electricity, we have the excitement by electricity of nerve-force in the electric fishes and a few other animals. Certain phenomena of animal heat seem to indicate that nerve-force may directly produce elevation of temperature, and there are forms of animal luminosity which do not appear to depend upon an ordinary combustive process, but which rather resemble electric scintillations and seem immediately dependent on an exertion of nerve-force. Further, the peculiar influence of states of the nervous system upon the composition of various secretions can only be explained by supposing that nerve-force has a direct power of modifying chemical action. So that of this, the highest form of vital force, all the material manifestations are of a kind that bring us back again into the region of physics and chemistry.

But there is another aspect under which we have to view nerve-force—that of its relation to mental phenomena. That the excitement of this force in a certain part of our nervous apparatus is capable of producing a change in our state of consciousness, is the only explanation that can be offered of our recipience of Sensations from impressions made upon our organs of sense. So, again, that the state of mental activity which we term the Will, can so excite the nerve-force of the central organs as to occasion its transmission to the muscular apparatus, is the only explanation that can be offered of our power of voluntary motion. These two simple facts seem quite adequate to establish a "correlation" between nerve-force and mental agency, which is not less complete than that which has been shown to exist between nerve-force and electricity; and we are led to the same conclusion by a careful appreciation of the fact, which all physiological knowledge of the conditions of mental activity tends to establish, that this activity, like exertion of muscular force, can only be sustained, as man is at present constituted, at the expense of the death and disintegration of the nervous substance. This idea of "correlation" once started, is found to give a scientific expression to a vast mass of facts demonstrative of the intimate connection between body and mind, which, though accepted as conformable to the universal experience of mankind, have not yet found their place in systematic treatises; since they occupy that "debatable "ground" between metaphysics and physiology which the votaries of each of these sciences, far from wishing to claim it for themselves, are desirous to cede to the dwellers on the other side of the border. Take, for example, the production of temporary insanity by intoxicating agents, on the one hand; the influence of the emotions, not merely on the quantity, but also on the quality, of the secretions, on the other. These are unmistakable phenomena, that have just as great a claim to be examined and accounted for as those of ordinary mental or corporeal activity; and which have yet been passed by, simply because no one has yet been able to suggest any other than a "material" explanation of them.

We shall have greatly failed in our purpose, however, if we have not by this time led our readers to perceive how complete is the distinction between *matter* and *force*, and how close is the relation between *force* and *mind*. Matter is in no case more than the embodiment or instrument of force; all its (so-called) active states being merely the manifestations of an energy, which, under different forms, is unceasingly operative. Nor can it be fairly said, that in substituting the doctrine of force for that of the "imponderables," we are only setting up one hypothetical entity in place of another. Force is truly more of a reality to us than matter itself; for we cannot become cognisant even of the most fundamental property of matter—its occupation of space—without the consciousness of resistance. We cannot, it is true, isolate force from matter; but we have two modes of judging of it—one objective, the other subjective; one based upon observation of external phenomena, the other on the direct revelation of our own consciousness. And we hold it to be by the combination of both sets of considerations that our truest and most definite ideas of dynamical agency are to be attained. We are conscious of the exertion of a power, when we either produce or resist motion; whenever, therefore, we see bodies in motion, we infer that only by a like exertion of power could that motion have originated; so when the retardation of motion gives rise to heat, or heat (in ceasing to manifest itself as such) gives rise to expansive force, we perceive that it is only the manifestation that is changed, the fundamental power remaining the same. And as we are thus led by the "correlation" doctrine to consider the various agencies of nature as the expression of a conscious will, we find the highest science completely according with the highest religion, in directing us to recognize the omnipresent and constantly sustaining energy of a personal Deity in every phenomenon of the universe around us—the pantheistic and anthropomorphic conceptions of His character being thus brought into harmony, when we view "Nature" as the embodiment of the Divine volition, the "forces of Nature" as so many diversified modes of its manifestation, and the "laws of Nature" as nothing but man's expressions of the uniformities which his limited observation can discern in its phenomena.

VI.

MAN THE INTERPRETER OF NATURE.

[Presidential Address at the meeting of the British Association for the Advancement of Science, Brighton, 1872.]

My Lords, Ladies, and Gentlemen,—Thirty-six years have now elapsed since at the first and (I regret to say) the only meeting of this Association held in Bristol—which Ancient city followed immediately upon our national Universities in giving it a welcome—I enjoyed the privilege which I hold it one of the most valuable functions of these annual assemblages to bestow: that of coming into personal relation with those distinguished men whose names are to every cultivator of science as "household words," and the light of whose brilliant example, and the warmth of whose cordial encouragement are the most precious influences by which his own aspirations can be fostered and directed. Under the presidency of the Marquis of Lansdowne, with Conybeare and Prichard as vice-presidents, with Vernon Harcourt as general secretary, and John Phillips as assistant-secretary, were gathered together Whewell and Peacock, James Forbes and Sir W. Rowan Hamilton, Murchison and Sedgwick, Buckland and De la Beche, Henslow and Daubeny, Roget, Richardson, and Edward Forbes, with many others, perhaps not less distinguished, of whom my own recollection is less vivid.

In his honoured old age, Sedgwick still retains, in the academic home of his life, all his pristine interest in whatever bears on the advance of the science he has adorned as well as enriched; and Phillips still cultivates with all his old enthusiasm the congenial soil to which he has been transplanted. But the rest—our fathers and elder brothers—"Where are they?" It is for us of the present generation to show that they live in our lives; to carry forward the work which they commenced; and to transmit the influence of their example to our own successors.

There is one of these great men, whose departure from among us since last we met claims a special notice, and whose life—full as it was of years and honours—we should have all desired to see prolonged for a few months, could its feebleness have been unattended with suffering. For we should all then have sympathized with Murchison, in the delight with which he would have received the intelligence of the safety of the friend in whose scientific labours and personal welfare he felt to the last the keenest interest. That this intelligence, which our own expedition for the relief of Livingstone would have obtained (we will hope) a few months later, should have been brought to us through the generosity of one, and the enterprising ability—may I not use our peculiarly English word, the "pluck"—of another of our American brethren, cannot but be a matter of national regret to us. But let us bury that regret in the common joy which both nations feel in the result; and while we give a cordial welcome to Mr. Stanley, let us glory in the prospect now opening, that England and America will co-operate in that noble object which—far more than the discovery of the sources of the Nile—our great traveller has set before himself as his true mission, the extinction of the slave trade.

At the last meeting of this association, I had the pleasure of being able to announce, that I had received from the First Lord of the Admiralty a favourable reply to a representation I had ventured to make to him, as to the importance of prosecuting on a more extended scale the course of inquiry into the physical and biological conditions of the deep sea, on which, with my colleagues Professor Wyville Thomson and Mr. J. Gwyn Jeffreys, I had been engaged for the three preceding years. That for which I had asked was a circumnavigating expedition of at least three years' duration, provided with an adequate scientific staff, and with the most complete equipment that our experience could devise. The Council of the Royal Society having been led by the encouraging tenor of the answer I had received, to make a formal application to this effect, the liberal arrangements of the Government have been carried out under the advice of a scientific Committee, which included representatives of this Association. Her Majesty's ship *Challenger*, a vessel in every way suitable for the purpose, is now being fitted out at Sheerness; the command of the expedition is intrusted to Captain Nares, an officer of whose high qualifications I have myself the fullest assurance; while the scientific charge of it will be taken by my excellent friend Professor Wyville Thomson, at whose suggestion it was that these investigations were originally commenced, and whose zeal for the efficient prosecution of them is shown by his relinquishment for a time of the important academic position he at present fills. It is anticipated that the expedition will sail in November next; and I feel sure that the good wishes of all of you will go along with it.

The confident anticipation expressed by my predecessor, that for the utilization of the total eclipse of the sun then impending, our Government would "exercise the same wise liberality as "heretofore in the interests of science," has been amply fulfilled. An eclipse-expedition to India was organized at the charge of the Home Government, and placed under the direction of Mr. Lockyer; the Indian Government contributed its quota to the work; and a most valuable body of results was obtained, of which, with those of the previous year, a report is now being prepared under the direction of the Council of the Astronomical Society.

It has been customary with successive occupants of this chair, distinguished as leaders in their several divisions of the noble army of science, to open the proceedings of the meetings over which they respectively presided, with a discourse on some aspect of Nature in her relation to man. But I am not aware that any one of them has taken up the other side of the inquiry—that which concerns man as the "Interpreter of Nature;" and I have therefore thought it not inappropriate to lead you to the consideration of the mental processes, by which are formed those fundamental conceptions of matter and force, of cause and effect, of law and order, which furnish the basis of all scientific reasoning, and constitute the *Philosophia prima* of Bacon. There is a great deal of what I cannot but regard as fallacious and misleading philosophy—"oppositions of science falsely so called"—abroad in the world at the present time. And I hope to satisfy you, that those who set up *their own conceptions* of the orderly sequence which they discern in the phenomena of Nature, as fixed and determinate *Laws*, by which those phenomena not only *are* within all human experience, but always *have been*, and always *must be*, invariably governed, are really guilty of the intellectual arrogance they condemn in the systems of the ancients, and place themselves in diametrical antagonism to those real philosophers, by whose comprehensive grasp and penetrating insight that order has been so far disclosed. For what love of the truth as it is in Nature was ever more conspicuous, than that which Kepler displayed, in his abandonment of each of the ingenious conceptions of the planetary system which his fertile imagination had successively devised, so soon as it proved to be inconsistent with the facts disclosed by observation? In that almost admiring description of the way in which his enemy Mars, "whom he had left at home a despised "captive," had "burst all the chains of the equations, and broke "forth from the prisons of the tables," who does not recognize the justice of Schiller's definition of the real philosopher, as one who always loves truth better than his system? And when at last he had gained the full assurance of a success so complete that (as he says) he thought he must be dreaming, or that he had been reasoning in a circle, who does not feel the almost sublimity of the self-abnegation, with which, after attaining what was in his own estimation such a glorious reward of his life of toil, disappointment, and self-sacrifice, he abstains from claiming the applause of his contemporaries, but leaves his fame to after-ages in these noble words: "The book is written; to be read either now or by "posterity, I care not which. It may well wait a century for a "reader, as God has waited six thousand years for an observer."

And when a greater than Kepler was bringing to its final issue that grandest of all scientific conceptions, long pondered over by his almost superhuman intellect—which linked together the heavens and the earth, the planets and the sun, the primaries and their satellites, and included even the vagrant comets, in the *nexus* of a universal attraction—establishing for all time the truth for whose utterance Galileo had been condemned, and giving to Kepler's laws a significance of which their author had never dreamed,—what was the meaning of that agitation which prevented the philosopher from completing his computation, and compelled him to hand it over to his friend? That it was not the thought of his own greatness, but the glimpse of the grand universal order thus revealed to his mental vision, which shook the serene and massive soul of Newton to its foundations, we have the proof in that beautiful comparison in which he likened himself to a child picking up shells on the shore of the vast ocean of truth—a comparison which will be evidence to all time at once of his true philosophy and of his profound humility.

Though it is with the intellectual representation of Nature which we call *science* that we are primarily concerned, it will not be without its use to cast a glance in the first instance at the other two principal characters under which man acts as her interpreter —those, namely, of the artist and of the poet.

The Artist serves as the interpreter of Nature, not when he works as the mere copyist, delineating that which he sees with his bodily eyes, and which we could see as well for ourselves; but when he endeavours to awaken within us the perception of those beauties and harmonies which his own trained sense has recognized, and thus impart to us the pleasure he has himself derived from their contemplation. As no two artists agree in the original constitution and acquired habits of their minds, all look at Nature with different (mental) eyes; so that to each, *Nature is what he individually sees in her.*

The Poet, again, serves as the interpreter of Nature, not so much when by skilful word-painting (whether in prose or verse) he calls up before our mental vision the picture of some actual or ideal scene, however beautiful; as when, by rendering into appropriate forms those deeper impressions made by the nature around him on the moral and emotional part of his own nature, he transfers these impressions to the corresponding part of ours. For it is the attribute of the true poet to penetrate the secret of those mysterious influences which we all unknowingly experience; and having discovered this to himself, to bring others, by the power he thus wields, into the like sympathetic relation with Nature—evoking with skilful touch the varied response of the soul's finest chords, heightening its joys, assuaging its griefs, and elevating its aspirations. Whilst, then, the artist aims to picture what he *sees* in Nature, it is the object of the poet to represent what he *feels* in Nature; and to each true poet, *Nature is what he individually finds in her.*

The Philosopher's interpretation of Nature *seems* less individual than that of the artist or the poet, because it is based on facts which any one may verify, and is elaborated by reasoning processes of which all admit the validity. He looks at the universe as a vast book lying open before him, of which he has in the first place to learn the characters, then to master the language, and finally to apprehend the ideas which that language conveys. In that book there are many chapters, treating of different subjects; and as life is too short for any one man to grasp the whole, the scientific interpretation of this book comes to be the work of many intellects, differing, not merely in the range, but also in the character of their powers. But whilst there are "diversities of gifts," there is "the same spirit." While each takes his special direction, the general method of study is the same for all. And it is a testimony alike to the truth of that method and to the unity of Nature, that there is an ever-increasing tendency towards agreement among those who use it aright—temporary differences of interpretation being removed, sometimes by a more complete mastery of her language, sometimes by a better apprehension of her ideas—and lines of pursuit which had seemed entirely distinct or even widely divergent, being found to lead at last to one common goal. And it is this agreement which gives rise to the general belief—in many, to the confident assurance—that the scientific interpretation of Nature represents her, not merely as she *seems*, but as she *really is.*

But when we carefully examine the foundation of that assurance, we find reason to distrust its security; for it can be shown to be no less true of the scientific conception of Nature, than it is of the artistic or the poetic, that it is *a representation framed by the mind itself* out of the materials supplied by the impressions which external objects make upon the senses; so that to each man of science, *Nature is what he individually believes her to be.* And that belief will rest on very different bases, and will have very unequal values, in different departments of science. Thus in what are commonly known as the "exact" sciences, of which astronomy may be taken as the type, the data afforded by precise methods of observation can be made the basis of reasoning, in every step of which the mathematician feels the fullest assurance of certainty; and the final deduction is justified either by its conformity to known or ascertainable facts—as when Kepler determined the elliptic orbit of Mars; or by the fulfilment of the predictions it has sanctioned—as in the occurrence of an eclipse or an occultation at the precise moment specified many years previously; or, still more emphatically, by the actual discovery of phenomena till then unrecognized—as when the perturbations of the planets, shown by Newton to be the necessary results of their mutual attraction, were proved by observation to have a real existence; or as when the unknown disturber of Uranus was found in the place assigned to him by the computations of Adams and Le Verrier.

We are accustomed, and I think most rightly, to speak of these achievements as triumphs of the human intellect. But the very phrase implies that the work is done by mental agency. And even in the very first stage of the process—*the interpretation of observations*—there is often a liability to serious error. Of this we have a most noteworthy example in the fact that the estimated distance of the earth from the sun, deduced from observations of the last transit of Venus, is now pretty certainly known to be about three millions of miles too great; the strong indications of such an excess afforded by the nearly coincident results of other modes of inquiry having led to a re-examination of the record, which was found, when fairly interpreted, fully to *justify*—if not even to require—the reduction. Even the verification of the prediction is far from proving the intellectual process by which it was made to have been correct. For we learn from the honest confessions of Kepler, that he was led to the discovery of the elliptic orbit of Mars by a series of happy accidents, which turned his erroneous guesses into the right direction; and to that of the passage of the radius vector over *equal areas in equal times*, by the notion of a whirling force emanating from the sun, which we now regard as an entirely wrong conception of the cause of orbital revolution.* It should always

* See Drinkwater's "Life of Kepler," in the Library of Useful Knowledge, pp. 26–35.

be remembered, moreover, that the Ptolemaic system of astronomy, with all its cumbrous ideal mechanism of "centric and excentric, "cycle and epicycle, orb in orb," did intellectually represent all that the astronomer, prior to the invention of the telescope, could see from his actual standpoint, the earth, with an accuracy which was proved by the fulfilment of his predictions. And in that last and most memorable anticipation which has given an imperishable fame to our two illustrious contemporaries, the inadequacy of the basis afforded by actual observation of the perturbations of Uranus, required that it should be supplemented by an assumption of the probable distance of the disturbing planet beyond, which has been shown by subsequent observation to have been only an approximation to the truth.

Even in this most exact of sciences, therefore, we cannot proceed a step, without translating the actual phenomena of Nature into intellectual representations of those phenomena; and it is because the Newtonian conception is not only the most simple, but is also, up to the extent of our present knowledge, *universal* in its conformity to the facts of observation, that we accept it as the only scheme of the universe yet promulgated, which satisfies our intellectual requirements.

When, under the reign of the Ptolemaic system, any new inequality was discovered in the motion of a planet, a new wheel had to be added to the ideal mechanism, as Ptolemy said, "to "save appearances." If it should prove, a century hence, that the motion of Neptune himself is disturbed by some other attraction than that exerted by the interior planets, we should confidently expect that not an *ideal* but a *real* cause for that disturbance will be found in the existence of another planet beyond. But I trust that I have now made it evident to you, that this confident expectation is not justified by any absolute necessity of Nature, but arises entirely out of *our belief* in her uniformity; and into the grounds of this and other primary beliefs, which serve as the foundation of all scientific reasoning, we shall presently inquire.

There is another class of cases, in which an equal certainty is generally claimed for conclusions that seem to flow immediately from observed facts, though really evolved by intellectual processes; the apparent simplicity and directness of those processes either causing them to be entirely overlooked, or veiling the assumptions on which they are based. Thus Mr. Lockyer speaks as confidently of the sun's chromosphere of incandescent hydrogen, and of the local outbursts which cause it to send forth projections tens of thousands of miles high, as if he had been able to capture a flask of this gas, and had generated water by causing it to unite with oxygen. Yet this confidence is entirely based on the assumption, that a certain line which is seen in the spectrum of a hydrogen flame, *means* hydrogen also when seen in the spectrum of the sun's chromosphere; and high as is the probability of that assumption, it cannot be regarded as a demonstrated certainty, since it is by no means inconceivable that the same line *might* be produced by *some other* substance at present unknown. And so when Dr. Huggins deduces from the different relative positions of certain lines in the spectra of different stars, that these stars are moving from or towards us in space, his admirable train of reasoning is based on the assumption that these lines have *the same meaning*—that is, that they *represent the same elements*—in every luminary. That assumption, like the preceding, may be regarded as possessing a sufficiently high probability to justify the reasoning based upon it; more especially since, by the other researches of that excellent observer, the same chemical elements have been detected as vapours in those filmy cloudlets which seem to be stars in an early stage of consolidation. But when Frankland and Lockyer, seeing in the spectrum of the yellow solar prominences a certain bright line not identifiable with that of any known terrestrial flame, attribute this to a hypothetical new substance which they propose to call Helium, it is obvious that their assumption rests on a far less secure foundation; until it shall have received that verification, which, in the case of Mr. Crookes's researches on Thallium, was afforded by the actual discovery of the new metal, whose presence had been indicated to him by a line in the spectrum not attributable to any substance then known.

In a large number of other cases, moreover, our scientific interpretations are clearly matters of *judgment;* and this is eminently a *personal act*, the value of its results depending in each case upon the qualifications of the *individual* for arriving at a correct decision.

The surest of such judgments are those dictated by what we term "common sense," as to matters on which there seems no room for difference of opinion, because every sane person comes to the same conclusion, although he may be able to give no other reason for it than that it appears to him "self-evident." Thus while philosophers have raised a thick cloud of dust in the discussion of the basis of our belief in the existence of a world external to ourselves—of the Non-Ego, as distinct from the Ego—and while every logician claims to have found some flaw in the proof advanced by every other—the common sense of mankind has arrived at a decision that is practically worth all the arguments of all the philosophers who have fought again and again over this battle-ground. And I think it can be shown that the trustworthiness of this common sense decision arises from its dependence, not on any one set of experience, but upon *our unconscious co-ordination of the whole aggregate of our experiences*—not on the conclusiveness of any one train of reasoning, but on *the convergence of all our lines of thought towards this one centre.*

Now this "common sense," disciplined and enlarged by appropriate culture, becomes one of our most valuable instruments of scientific inquiry; affording in many instances the best, and sometimes the only, basis for a rational conclusion. Let us take as a typical case, in which no special knowledge is required, what we are accustomed to call the "flint implements" of the Abbeville and Amiens gravel-beds. No logical proof can be adduced that the peculiar shapes of these flints were given to them by human hands; but does any unprejudiced person now doubt it? The evidence of *design*, to which, after an examination of one or two such specimens, we should only be justified in attaching a probable value, derives an irresistible cogency from accumulation. On the other hand, the *im*probability that these flints acquired their peculiar shape by *accident*, becomes to our minds greater and greater as more and more such specimens are found; until at last this hypothesis, although it cannot be directly disproved, is felt to be almost inconceivable, except by minds previously "possessed" by the "dominant idea" of the modern origin of man. And thus what was in the first instance a matter of discussion, has now become one of those "self-evident" propositions, which claim the unhesitating assent of all whose opinion on the subject is entitled to the least weight.

We proceed upward, however, from such questions as the common sense of mankind generally is competent to decide, to those in which special knowledge is required to give value to the judgment; and thus the interpretation of Nature by the use of that faculty comes to be more and more *individual;* things being perfectly "self-evident" to men of special culture, which ordinary men, or men whose training has lain in a different direction, do not apprehend as such. Of all departments of science, geology seems to me to be the one that most depends on this specially-trained "common sense;" which brings as it were into one focus the light afforded by a great variety of studies—physical and chemical, geographical and biological; and throws it on the pages of that great stone book, on which the past history of our globe is recorded. And whilst astronomy is of all sciences that which may be considered as most nearly representing Nature as she really is, geology is that which most completely represents her as seen through the medium of the interpreting mind; the meaning of the phenomena that constitute its data being in almost every instance open to question, and the judgments passed upon the same facts being often different according to the qualifications of the several judges. No one who has even a general acquaintance with the history of this department of science can fail to see that the geology of each epoch has been the reflection of the minds by which its study was then directed; and that its true progress dates from the time when that "common sense" method of interpretation came to be *generally* adopted, which consists in seeking the explanation of past changes in the forces at present in operation, instead of invoking the aid of extraordinary and mysterious agencies, as the older geologists were wont to do, whenever they wanted—like the Ptolemaic astronomers—"to save appearances." The whole tendency of the ever-widening range of modern geological inquiry has been to show how little reliance can be placed upon the so-called "laws" of stratigraphical and palæontological succession, and how much allowance has to be made for local conditions. So that while the astronomer is constantly enabled to point to the fulfilment of his predictions as an evidence of the correctness of his method, the geologist is almost entirely destitute of any such means of verification. For the value of any prediction that he may hazard—as in regard to the existence or non-existence of coal in any given area—depends not only upon the truth of the general doctrines of geology in regard to the succession of stratified deposits, but still more upon the detailed knowledge which he may have acquired of the distribution of those deposits in the particular locality. Hence no reasonably-judging man would discredit either the general doctrines or the methods of geology, because the prediction proves untrue in such a case as that now about to be brought in this neighbourhood to the trial of experience.

We have thus considered man's function as the scientific interpreter of Nature in two departments of natural knowledge; one of which affords an example of the strictest, and the other of the freest method, which man can employ in constructing his intellectual representation of the universe. And as it would be found that in the study of all other departments the same methods are used, either separately or in combination, we may pass at once to another part of our inquiry.

The whole fabric of geometry rests upon certain axioms which every one accepts as true, but of which it is necessary that the truth should be *assumed*, because they are incapable of demonstration. So, too, the deliverances of our "common sense" derive their trustworthiness from what we consider the "self-evidence" of the propositions affirmed. There are, then, certain primary beliefs, which constitute the groundwork of all scientific reasoning; and we have next to inquire into their origin.

This inquiry brings us face to face with one of the great philosophical problems of our day, which has been discussed by logicians and metaphysicans of the very highest ability as leaders of opposing schools, with the one result of showing how much can be said on each side. By the *intuitionalists*, it is asserted that the tendency to form these primary beliefs is inborn in man, an original part of his mental organization; so that they grow up spontaneously in his mind as its faculties are gradually unfolded and developed, requiring no other experience for their genesis, than that which suffices to call these faculties into exercise. But by the advocates of the doctrine which regards *experience* as the basis of all our knowledge, it is maintained that the primary beliefs of each individual are nothing else than generalizations which he forms of such experiences as he has either himself acquired or has consciously learned from others; and they deny that there is any original or intuitive tendency to the formation of such beliefs, beyond that which consists in the power of retaining and generalizing experiences.

I have not introduced this subject with any idea of placing before you even a summary of the ingenious arguments by which these opposing doctrines have been respectively supported; nor should I have touched on the question at all, if I did not believe that a means of reconcilement between them can be found in the idea, that the *intellectual intuitions of any one generation are the embodied experiences of the previous race.* For, as it appears to me, there has been a progressive improvement in the *thinking power* of man; every product of the culture which has preceded serving to prepare the soil for yet more abundant harvests in the future.

Now, as there can be no doubt of the hereditary transmission in man of acquired constitutional peculiarities, which manifest themselves alike in tendencies to bodily and to mental disease, so it seems equally certain that *acquired mental habitudes* often impress themselves on his organization, with sufficient force and permanence to occasion their transmission to the offspring as *tendencies to similar modes of thought.* And thus, while all admit that *knowledge* cannot thus descend from one generation to another, an increased *aptitude* for the acquirement, either of knowledge generally, or of some particular kind of it, may be thus inherited. These tendencies and aptitudes will acquire additional strength, expansion, and permanence, in each new generation, from their habitual exercise upon the materials supplied by a continually enlarged experience; and thus the *acquired* habitudes produced by the intellectual culture of ages, will become a "second nature" to every one who inherits them.*

* This doctrine was first explicitly put forth by Mr. Herbert Spencer; in whose philosophical treatises it will be found most ably developed. I am glad to be able to append the following extract from a letter which Mr. John Mill, the great master of the experiential school, was good enough to write to me a few months since, with reference to the attempt I had made to place

We have an illustration of this progress in the fact of continual occurrence, that conceptions which prove inadmissible to the minds of one generation, in consequence either of their want of intellectual power to apprehend them, or of their preoccupation by older habits of thought, subsequently find a universal acceptance, and even come to be approved as "self-evident." Thus the first law of motion, divined by the genius of Newton, though opposed by many philosophers of his time as contrary to all experience, is now accepted by common consent, not merely as a legitimate inference from experiment, but as the expression of a necessary and universal truth; and the same axiomatic value is extended to the still more general doctrine, that energy of *any* kind, whether manifested in the "molar" motion of masses, or consisting in the "molecular" motions of atoms, *must* continue under some form or other without abatement or decay; what all admit in regard to the indestructibility of matter, being accepted as no less true of force, namely, that as *ex nihilo nil fit*, so *nil fit ad nihilum*.*

But, it may be urged, the very conception of these and similar great truths is in itself a typical example of intuition. The men who divined and enunciated them stand out above their fellows, as possessed of a genius which could not only combine but create, of an insight which could clearly discern what reason could but dimly shadow forth. Granting this freely, I think it may be shown that the intuitions of individual genius are but specially exalted forms of endowments which are the general property of the race

"common sense" upon this basis (*Contemporary Review*, February, 1872):— "When states of mind in no respect innate or instinctive have been frequently "repeated, the mind acquires, as is proved by the power of habit, a greatly "increased facility of passing into those states; and this increased facility must "be owing to some change of a physical character in the organic action of the "brain. There is also considerable evidence that such acquired facilities of "passing into certain modes of cerebral action can, in many cases, be trans-"mitted, more or less completely, by inheritance. The limits of this power "of transmission, and the conditions on which it depends, are a subject now "fairly before the scientific world; and we shall doubtless in time know much "more about them than we do now. But so far as my imperfect knowledge "of the subject qualifies me to have an opinion, I take much the same view of "it that you do, at least in principle."

* This is the form in which the doctrine now known as that of the "Conservation of Energy" was enunciated by Dr. Mayer, in the very remarkable essay published by him in 1845, entitled, "Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel."

at the time, and which have come to be so in virtue of its whole previous culture. Who, for example, could refuse to the marvellous aptitude for perceiving the relations of numbers, which displayed itself in the untutored boyhood of George Bidder and Zerah Colburn, the title of an intuitive gift? But who, on the other hand, can believe that a Bidder or a Colburn could suddenly arise in a race of savages who cannot count beyond five? Or, again, in the history of the very earliest years of Mozart, who can fail to recognize the dawn of that glorious genius, whose brilliant but brief career left its imperishable impress on the art it enriched? But who would be bold enough to affirm that an infant Mozart could be born amongst a tribe, whose only musical instrument is a tom-tom, whose only song is a monotonous chant?

Again, by tracing the gradual *genesis* of some of those ideas which we now accept as "self-evident,"—such, for example, as that of the "uniformity of Nature"—we are able to recognize them as the expressions of certain intellectual tendencies, which have progressively augmented in force in successive generations, and now manifest themselves as acquired mental instincts that penetrate and direct our ordinary course of thought. Such instincts constitute a precious heritage, which has been transmitted to us with ever-increasing value through the long succession of preceding generations; and which it is for us to transmit to those who shall come after us, with all that further increase which our higher culture and wider range of knowledge can impart.

And now, having studied the working action of the human intellect in the scientific interpretation of Nature, we shall examine the general character of its products; and the first of these with which we shall deal is our conception of *matter* and of its relation to *force*.

The psychologist of the present day views matter entirely through the light of his own consciousness: his idea of matter in the abstract being that it is a "something" which has a permanent power of exciting sensations; his idea of any "property" of matter being the mental representation of some kind of sensory impression he has received from it; and his idea of any particular kind of matter being the representation of the whole aggregate of the sense-perceptions which its presence has called up in his mind. Thus when I press my hand against this table, I recognize its unyieldingness through the conjoint medium of my sense of touch, my muscular sense, and my mental sense of effort, to which it will be convenient to give the general designation of the tactile sense; and I attribute to that table a *hardness* which resists the effort I make to press my hand into its substance, whilst I also recognize the fact that the force I have employed is not sufficient to move its mass. But I press my hand against a lump of dough; and finding that its substance yields under my pressure, I call it *soft.* Or again, I press my hand against this desk; and I find that although I do not thereby change its *form*, I change its *place;* and so I get the tactile idea of *motion.* Again, by the impressions received through the same sensorial apparatus, when I lift this book in my hand, I am led to attach to it the notion of *weight* or ponderosity; and by lifting different solids of about the same size, I am enabled, by the different degrees of exertion I find myself obliged to make in order to sustain them, to distinguish some of them as *light*, and others as *heavy.* Through the medium of another set of sense-perceptions which some regard as belonging to a different category, we distinguish between bodies that *feel* "hot" and those that *feel* "cold;" and in this manner we arrive at the notion of differences of temperature. And it is through the medium of our tactile sense, without any aid from vision, that we first gain the idea of *solid form*, or the three dimensions of space.

Again, by the extension of our tactile experiences, we acquire the notion of *liquids*, as forms of matter yielding readily to pressure, but possessing a sensible weight which may equal that of solids: and of *air*, whose resisting power is much slighter, and whose weight is so small that it can only be made sensible by artificial means. Thus, then, we arrive at the notions of *resistance* and of *weight* as properties common to all forms of matter; and now that we have got rid of that idea of light and heat, electricity and magnetism, as "imponderable fluids," which used to vex our souls in our scientific childhood, and of which the popular term "electric fluid" is a "survival," we accept these properties as affording the practical distinction between the "material" and the "immaterial."

Turning, now, to that other great portal of sensation, the sight, through which we receive most of the messages sent to us from the universe around, we recognize the same truth. Thus it is agreed alike by physicists and physiologists, that *colour* does not exist *as such* in the object itself; which has merely the power of reflecting or transmitting a certain number of millions of undulations in a second; and these only produce that affection of our consciousness which we call colour, when they fall upon the retina of the living percipient. And if there be that defect either in the retina or in the apparatus behind it, which we call "colour-blindness" or Daltonism, some particular hues cannot be distinguished, or there may even be no power of distinguishing any colour whatever. If we were all like Dalton, we should see no difference, except in form, between ripe cherries hanging on a tree, and the green leaves around them: if we were all affected with the severest form of colour-blindness, the fair face of Nature would be seen by us as in the chiaroscuro of an engraving of one of Turner's landscapes, not as in the glowing hues of the wondrous picture itself. And in regard to our visual conceptions it may be stated with perfect certainty, as the result of very numerous observations made upon persons who have acquired sight for the first time, that these do *not* serve for the recognition even of those objects with which the individual had become most familiar through the touch, until the two sets of sense-perceptions have been co-ordinated by experience.*

When once this co-ordination has been effected, however, the composite perception of form which we derive from the visual sense alone is so complete, that we seldom require to fall back upon the touch for any further information respecting that quality of the object.—So, again, while it is from the co-ordination of the two dissimilar pictures formed by any solid or projecting object upon our two retinæ, that (as Sir Charles Wheatstone's admirable investigations have shown) we ordinarily derive through the sight

* Thus, in a recently recorded case in which sight was imparted by operation to a young woman who had been blind from birth, but who had nevertheless learned to work well with her needle, when the pair of scissors she had been accustomed to use was placed before her, though she described their shape, colour, and glistening metallic character, she was utterly unable to recognize them *as scissors* until she put her finger on them, when she at once named them, laughing at her own stupidity (as she called it) in not having made them out before.

alone a correct notion of its *solid* form, there is adequate evidence that this notion, also, is a mental *judgment* based on the experience we have acquired in early infancy by the consentaneous exercise of the visual and tactile senses.

Take, again, the case of those wonderful instruments by which our visual range is extended almost into the infinity of space, or into the infinity of minuteness. It is the mental not the bodily eye, that takes cognizance of what the telescope and microscope reveal to us. For we should have no well-grounded confidence in their revelations as to the *unknown*, if we had not first acquired experience in distinguishing the true from the false by applying them to *known* objects; and every interpretation of what we see through their instrumentality is a *mental judgment* as to the probable form, size, and movement of bodies removed by either their distance or their minuteness from being cognosced by our tactile sense.

The case is still stronger in regard to that last addition to our scientific *armamentum*, which promises to be not inferior in value either to the telescope or the microscope; for it may be truly said of the spectroscope, that it has not merely extended the range of our vision, but has almost given us a new sense, by enabling us to recognize distinctive properties in the chemical elements which were previously quite unknown. And who shall now say that we know all that is to be known as to any form of matter; or that the science of the *fourth* quarter of this century may not furnish us with as great an enlargement of our knowledge of its properties, and of our power of recognizing them, as that of its *third* has done?

But, it may be said, is not this view of the material universe open to the imputation that it is "evolved out of the depths of our own consciousness"—a projection of our own intellect into what surrounds us—an *ideal* rather than a *real* world? If all we know of matter be an "intellectual conception," how are we to distinguish this from such as we form in our dreams?—for these, as our Laureate no less happily than philosophically expresses it, are "true while they last." Here our "common sense" comes to the rescue. We "awake, and behold it was a dream." Every healthy mind is conscious of the difference between its waking and its dreaming experiences; or, if it is now and then puzzled to answer the question, "Did this really happen, or did I dream it?" the perplexity arises from the consciousness that it *might* have happened. And every healthy mind, finding its own experiences of its waking state not only self-consistent, but consistent with the experiences of others, accepts them as the basis of its beliefs, in preference to even the most vivid recollections of its dreams.

The lunatic pauper who regards himself as a king, the asylum in which he is confined as a palace of regal splendour, and his keepers as obsequious attendants, is so "possessed" by the conception framed by his disordered intellect, that he *does* project it out of himself into his surroundings; his refusal to admit the corrective teaching of common sense being the very essence of his malady. And there are not a few persons abroad in the world, who equally resist the teachings of educated common sense, whenever they run counter to their own preconceptions; and who may be regarded as—in so far—affected with what I once heard Mr. Carlyle pithily characterize as a "diluted insanity."

It has been asserted, over and over again, of late years, by a class of men who claim to be the only true interpreters of Nature, that we know nothing but matter and the laws of matter, and that force is a mere fiction of the imagination. May it not be affirmed, on the other hand, that while our notion of *matter* is a conception of the intellect, *force* is that of which we have the *most* direct—perhaps even the *only* direct—cognizance? As I have already shown you, the knowledge of resistance and of weight which we gain through our tactile sense is derived from our own perception of *exertion;* and in vision, as in hearing, it is the force with which the undulations strike the sensitive surface that affects our consciousness with sights or sounds. True it is that in our visual and auditory sensations, we do not, as in our tactile, *directly* cognosce the force which produces them; but the physicist has no difficulty in making sensible to us indirectly the undulations by which sound is propagated, and in proving to our intellect that the force concerned in the transmission of light is really enormous.*

* See Sir John Herschel's "Familiar Lectures on Scientific Subjects."

It seems strange that those who make the loudest appeal to experience as the basis of all knowledge, should thus disregard the most constant, the most fundamental, the most direct of all experiences; as to which the common sense of mankind affords a guiding light much clearer than any that can be seen through the dust of philosophical discussion. For, as Sir John Herschel most truly remarked, the universal consciousness of mankind is as much in accord in regard to the existence of a real and intimate connection between cause and effect, as it is in regard to the existence of the external world; and that consciousness arises to every one out of his own sense of *personal* exertion in the origination of changes by his individual agency.

Now while fully accepting the logical definition of cause as the "antecedent or concurrence of antecedents on which the "effect is invariably and unconditionally consequent," we can always single out one *dynamical* antecedent—the power which does the work—from the aggregate of *material conditions* under which that power may be distributed and applied. No doubt the term cause is very loosely employed in popular phraseology; often (as Mr. Mill has shown) to designate the occurrence that immediately preceded the effect;—as when it is said that the spark which falls into a barrel of gunpowder is the cause of its explosion, or that the slipping of a man's foot off the rung of a ladder is the cause of his fall. But even a very slightly trained intelligence can distinguish the power which acts in each case, from the conditions under which it acts. The force which produces the explosion is locked up (as it were) in the powder; and ignition merely liberates it, by bringing about new chemical combinations. The fall of the man from the ladder is due to the gravity which was equally pulling him down while he rested on it; and the loss of support, either by the slipping of his foot, or by the breaking of the rung, is merely that change in the material conditions which gives the power a new action.

Many of you have doubtless viewed with admiring interest that truly wonderful work of human design, the Walter printing-machine. You first examine it at rest; presently comes a man, who simply pulls a handle towards him; and the whole inert mechanism becomes instinct with life,—the continuous sheet of four miles of blank paper which rolls off the cylinder at one end, being delivered at the other, without any intermediate human agency, as separate *Times* newspapers, at the rate of 15,000 an hour. Now what is the *cause* of this most marvellous effect? Surely it lies essentially in the power or force which the pulling of the handle brought to bear on the machine from some extraneous source of power,—which we in this instance know to be a steam-engine on the other side of the wall. This force it is, which, distributed through the various parts of the mechanism, really performs the action of which each is the instrument; *they* only supply the vehicle for its transmission and application. The man comes again, pushes the handle in the opposite direction, detaches the machine from the steam-engine, and the whole comes to a stand; and so it remains, like an inanimate corpse, until recalled to activity by the renewal of its moving power.

But, say the reasoners who deny that force is anything else than a fiction of the imagination, the revolving shaft of the steam-engine is "matter in motion;" and when the connection is established between that shaft and the one that drives the machine, the *motion* is communicated from the former to the latter, and thence distributed to the several parts of the mechanism. This account of the operation is just what an observer might give, who had looked on with entire ignorance of everything but what his *eyes* could *see;* the moment he puts his *hand* upon any part of the machinery, and tries to stop its motion, he takes as direct cognizance, through his *feeling* of the effort required to resist it, of the *force* which produces that motion, as he does through his *eye* of the motion itself.

Now since it is universally admitted that our notion of the external world would be not only incomplete, but erroneous, if our visual perceptions were not supplemented by our tactile, so, as it seems to me, our interpretation of the phenomena of the universe must be very inadequate, if we do not mentally co-ordinate the idea of force with that of motion, and recognize it as the "efficient cause" of those phenomena,—the "material conditions" constituting (to use the old scholastic term) only "their "formal cause." And I lay the greater stress on this point, because the mechanical philosophy of the present day tends more and more to express itself in terms of *motion* rather than in terms of *force*;—to become *kinetics* instead of *dynamics*.

Thus from whatever side we look at this question,—whether the common sense of mankind, the logical analysis of the relation between cause and effect, or the study of the working of our own intellects in the interpretation of Nature,—we seem led to the same conclusion; that the notion of *force* is one of those elementary forms of thought with which we can no more dispense, than we can with the notion of space or of succession. And I shall now, in the last place, endeavour to show you that it is the substitution of the dynamical for the mere phenomenal idea, which gives their highest value to our conceptions of that order of Nature, which is worshipped as itself a god by the class of interpreters whose doctrine I call in question.

The most illustrative as well as the most illustrious example of the difference between the mere generalization of phenomena and the dynamical conception that applies to them, is furnished by the contrast between the so-called laws of planetary motion discovered by the persevering ingenuity of Kepler, and the interpretation of that motion given us by the profound insight of Newton. Kepler's three laws were nothing more than comprehensive statements of certain groups of phenomena determined by observation. The *first*, that of the revolution of the planets in elliptical orbits, was based on the study of the observed places of Mars alone; it might or might not be true of the other planets; for, so far as Kepler knew, there was no reason why the orbits of some of them might not be the excentric circles which he had first supposed that of Mars to be. So Kepler's *second* law of the passage of the radius vector over equal areas in equal times, so long as it was simply a generalization of facts in the case of that one planet, carried with it no *reason* for its applicability to other cases, except that which it might derive from his erroneous conception of a whirling force. And his *third* law was in like manner simply an expression of a certain harmonic relation which he had discovered between the times and the distances of the planets, having no more *rational* value than any other of his numerous hypotheses.

Now the Newtonian "laws" are often spoken of as if they were merely *higher generalizations* in which Kepler's are included; to me they seem to possess an altogether different character. For starting with the conception of two *forces*, one of them tending to produce continuous uniform motion in a straight line, the other tending to produce a uniformly accelerated motion towards a fixed point, Newton's wonderful mastery of geometrical reasoning enabled him to show that, if these *dynamical* assumptions be granted, Kepler's *phenomenal* "laws," being necessary consequences of them, must be *universally* true. And while that demonstration would have been alone sufficient to give him an imperishable renown, it was his still greater glory to divine that the fall of the moon towards the earth—that is, the deflection of her path from a tangential line to an ellipse—*is a phenomenon of the same order* as the fall of a stone to the ground; and thus to show the applicability to the entire universe, of those simple dynamical conceptions which constitute the basis of the geometry of the Principia.

Thus, then, whilst no "law" which is simply a *generalization of phenomena* can be considered as having any *coercive* action, we may assign that value to laws which express *the universal conditions of the action of a force* whose existence we learn from the testimony of our own consciousness. The assurance we feel that the attraction of gravitation *must* act under all circumstances according to those simple laws which arise immediately out of our dynamical conception of it, is of a very different order from that which we have in regard (for example) to the laws of chemical attraction, which are as yet only generalizations of phenomena. And yet even in that strong assurance, we are required by our examination of the basis on which it rests, to admit a *reserve* of the *possibility* of something different; a reserve which we may well believe that Newton himself must have entertained.

A most valuable lesson as to the allowance we ought always to make for the unknown "possibilities of Nature," is taught us by an exceptional phenomenon so familiar that it does not attract the notice it has a right to claim. Next to the law of the universal attraction of masses of matter, there is none that seems to have a wider range than that of the *expansion of bodies by heat and their contraction by cold.* Excluding water and one or two other substances, the fact of such expansion might be said to be *invariable;* and, as regards bodies whose gaseous condition is known, the law of expansion can be stated in a form no less simple and definite than the law of gravitation. Supposing those exceptions, then, to be unknown, the law would be *universal* in its range. But it comes to be discovered that water, whilst conforming to it in its expansion from $39\frac{1}{2}°$ *upwards* to its boiling-point, as also, when it passes into steam, to the special law of expansion of vapours, is exceptional in *expanding* also from $39\frac{1}{2}°$ *downwards* to its freezing-point; and of this failure in the universality of the law, no rationale can be given. Still more strange is it, that by dissolving a little *salt* in water, we should remove this exceptional peculiarity; for *sea*-water continues to contract from $39\frac{1}{2}°$ downwards to its freezing-point 12° or 14° lower, just as it does with reduction of temperature at higher ranges.

Thus from our study of the mode in which we arrive at those conceptions of the orderly sequence observable in the phenomena of Nature which we call "laws," we are led to the conclusion that they are human conceptions, subject to human fallibility; and that they *may* or *may not* express the ideas of the great Author of Nature. To set up these laws as self-acting, and as either excluding or rendering unnecessary the power which alone can give them effect, appears to me as arrogant as it is unphilosophical. To speak of *any* law as "regulating" or "governing" phenomena, is only permissible on the assumption that the law is the expression of the *modus operandi* of a governing power.—I was once in a great city which for two days was in the hands of a lawless mob. Magisterial authority was suspended by timidity and doubt; the force at its command was paralyzed by want of resolute direction. The "laws" were on the statute book, but there was no power to enforce them. And so the powers of evil did their terrible work; and fire and rapine continued to destroy life and property without check, until new power came in, when the reign of law was restored.

And thus we are led to the culminating point of man's intellectual interpretation of Nature—his recognition of the unity of the power, of which her phenomena are the diversified manifestations. Towards this point all scientific inquiry now tends. The convertibility of the physical forces, the correlation of these with the vital, and the intimacy of that *nexus* between mental and bodily activity, which, explain it as we may, cannot be denied, all lead upward towards one and the same conclusion; and the pyramid of which that philosophical conclusion is the apex, has its foundation in the primitive instincts of humanity.

By our own remote progenitors, as by the untutored savage of the present day, every change in which human agency is not apparent was referred to a particular animating intelligence. And thus they attributed not only the movements of the heavenly bodies, but all phenomena of Nature, each to its own deity. These deities were invested with more than human power; but they were also supposed capable of human passions, and subject to human capriciousness. As the uniformities of Nature came to be more distinctly recognized, some of these deities were invested with a dominant control, while others were supposed to be their subordinate ministers. A serene majesty was attributed to the greater gods who sit above the clouds; while their inferiors might "come down to earth in the likeness of men." With the growth of the scientific study of Nature, the conception of its harmony and unity gained ever-increasing strength. And so among the most enlightened of the Greek and Roman philosophers, we find a distinct recognition of the idea of the unity of the directing mind from which the order of Nature proceeds; for they obviously believed that, as our modern poet has expressed it—

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

The science of modern times, however, has taken a more special direction. Fixing its attention exclusively on the *order* of Nature, it has separated itself wholly from theology, whose function it is to seek after its *cause.* In this, science is fully justified, alike by the entire independence of its objects, and by the historical fact that it has been continually hampered and impeded in its search for the truth as it is in Nature, by the restraints which theologians have attempted to impose upon its inquiries. But when science, passing beyond its own limits, assumes to take the place of theology, and sets up its own conception of the *order* of Nature as a sufficient account of its *cause*, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends.

For whilst the deep-seated instincts of humanity, and the profoundest researches of philosophy, alike point to mind as the one and only source of power, it is the high prerogative of science to demonstrate the *unity* of the power which is operating through the limitless extent and variety of the universe, and to trace its *continuity* through the vast series of ages that have been occupied in its evolution.

VII.

ON THE PSYCHOLOGY OF BELIEF.

[The Roscoe lecture, delivered before the Literary and Philosophical Society of Liverpool, November 24, 1873.]

THE progress of thought has been likened, by an able writer of our time, to a succession of waves which sweep over the minds of men at distant intervals :—

"There are periods of comparative calm and stagnation, and "then times of gradual swelling and upheaving of the deep, till "some great billow slowly rears its crest above the surface, higher "and still higher, to the last; when, with a mighty convulsion, "amid foam and spray, and 'noise of many waters,' it topples "over and bursts in thunder up the beach, bearing the flood line "higher than before."

"In the eyes of those who have watched intelligently the signs "of the times," continued Miss Cobbe, "it seems that some such "wave as this is even now gathering beneath us, a deeper and "broader wave than has ever yet arisen. No partial and tem-"porary rippling of the surface is it now, but a whole mass of "living thought seems steadily and slowly upheaved, and the "ocean is moved to its depths." *

The experience of the last ten years has so fully justified this grave warning, that it clearly becomes all who duly care for their own and their children's welfare, to look well to the foundations of their beliefs, which are likely soon to be tested by such a wave as

* Preface to the collected works of Theodore Parker, 1863.

has never before tried their solidity. New methods of research, new bodies of facts, new modes of interpretation, new orders of ideas, are concurring to drive onwards a flood which will bear with unprecedented force against our whole fabric of doctrine; and no edifice is safe against its undermining power, that is not firmly bedded on the solid rock of truth. How, then, are we to prepare ourselves to meet it? Shall we, like Canute and his courtiers, rest secure in our own supremacy, and try to keep back the waves by simply forbidding their advance? We need not go as far as Rome for examples of this mode of dealing with the difficulty; for we have a good many minor popes at home, who can scold quite as well—and just as ineffectually. Shall we go out, as Mrs. Partington did, with pattens and broom, to try and sweep away the Atlantic? Such seems to me the method of those who aim to put down a great scientific hypothesis by citing a text or two;* setting themselves up on the pattens of authority, and using arguments that are no more capable of holding water than the incoherent twigs of a besom. Or shall we imitate the able engineer, who, without experience of the power of a Channel-sea driven onwards at highest spring-tide by a south-west gale, thought to protect his railway-embankment by a massive wall? That wall was broken down, that embankment washed away, by the very first storm that tested its security. And so will it be with any barrier which the intellect of man may try to erect against the progress of other intellects than his own; for it is only the Source of all Thought who can say "Hitherto "shalt thou come, and no further, and here shall thy proud waves "be stayed."

To what example, then, can we look? What better can we wish for than is supplied by that wonderful edifice, which, for more than a century, braving the violence of the most destructive storms, has calmly and unintermittingly displayed its guiding light to the wave-tossed mariner, and which has furnished the pattern of every similar beacon elsewhere erected for the direction and warning of the navigator. I need not tell you to what I refer; for Smeaton and the Eddystone are household words to every Briton. But I would show you something of the mind of the man

* See "Priests and Philosophers," by the Rev. W. Greswell.

who executed what has been characterized * as "the most arduous "undertaking that had fallen to any engineer, and than which none "was ever more successfully executed;" and something of the way in which he prepared himself for his great work.

The mind of Smeaton is made known to us in that admirable series of reports on engineering subjects, which were described by the same competent authority, "as a mine of wealth for the sound "principles which they unfold, and the able practice they exemplify; "both alike based on close observation of the operations of Nature, "and affording many fine examples of cautious sagacity in applying "the instructions she gives to the means within the reach of art." It was to Nature, not to the time-honoured traditions of his profession, that this great practical philosopher went, when he had to deal with the problem of the Eddystone. He saw in the bole of the oak which had stood the blasts of centuries, the shape that would not only give to his tower the greatest inherent strength, but would project upwards, instead of directly resisting, the dash of the impetuous waves. And he then brought all the resources of constructive skill to carry out this sagacious design; erecting on a broad and solid foundation that beautifully formed superstructure, which not only bears aloft the far-shining and welcome light, but serves as the dwelling-place for those who are charged with its maintenance.

And this, it seems to me, is the way in which we should endeavour to erect our own fabric of thought, if we wish it to be enduring in itself—withstanding alike the rude assaults of external force, and the gradual weakening of internal decay—and to afford a guiding light to others. Our foundations must be laid broad and deep in the intellectual, moral, and physical constitution of man, and his relation to all that is outside him. Those fixed and immutable principles of reason on which all knowledge is based, must be solidly and patiently built up, course by course; each securely bolted-down to that which supports it. We must learn early "to distinguish what is just in itself, from what is merely "accredited by illustrious names." We must cultivate the insight which shall enable us to detect a fallacy of observation, or a

* Introduction to the first volume of the "Transactions of the Institution of Civil Engineers."

weakness of deduction; and determinately reject from our ground-tiers every stone that is not fit to bear the weight of the super-structure we intend to raise upon them. Recognizing it as a fact in the history of human thought, that every great error contains some admixture of truth, from which its power over men's minds is essentially derived, we must so shape our fabric that it shall direct, rather than oppose, the force of the aggressive wave. And then, though our skill may not suffice to give permanence to our weaker superstructure, though our lantern may be shattered and our light may for a time be extinguished, we shall retain a secure basis on which to rebuild our tower, crowning it with a new and more enduring dome, and setting in it a lamp of yet brighter lustre.

Such, I persuade myself, would have been the mode in which we should have been counselled by the calm wisdom and richly stored historic experience of that illustrious man, whose memory you are now met to honour; had he lived into these times, and been brought face to face with the problems we have now to meet. Accustomed as I have been from boyhood to hear his name mentioned with affectionate respect, counting some of his descendants among my most valued friends, and not unfamiliar with the general bearing of his historic writings, I cannot be ignorant of the life-long consistency with which he advocated the cause of human freedom and human progress; of the grave severity with which he reflected on the intolerance of those re-formers, who, while struggling against the absolutism of papal Rome, endeavoured to make themselves scarcely less absolute; and of the true philosophy and lenient charity with which he attributed that intolerance to the habit ingrained in their nature by their early training, of which it was scarcely in their power to divest themselves.

And in now inviting your attention to that most important question of practical psychology,—the mode in which our beliefs are formed, and the degree in which we are personally responsible for them,—I am but following a path which he marked out, towards a conclusion in which I persuade myself that he would have concurred.

Our beliefs must be carefully distinguished from our knowledge; and they seem to me to bear much the same relation to it, that our furniture has to the building in which we put it. The walls (are or ought to be) solid and enduring; so is everything that deserves to be called knowledge. Each stone supports, and is supported by, the rest; and nothing but a weakness of its foundation or a decay of its material can make our fabric of thought uninhabitable. But the beliefs with which we furnish it have not the same durability. Adapted to meet our temporary needs, they may be either poor in material, or but slightly put together. A carpet wears out, and, when past shifting and patching, must be replaced by a new one; a table or a chair breaks down, and, after successive repairs, is discarded as no longer serviceable. Or perhaps our requirements change; and some article which was at first made expressly in accordance with them, proves no longer suitable to our needs; so that, finding it in our way, we wish to get rid of it. Some pieces of our furniture, again, originally of more substantial make, have become faded and old-fashioned; but they may be family heirlooms, or we may have ourselves become attached to them; and so, not liking to discard them altogether, we put them away in some dark corner, or perhaps consign them to a seldom-visited lumber-room, where they rest almost forgotten in their obscurity. But at last some ray of sunshine throws a brighter light than usual upon our dark corner; or the opening of the shutters of our lumber-room lets into it the unwonted light of day; and we then find our old sofas and four-post beds so moth-eaten and decayed, that we turn them out of our house instanter.

I shall not pursue this comparison at present, but propose to resume and develop it hereafter.

Although belief, as Dr. Reid truly says, "admits of all degrees, from the slightest suspicion to the fullest assurance," yet we commonly use the term to designate that form of assent to any particular proposition, which, while falling short of positive certainty, is yet sufficiently complete not only to serve as the basis of our further reasoning, but to direct our course of action. And it is chiefly in this sense that I shall use the term on the present occasion; distinguishing belief, on the one hand, from that complete assurance which constitutes positive knowledge, and, on the other, from that merely speculative or provisional acceptance of a proposition, which neither shapes our thought, nor governs our action, and which really constitutes little more than an absence of *dis*belief in it.

You are all familiar with that current doctrine in regard to the nature of belief, which assumes that we "try" every proposition in our court of intellect, just as we try a prisoner in a court of law. We are supposed to listen with equal attention to the evidence adduced on each side, and to give our best consideration to the arguments which the opposing advocates erect upon it. Holding our intellectual balance with eyes blinded like those of Justice, we poise against each other the two aggregates of *pro* and *con*; and according as one or the other scale is made to go down by the "preponderance of evidence," do we accept or reject the proposition. But how comes it, if this be the whole account of our procedure, that the judgments of different men on the very same evidence are so notoriously diverse? The great Tichborne case, for example, cannot be brought up in any society, without eliciting opposite verdicts from self-constituted jurymen, who profess to have followed the course of the whole trial with the greatest care, and whose judgment cannot be supposed to have been swayed by the least admixture of partiality or self-interest. The clue to this diversity is found in the further fact, that even those who agree in their conclusion, will often be found to have formed it on dissimilar grounds; the respective weights of the several evidentiary facts being very differently estimated by different individuals. And thus we are led to this result; that the weights or probative values of such evidentiary facts are *not absolute quantities*, but *matters of personal estimate*; being—like our sensations of heat or cold as compared with the indications of the thermometer—the expressions of their effects upon our own consciousness. For while there are some things as to which the common consciousness of mankind is in perfect accord, there are others which impress different individuals so diversely, that we are forced to regard what may be termed the *personal equation* *

* This term is used by astronomers to mark the quickness of sight by which each of several observers is characterized; any visual phenomenon that is being watched for by two observers at once (as, for example, the contact of

of each recipient, as a factor whose importance is at least equal to that of the impressing force, in the determination of the resultant belief.

The nature of this "personal equation," and the degree in which its determination lies within our own power, constitute, therefore, an essential part of our inquiry.

No one can attend to his own habitual course of thought without recognizing it as a fact, that the judgments which determine his beliefs in regard to a very large proportion of the propositions that are constantly coming before him (as, for example, in the reading of his daily newspaper), are so direct and immediate, so little governed by any processes of conscious ratiocination, as to have much of the *intuitive* character. We estimate the worth of each statement, partly by our appreciation of the external evidence on which it rests, but still more (in most cases at least) by what we call the internal evidence of its *intrinsic probability*. But this intrinsic probability, like the respective weights of the several facts which make up the aggregate of the external evidence, may be estimated very differently by different individuals; the "personal equation" of each being often its most important factor. For while there are some propositions which are at once decided with absolute unanimity by an appeal to the "common sense" of mankind, there are others on which very different decisions are given, with no less directness and assurance, by different individuals, according to the respective mental state of each at the moment; the response of every individual mind to any such question asked of it, being as much the result of the antecedent condition of that mind, as our feeling of heat or cold when we plunge our hands into a basin of lukewarm water is dependent upon their previous thermal condition.*

Let us take as an example of an immediate judgment in which there would be a general if not an universal accordance that which any person of average intelligence would give upon the case put by Paley in the opening sentence of his "Natural

a star with the wire of the transit instrument) being usually seen appreciably sooner by one of them than by the other.

* Thus if we immerse the right hand for a short time in cold water, and the left in hot, and then transfer them both to water of medium temperature, this will be felt as warm by the right, and as cold by the left.

Theology":—"In crossing a heath, suppose I pitched my foot "against a stone, and were asked how the stone came to be there: "I might possibly answer that, for anything I knew to the con-"trary, it had lain there for ever; nor would it perhaps be very "easy to show the absurdity of this answer." Now, what is it that determines our immediate rejection of a proposition, which, as Paley says truly, cannot be easily refuted by any strict logical process? Perhaps neither the child nor the savage would have anything to say against it; yet no member of an educated community could entertain it for a moment. For what we call our ordinary common sense pronounces its adverse decision in the most distinct and explicit form, immediately that the proposition is brought before its tribunal; its judgment being an *acquired intuition*, which may be regarded as the general resultant of a great aggregate of familiar experiences, embodied in each individual's reason.

But in a large proportion of cases, the matter is one which lies outside the range of ordinary "common sense;" some special preparedness being required for the right appreciation of the inherent probability of the statement. One among my audience, for example, who has no previous information on the subject, happens to read the entertaining and (in certain aspects) very suggestive "Autobiography of Robert Houdin the Conjuror," and meets, near its conclusion, with the following passage:—

"The furnace (of an iron-foundry) was opened, and a jet of "molten metal, about the thickness of my arm, burst forth. "Sparks flew in every direction, as if it were a firework perform-"ance. After the lapse of a few minutes, my companion walked "up to the furnace, and calmly began washing his hands in the "metal, as if it had been lukewarm water. I walked forward in "my turn; I imitated my companion's movements; I literally "dabbled in the burning liquid; I took a handful of the metal "and threw it in the air, and it fell back in a fire-shower on the "ground. The impression I felt in touching this molten iron can "only be compared to what I should have experienced in handling "liquid velvet, if I may so express myself."

Any ordinary reader would be fully justified in treating this wonderful narration as Houdin's account of some new kind of conjuring trick, like the "inexhaustible bottle," the "aërial suspension," or the "second sight," mentioned in his previous pages. For he would scarcely be more able to conceive of a man literally and actually immersing his hands in molten iron, without any special preparation, and withdrawing them unharmed, than he could suppose an unlimited quantity of several different liquids to be poured out of a single bottle.

Another reader, however, finds no inherent improbability in the narration; for he knows that a special study had been made by M. Boutigny of that "spheroidal state" of bodies, of which we have a familiar example in the rolling and jumping of drops of water upon a red-hot iron plate; and that between this phenomenon (which is in itself sufficiently wonderful, when we come to think of it) and the harmless immersion of the hand in molten iron, M. Boutigny had worked out a continuous series of experimental marvels, all of them referable to the same simple and intelligible principle,—viz. the interposition of a film of vapour between the heated plate and the water thrown upon it, or between the molten iron and the hand immersed in it,* which prevents absolute contact between the two. Our second reader might himself, perhaps, have been present at the meeting of the British Association in 1845, at which M. Boutigny gave an account of these investigations, and publicly exhibited the freezing of *water* in a red-hot platinum crucible (an experiment which Faraday afterwards "capped" by freezing *mercury* in a like vessel); and at which, also, one of the workmen at Messrs. Ransome and May's foundry, in the presence of a large number of competent witnesses, did exactly what Houdin describes. Or, if he was not himself present, he knows that M. Boutigny's experiments were fully accepted as genuine at the time by the whole scientific world; that they have never in any way been called in question; and that the doctrine founded upon them is now universally recognized as an established principle in physics. Thus he has been prepared by his previous training for the ready acceptance of Houdin's narration; he feels assured that the occurrence *might*

* If the hand be naturally moist, there is no need of any preparation whatever; if it be dry, the hand should be previously dipped in water and wiped on a towel.

have happened exactly as it is described, this very M. Boutigny being named by Houdin as his companion and exemplar; and looking to the reason assigned by Houdin for inquiring into the subject—viz. his desire to account for the wonders he had himself witnessed in the performances of the Arab conjurors, whom he was sent by the French Government to outdo (these men walking with bare feet upon red-hot bars of iron, and licking red-hot plates with their tongues)—he sees no reason for discrediting Houdin's statement that it really *did* happen.

To the well-informed physicist, the *internal* evidence of conformity to a general principle is here so satisfactory, that he needs but a very small weight of *external* testimony to justify his belief in the particular fact narrated. But to any one who comes freshly to the subject, the affirmation seems to rest on external testimony alone; while the negation afforded by the inherent improbability of the statement is to the mind so decisive, that he deems himself fully justified in repudiating it altogether. Supposing, however, that a scientific friend points out to him that he has no title to set up a judgment which has no other basis than his own ordinary common sense, against that of men who have given special attention to this department of inquiry, and who agree in asserting, not only that the fact is true, but that it admits of a satisfactory explanation; he then, if not over-confident in his own judgment, withdraws the negation, and accepts the affirmative, in deference to the authority by which it is supported; still, however, without feeling that assurance which constitutes "conviction." But, further, if he can then be induced to go, step by step, through the whole series of experimental researches which lead up to this wonderful climax, he comes to feel the full force of that internal evidence, which not only removes all difficulty in the acceptance of the asserted fact, but shows that it has an inherent probability of its own, as a particular case of a well-established general principle. And yet I suspect that, however strong his mental conviction as to the safety of the act, there is not one of us who would venture to hold his hand in a stream of molten iron, until he had previously seen another person do so with impunity.

Another illustration, in a very different line of inquiry, may be drawn from the recent case of Louise Lateau, a Belgian peasant girl, who has exhibited the curious phenomenon of "stigmatization,"—that is, a spontaneous periodical bleeding, without any actual wounds, from the hands and feet, the forehead and the side, which were pierced in the crucified Saviour. By Catholics, this occurrence (like previous cases of the same kind) has been trumpeted as miraculous; while by Protestants, it has been denounced as an imposture. Here we at once see how completely the antecedent condition of each mind has determined the response; the external testimony as to the facts of the case which satisfies the former, being altogether repudiated by the latter, on account of what they regard as its inherent improbability. But to the physiologist who has carefully studied the local effects which concentrated attention can exert on bodily organs, especially when coupled with a strong expectation of a certain result (such expectation being peculiarly efficacious when coupled with strong religious emotion), the case presents no difficulty whatever. The testimony of the numerous and competent medical witnesses, fully on their guard against sources of fallacy, and determined to detect the cheat, if cheat there were, affords as strong a body of external evidence as could be brought to prove the reality of any occurrence whatever. And so far from finding any inherent improbability in their narrative, I can only say for myself, that its internal evidence is to my mind quite as strong as its external. The subject of it was obviously one of that class of young women who are known to every medical practitioner as peculiarly liable to "possession" by dominant ideas; and this possession manifested itself in a periodical "ecstasy," a form of natural somnambulism, in which the mind, entirely closed to the external world, is given up entirely to its own contemplations. Her current of thought and feeling in this state uniformly ran in the direction of the Saviour's Passion, the whole scene of which seemed to pass before her mind, as might be judged from her expressive actions; and a strong evidence of the reality of the condition was afforded by the fact that, according to the testimony of the medical witnesses, each fit terminated in a state of extreme physical prostration, which could not have been simulated—the pulse being scarcely perceptible, the breathing slow and feeble, and the whole surface bedewed with a cold perspiration. Now the transudation of blood from the skin through the orifices of the perspiratory ducts, under strong emotional excitement, being a well-authenticated physiological fact, there seems to me nothing in the least degree improbable in the narrative; on the contrary, any one who accepts the "charming away" of warts, and the cure of more serious maladies, as results of a strongly excited "expectant attention," will regard the stigmatization of an Ecstatica as the natural result of the intense concentration of her thoughts and feelings on a subject that obviously had a peculiar attraction for them.

Thus the belief of the Catholic partizan in the "miraculous" theory, that of his Protestant opponent in the "cheat" theory, and that of the scientific physiologist in the "natural" theory, all of which have the same external testimony as one of their factors, are severally governed by the "personal equation" which constitutes the other factor,—namely, *that antecedent mental state* which really settles the value to be assigned to the external testimony, by what it regards as the inherent probability or improbability of the fact, and thus indirectly determines the "preponderance of evidence." Either may, if he thinks proper, accuse each of the two others of being "prejudiced" in favour of his own particular belief; but the "prejudice" is simply, in each case, a resultant of previous training. I, on the one hand, who accept the scientific explanation, have no right to charge the devout Catholic with absurd superstition, because, having been brought up in the belief that miracles are worked at the present day for the authentication of Divine truth, he accepts this particular case as belonging to the "miraculous" category; but he, on the other, is not entitled to brand me as a sceptic or an infidel, because, having been brought up in the belief that the age of miracles has ceased, my scientific studies lead me to a rational explanation of the facts which I agree with him in accepting. I may fairly, however, deny the right of his Protestant opponent to question either the honesty or the competence of witnesses, whose prepossessions were obviously rather against than in favour of the genuineness of the phenomena; merely because, while refusing to admit their "miraculous" character, he has not given sufficient attention to the body of evidence relating to the influence of mental upon bodily states,* to be able to recognize their "naturalness."

I would now ask you to accompany me in the examination of a still more remarkable phenomenon, which attracted considerable attention some years ago, but of which nothing (so far as I know) has been lately heard; that, namely, which the late Mr. Braid of Manchester termed "human hybernation." It is known to most persons who have resided long in India, that certain Hindoo devotees are reputed to have the power of passing at will into a condition of death-like torpor, and of remaining for days or even weeks in that condition without the loss of their vitality, so that they may be resuscitated by appropriate means, although they have been all that time buried so securely in a vault, as to be absolutely cut off from supplies of food, and almost entirely secluded from air. But I suppose that there are few who have regarded such statements as deserving of any serious attention; the wonderful jugglery by which the celebrated "tree trick" is performed, being, it may be supposed, quite adequate to impress witnesses of no extraordinary penetration with a belief in the genuineness of phenomena that were merely contrived for the purpose of deceit. But the narratives which Mr. Braid obtained from witnesses not only of unimpeachable veracity but of the fullest competence, to whom every facility for the most careful scrutiny was accorded, put the matter in an entirely different light. In one of these cases, vouched for by Sir Claude Wade, who was long our political agent at the Court of Runjeet Singh, the fakeer was buried in an underground cell for six weeks; and having been twice dug out by Runjeet Singh during that period, was found on each occasion in precisely the same condition of apparent death as when first buried. In another case, mentioned by Lieutenant Boileau, in his "Narrative of a Journey in Rajwarra," in 1835, the man had been buried for ten days, in a grave lined with masonry and covered with large slabs of stone, and strictly guarded; and he assured Lieutenant Boileau that he was ready to submit to an interment of a twelvemonth's duration, if desired. In a third case, cited by Mr. Braid, the trial was made under the direct supervision of a British officer, a period of nine

* See Dr. Tuke's work on the "Influence of the Mind on the Body."

days having been stipulated for on the part of the devotee; but the officer, fearing that he might incur blame if the result should be fatal, had the fakeer dug out on the third day, without any previous notice. In each case we have the testimony of British medical officers as to the condition of the body when exhumed; and in this all the narratives agree. Its appearance was perfectly corpse-like; no pulsation could be detected either in the heart or in the arteries (there was no stethoscopy in those days); and there were no perceptible movements of breathing. The means of restoration employed by the attendants of the saint were just what we should ourselves employ in a case of "suspended animation;" namely, friction of the surface, the application of warmth, and the administration of stimulants as soon as the power of swallowing returned.

Still it may be said that it is so intrinsically improbable, not to say impossible, that a state of apparent death could be self-induced in the first instance, and could then endure for weeks (to say nothing of months) without the absolute loss of vitality, that it is more likely that even these most competent and trustworthy witnesses were deceived, than that the facts really happened as narrated by them. And a determined sceptic might feel himself justified in likening their narratives to the wonderful stories told by Marco Polo, as to the chain thrown up into the air, the climbing-up of this chain by a boy until he was out of sight, the falling to the ground of his head, body, and limbs in separate pieces, and their spontaneous reunion, so that the boy got up and walked alive and whole in the presence of a circle of spectators.

But the scientific physiologist, as in the preceding instance, sees a clue to the rational explanation of the cases of the buried fakeers; which leads him to view the testimony given in regard to them by the cautious, sceptical, and well-informed witnesses who vouch for them, in a very different light from that of the wonder-loving traveller of the middle ages.

In the first place, the state of "suspended animation" or "apparent death" is one of which the existence cannot be denied; since it is continually produced by drowning, and sometimes occurs spontaneously. And that such a state might be maintained in India under the circumstances described, for a much longer period than in this country, may be fairly attributed to the warmth of the tropical soil; which will prevent any considerable reduction of the temperature of the body buried in it, notwithstanding the almost entire suspension of its internal heat-producing operations. Again, it has been experimentally ascertained that even warm-blooded mammals, whose hybernation is profound, can be kept under water for an hour or more without injury; although, in their ordinary condition of activity, they would be killed by a submersion of three or four minutes. And thus there is nothing, in the almost complete privation of air, that militates against the probability that the buried fakeer might remain enclosed in a narrow vault, without suffering from the want of it; for the nearly complete suspension of all the functions of life will reduce the demand for air, as for food, almost to zero.

But, secondly, there is to the well-informed physiologist no inherent improbability in the self-induction of this curious condition. For, in the first place, he has the standard case of Colonel Townsend, which no medical authority has ever ventured to call in question, so high was the authority of Dr. Cheyne, the eminent physician by whom it was recorded. And Mr. Braid, in the course of his experiments on that form of artificial somnambulism which he termed hypnotism, met with several cases (of which I myself saw more than one) in which the self-induction of that state produced a marked lowering of the pulse and respiration; the reduction being such in one instance as seriously to alarm Mr. Braid, and to necessitate the immediate termination of the experiment.

The inherent improbability of the asserted phenomena, then, being thus weakened or even removed by scientific inquiry, we are free to attach whatever weight to the testimony in their favour we may think it deserves on its own account. And I long since expressed my own conviction, that though we may scarcely accept that testimony as affording a satisfactory basis for positive assurance, we have no right whatever to refuse to believe it. The case seemed to me to be one fairly calling for that "suspension of the judgment," which our great Faraday used to advocate, as preferable in many instances to that premature "making up of our minds," which often involves either our *un*-making them again at some subsequent time when fresh evidence has been adduced, or our persistence, from mere obstinacy, in a belief which we should not have adopted in the first instance, if the whole case had been then before us.

But having happened long since to speak on the subject to Professor Max Müller, I learned from him the additional very important fact, that this condition of self-induced suspension of vital activity forms, as it were, the climax of a whole series of states, with two of which I was myself very familiar—"electro-biology," or artificial reverie, and "hypnotism," or artificial somnambulism; both of them admirably studied by Mr. Braid, through whose kindness I had many opportunities of investigating their phenomena. The self-induction of these states, practised by the Hindoo devotees, is part of a system of religious philosophy which is termed the Yoga; and by the kindness of Professor Max Müller I possess a very curious account of this philosophy, printed at Benares twenty-two years ago, by Sub-Assistant Surgeon Paul, who had carefully studied it. It appears from this that the object of the whole system is to induce a state of mystical self-contemplation, tending to the absorption of the soul of the individual into the Supreme Soul, the Creator, Preserver, and Destroyer of the World; and that the lower forms of it consist in the adoption of certain fixed postures, which seem to act much in the same way with the fixation of the vision in Mr. Braid's methods. The first state, *pránáyáma*, corresponds very closely with that of reverie or abstraction; the mind being turned in upon itself and entirely given up to devout meditation, but the sensibility to external impressions not being altogether suspended. The second state, *pratyáhára*, is one which—the external senses being closed, while the mind is still active—corresponds with some forms of somnambulism. Those who have attained the power of inducing this condition, then practise *dharána*, a stage of complete quiescence of body and mind, corresponding with what is known as catalepsy,—the body remaining in any posture in which it may be placed. From this they pass into the *dhyána*, in which they believe themselves to be surrounded by flashes of external light or electricity, and thus to be brought into communion with the Universal Soul, which endows them with a clairvoyant power. And the final state of *samâdhi*, which they themselves liken to the hybernation of animals, and in which the respiratory movements are suspended, is regarded as that of absolute mental tranquillity, which, according to these mystics, is the highest state which man can attain; the individual being absolutely incapable of committing sin in thought, act, or speech, and having his thoughts completely occupied with the idea of Brahma, or the Supreme Soul, without any effort of his own mind.

From this point of view, then, the history of the buried fakeers presents a new significance; for so far from being an exceptional phenomenon, this self-induced state of suspended animation is one towards which the whole of their system of religious philosophy tends, and for which it provides, as it were, both the physical and the mental education. And the evidence thus derived from an entirely independent source, of the inherent probability of occurrences whose narration first called forth nothing but incredulity, seems now, in my judgment, sufficient to give a very decided preponderance to the scale of positive belief.

Now it is obvious that the state of belief of each one of yourselves, to whom the subjects of the three cases I have now discussed may be entirely new, will be mainly determined by the confidence you may be severally predisposed to place in *my* scientific knowledge. You may reasonably conclude that, although not a professed physicist, I should not declare to you my conviction that a man may hold his hand unharmed in a stream of molten iron, without having the strongest grounds for that assurance which the confirmation of *à priori* scientific probability can furnish to the testimony of competent and unprejudiced witnesses. And those of you who may know me not only as a physiologist, but as one who has for thirty years made a special study of the border-ground between physiology and psychology, will perhaps be disposed to think that I should not, without adequate reason, speak to you of the stigmatization of Louise Lateau, and of the buried life of the Hindoo Yogī, as not to be lightly put aside as cheats, but to be entertained as matters of serious investigation. In each of these cases, however, the question is obviously one as to which the decision between testimony and the dictates of common sense depends upon *special* knowledge; the negative verdict which almost every person of average intelligence would almost unhesitatingly pronounce, being liable to reversal by the lightening of the scale of general experience, while fresh weights are put by special investigation into the scale of testimony. And the "personal equation" which determines the belief of each individual who does not work out the inquiry for himself, here consists mainly in his confidence in the knowledge and judgment of another person. The evidentiary facts on which his scientific guide relies, may be utterly meaningless to himself; but he accepts them, as the merchant would a bill of exchange, on that guide's assurance of their worth; and the "preponderance of evidence," like the balance of an account, is decided accordingly. If any one who is either disqualified by ignorance from rightly appreciating the value of the evidentiary facts, or is unwilling to take the trouble of investigating the case, claims to dispose of it in an off-hand way in accordance with his "common sense" notions, we, who *have* studied the subject, take leave to tell him that it is a case requiring the *un*common sense that only special culture can bestow, without the possession of which his judgment is altogether worthless.

But I have now to direct our inquiry to that class of beliefs, which relate to matters lying within the scope of ordinary reason, upon which every thoughtful man feels himself not only competent but called upon to decide for himself, and yet as to which there is no less a diversity in the judgments formed upon the same evidence, than there is in the cases we have already considered.

While the world has been too ready to charge with moral culpability those who depart from the beaten tracks of religious or scientific orthodoxy, independent thinkers seem to me to have often been unjust as well as unwise in flinging back the accusation, and in imputing to those whose mental development has taken place under a particular system, and whose whole intellectual and moral nature has shaped itself into conformity with that system, either a wilful blindness to evidence which at once carries conviction to their own minds, or an intellectual incapacity to appreciate it. For, as I shall now endeavour to show you, the ordinary beliefs of every individual are mainly determined by a "personal equation" not less definite than that of the man who has studied some particular subject, though it is the exponent rather of his *general* than of his *special* culture. Here we shall find it convenient to resume our former comparison, and liken the mind of each individual to an edifice,—palace, dwelling-house, or cottage, as the case may be,—which, though partially furnished, still has some of its rooms entirely empty, while in others there are recesses, nooks, and corners remaining to be filled, or perhaps only a few pegs on which some lighter articles may be loosely hung.

Now it seems to me that our immediate acceptance or rejection of the propositions daily coming before us, as to which our judgment does not need to be *specially* informed, but which the *ordinary* common sense, or acquired instinct, of an average man is quite competent to decide, is determined on exactly the same principle, as our acceptance or rejection of (let us say) a book-case, which may be offered as likely to suit a certain recess in our library. For just as our decision is guided in the latter case by the *fitting-in* of the piece of furniture to the vacant nook, so does our intellectual *assent* to a new proposition depend upon its *fitting-in* to some appropriate place in our existing fabric of thought. The *fit* of this new bookcase may be so perfect, that we have no question whatever about retaining it; and it gradually, by use and habit, becomes to ourselves as much a part of the library, as if it had grown into its walls. And so a new belief, for which an appropriate place is ready in our fabric of thought, and which precisely fits into that place, not only obtains immediate acceptance, but ere long (if not called in question) is adopted into the fabric itself.

But, again, the fit of the bookcase may not be perfect in the first instance, and yet we may think so well of its general suitableness as not to like to let it go; and we then consider whether by some slight alteration either of the bookcase or of the recess, we can bring about an adjustment. If this can be done, we keep the bookcase; if it cannot, we send it back. Even so, the new proposition may not in the first instance find any place in our fabric of thought into which it can be received; and yet its want of accordance may be so slight, as to lead us to examine whether we cannot make it fit by some process of accommodation;—either our recess being widened by argument and discussion, or the proposition being narrowed by the limitation of its terms. If we can thus bring about a satisfactory "fit," we accept the proposition as part of our intellectual furniture; if not, we dismiss it,—at any rate for a time.

Now in this intellectual judgment, it seems clear to me that the will is no more involved at the moment of making it, than it is in that which is determined by the "preponderance of evidence." For if there be a complete suitableness, or a complete unsuitableness, between the new proposition and the vacant recess in our fabric of thought, we accept it without hesitation in the one case, we feel compelled to reject it in the other. So far, then, it is true that "we are no more responsible for our opinions than we "are for the colour of our skin." But, whenever the proposition comes to be the subject of *discussion*,—whether we are simply canvassing the practicability of fitting it into our recess, or are carrying it through the whole procedure of a trial on its merits, the will comes to exert a powerful influence on the result; as is truly expressed by that proverbial embodiment of universal experience, that "we easily believe what we wish." How, then, upon the theory of the instinctive or automatic nature of assent which I have been endeavouring to establish, is this influence exerted?

In those old political trials, which are now happily—so far as our own country is concerned—only matters of history, it not unfrequently happened that the prisoner's life or death, whilst determined by the verdict of a jury honestly meaning to be impartial, really depended on the partizan conduct of the presiding judge. For though the jury were all sworn, and really intended, to give a "true verdict according to evidence," yet the judge had it largely in his power to determine which way the balance should incline. In the first place, he might refuse even to consider the objections which the prisoner's counsel was fully justified in taking to the indictment, and might accept the reply of the crown-lawyer as all sufficient, when it did not really meet one of the points raised for the defence. Again, while treating the witnesses for the Crown with the utmost consideration, assuming the truth of every statement they may make, and placing every obstacle in the way of the sifting of their testimony by cross-examination, he treated the witnesses for the defence as if they were utterly unworthy of credit, and allowed the crown-counsel the utmost licence in his endeavour to lower the value of their testimony by unjustifiable insinuations or bullying assumptions. And in his "summing-up," he would so forcibly present to the jury both the law and the evidence on one side, and so determinately keep down the force of law and evidence on the other, that the jury might be honestly compelled, even against their own prepossessions, to give a most iniquitous verdict.

And so in the discussion of a question of intellectual truth, the will has the power of keeping some considerations more or less completely out of view, whilst it increases the force of others by fixing the attention upon them. Another familiar proverb, that "there are none so blind as those that *won't* see," precisely expresses the way in which the will thus exerts its influence. For as the opponents of the Copernican system refused to look at the satellites of Jupiter through the telescope of Galileo, so there are too many who wilfully turn away the eyes of their minds from inconvenient truths; or refuse to get a gleam of sunshine into the dark chambers of their intellects, where they hide as sacred treasures the antiquated beliefs of past ages, the worthlessness of which would be at once apparent if the full light of day were permitted to shine in upon them.

On the other hand, the will, when inspired by the habitual desire to act on the highest principles of *right*, determinately blinds us, not only to the direct promptings of self-interest, but to those arguments which we instinctively *feel* to be sophistical, though we may not be able logically to expose their fallacy; just as Nelson at Copenhagen turned his blind eye to the signal for his recall, which he did not think it for the honour of his country to obey.

But we must now carry this inquiry a step further back; and consider where the responsibility lies for the construction of that fabric of thought, the shape and dimensions of whose recesses determine the admissibility of the beliefs that constitute its furniture.

The general plan of that fabric may be said to be determined by our congenital constitution. Every being is, in the first instance, what Nature made him; and however much his capacities and tendencies may be developed and modified by subsequent influences. these cannot build up any superstructure that was not, as it were, sketched out in the original design. The foundations are laid, and the basement-storey reared, by the education and training we receive; and while we are in no degree responsible for this in the first instance, we gradually come to be so more and more, as we acquire that power of volitional selection, by which we can regulate the action of our intellectual faculties, and determine the choice of its objects—so far, at least, as this may be left to ourselves. But it is during this period of our lives that we are most powerfully, though unconsciously, influenced by that *aggregate* of external influences which the ancient Greeks designated as the Νόμος—a term we sometimes translate as "custom" and sometimes "law," and which may be considered as expressing that custom which has the force of law, and which has become so completely a "second nature" as to be less easily changed than any written law. Of this Νόμος the "caste" of India is doubtless the most conspicuous example; but no observant mind can fail to recognize the applicability to our own social condition of the admirable account given by Mr. Grote of the Greek conception of that "King of all" (to borrow the phrase cited by Herodotus from Pindar), which "exercises plenary power, spiritual as well as "temporal, over individual minds; moulding the emotions as well "as the intellect, according to the local type—determining the "sentiments, the belief and the predisposition in regard to new "matters tendered for belief, of every one—fashioning thought, "speech, points of view, no less than action—and reigning "under the appearance of habitual, self-suggested tendencies." —(*Plato and the other Companions of Sokrates,* vol. i. p. 249.)

The physiologist who believes that during the whole period of growth, the brain is shaping itself according to the mode in which it is habitually exercised, and that the nerve-tracks then laid down are maintained through life, even though disused, far more persistently than any that result from subsequent mental modifications, will most fully realize to himself the extreme importance of this Νόμος—the influence unconsciously exerted by the family life, the public opinion of the school and college, and the usages and habits of thought and feeling of the particular social class as a member of which the youth makes his first entrance into the world—not only in moulding the moral character, but in building up the fabric of thought. And it operates in this special way—that it shapes our mental recesses to the forms and dimensions of certain ancestral pieces of furniture that are waiting to be put into them; so that as the fabric is growing up, and one room is ready after another, these respectable beliefs find their appropriate places; the recipient never dreams of questioning their inherent use and value, because they "fit" in so perfectly; and so long as nothing occurs to make him doubt the security of his walls, and he does not experience any special inconvenience from the antique awkwardness of his furniture, he continues to give it a place, to the exclusion of articles of newer fashion and more attractive exterior.

In so far, then, as the fabric of thought of each individual has been built up by influences external to himself, he cannot be regarded as in any sense responsible for his acceptance of beliefs which that fabric has been shaped to receive; but he does become responsible, when the time comes for him to think for himself, to examine into the foundations of his knowledge, to test the goodness of its materials, and to try the security of its construction. Any one who is restrained from doing this, whether by passive indolence or by timorous apprehension of the possible results of inquiry, either to his own worldly interests or to those of others, is liable some time or other to find his fabric of thought overthrown, and himself buried in its ruins; and even though no wave should dash, no lightning-flash should shatter, it may ultimately fall to pieces from sheer decay. Every one, on the other hand, who recognizes his obligation to make the best use in his power of the faculties with which he finds himself gifted, and who looks at the search for truth as his noblest object, the attainment of it as his most glorious prize, will be constantly on the watch for opportunities of *improving* his fabric of knowledge, and of perfecting its furniture of beliefs. Now in doing this, he will find that as his fabric is altered (or rather, alters itself), his furniture must be changed in accordance with it; for the enlargement of one of his apartments may enable him to give place to some article which he was formerly obliged to reject, whilst the reduction of another may crowd out the fittings which were once most perfectly suited to it. Every one who has gone through a sufficiently long course of intellectual experiences, and has been accustomed to reflect upon them, must be conscious that this has often occurred to himself. He is surprised, on turning over the records of his earlier beliefs, to find how many of them he would now absolutely reject; not because they have been disproved by additional evidence, but because *he has himself grown out of them.*

And it is, further, by the use of the power which every man possesses of *enlarging*, as well as improving, his fabric of thought, by applying himself to the acquirement of new knowledge, that he gains a vastly increased capacity for the reception of a nobler and grander order of beliefs, such as he would have previously thought it impossible that he could ever come to possess. Suppose an American professor to have come over, a dozen years ago, to announce to the scientific public of Europe, that he had devised and perfected a method by which he was enabled to recognize in the incandescent atmosphere of the sun at least seventeen of the component elements of our own globe; that he had discovered the most notable of these to be hydrogen, which, heated to redness, forms a glowing envelope ordinarily at least five thousand miles thick, whence fiery tongues are shot forth from time to time, sometimes to the height of fifty thousand miles in a few minutes, their disappearance being often as rapid as their projection; and that he had ascertained the sun-spots to be the centres of circular storms, sometimes revolving at the rate of one hundred and twenty miles per second, which are set in motion by a downward rush of metallic vapours, dependent on a local cooling that can only be measured by thousands of degrees; what would have been our mental attitude? These propositions would, to most of us, whether scientific or unscientific, have seemed so completetely inadmissible into our fabric of thought, that we should have suspected our American friend of amusing himself by trying upon us one of those ingenious hoaxes for which his countrymen have shown a special aptitude.

Let us suppose our professor to have further assured us that he was able by the same method to determine the existence of many of the terrestrial elements even in the fixed stars; that he had found hydrogen not only to be universally present, but to perform the leading part in those changes which give rise in certain cases to the known variations in their brightness (a star previously invisible to the naked eye suddenly blazing out with a lustre surpassing that of Jupiter, and declining almost as rapidly); and that he was further able to prove that many of these luminaries have a motion of approach to or recession from us, such as no measurement of their angular positions could detect, no telescopic scrutiny would lead us even to surmise, though its rate may be fifty miles per second; we should scarcely have been unreasonable in regarding his statements as ingenious inventions devised to try how far our credulity might extend.

And if, not satisfied with this, he ventured a still higher flight, and had assured us that he had obtained by the same simple method the solution of that grand astronomical problem—the constitution of the nebulæ—which the ablest observers, armed with the largest and most perfect instruments, had declared to be beyond their ken; and that he could classify the irresolvable nebulæ with certainty into those which are mere whiffs of vapour, and those which are aggregations of stars too remote to be separately discerned;—we should, I think, have begun to respect his imaginative power for the sublimity of its conceptions, while the extravagance of this last assertion would have seemed fully to justify our repudiation of the whole series as utterly destitute of any claim on our belief.

But suppose that our Transatlantic visitor, instead of laying his claims before an incredulous public, had privately brought together some half-dozen of the most eminent physicists of Europe, who were acquainted with all that had been previously learned as to the constitution of the solar spectrum, and the modifications produced in flame by the presence of certain chemical elements;—he would have been able in a brief space, not only to satisfy them of the soundness of his basis, but to erect upon that basis a new and substantial addition to their fabric of knowledge, culminating in a lofty "heaven-kissing" tower, of which every stone should be so firmly and variously knitted to every other, as to leave no room for any suspicion of insecurity. And having, by the strictest methods of observation and experiment, verified his statements—step by step—as to all those facts which are capable of direct demonstration, and having become fully assured, in the course of their inquiries, of their visitor's personal good faith, they would have found no difficulty in crediting his accounts of those celestial marvels of rare occurrence, which it would be altogether beyond his power to reproduce.

I do not know any more remarkable fact in the Psychology of Belief, than the universality with which even the most wonderful—I might say the most romantic—results of Spectrum Analysis have been accepted as sober truth, not merely by the whole scientific world, but by the general public. And this universality is, I think, to be attributed to these two conditions:—first, that the absolute concurrence of scientific men on this subject gives to their statements the value (if I may so express myself) of bank-notes, which any one may convert into the standard gold of personal knowledge, merely by inquiring into the matter for himself;—and secondly, that these results are additions to our previous knowledge, and do not run counter to any established beliefs. But suppose they *had* done so, would they have been the less true in themselves, or have possessed any the less claim on universal acceptance? The old beliefs would clearly have had to give place in this instance, as they have had to do in many previous cases, to the new knowledge.

With one more practical application of this method of studying the psychology of belief, I must bring this discourse to a conclusion.

I alluded at its commencement to a great scientific hypothesis, which is now on its trial at the bar of public opinion, and which, if adopted as a principle of construction, will give a new shape to a large part of our fabric of thought; and I would say a few words of what seems to me the spirit in which that trial should be conducted. There are many of our securest beliefs, which depend on the convergence of a number of separate *probabilities* towards a common centre, while none of them are complete as *proofs;* the whole of what is commonly termed "circumstantial" evidence being, in fact, of this character. And just as the value of the "circumstances" depends on the testimony of experts,—a case of poisoning, for example, requiring the analysis of the chemist, and the examination of the morbid appearances by a pathologist,—so must the hypothesis of evolution be ultimately either established or disproved by its accordance or disaccordance with a vast aggregate of facts of Nature, which belong to different departments of scientific inquiry. The geologist traces the succession of plants and animals in palæontological order, and finds, as he advances in his studies, less and less evidence of interruption, and more and more of continuity, biological as well as physical. The zoologist and botanist, who have been accustomed to classify their multitudinous and diversified forms of plants and animals according to their "natural affinities," find a real meaning in their classification, a new significance in their terms of relationship, when these are used to represent what might be regarded with probability as actual community of descent. The morphologist who has been accustomed to trace a "unity of type" in each great group, and especially to recognize this in the presence of rudimentary parts which must be entirely useless to the animals that possess them, delights in the new idea which gives a perfect *rationale* of what had previously seemed an inexplicable superfluity. And the embryologist, who carries back his studies to the earliest phases of development, and follows out the grand law of Von Baer, "from the general to the special," in the evolution of every separate type, finds the extension of that law from the individual to the whole succession of organic life, impart to his soul a feeling of grandeur, like that which the physical philosopher of two hundred years ago must have experienced, when Newton first promulgated the doctrine of universal gravitation. And lastly, when the doctrine of evolution is looked at in its moral aspect, as one which leads man ever onwards and upwards, and which encourages his brightest anticipations of the ultimate triumph of truth over error, of knowledge over ignorance, of right over wrong, of good over evil, who shall presume to say that the convergence of all these great lines of thought, each of them the resultant of the patient toil of a whole army of scientific workers, is a fact of no account? *Absolute* truth, no man of science can ever hope to grasp; for he knows that all human search for it must be limited by human capacity. But he denies the right of any one else to impose upon him, as "absolute truth," his own fallible exposition of the revelation conveyed in the teachings of religiously-inspired men; for *he* claims an equal right to be accounted a true expositor of the revelation conveyed in the Divine Order of the Universe. And the real philosopher, who fixes his hope on a perpetual approximation to that absolute truth which he may never actually grasp—who, forgetting those things which are behind, is always reaching forth to those which are before—who tends towards perfection, without ever *pre*tending to it—and who is constantly striving upwards, so as either himself to reach, or to help his successors to reach, a yet loftier elevation—believes that he is thus best fulfilling his duty to the Great Giver of his own powers of thought, and to the Divine Author of that Nature in which he deems it his highest privilege to be able to read some of the thoughts of God.

VIII.

ON THE FALLACIES OF TESTIMONY IN RELATION TO THE SUPERNATURAL.

[*Contemporary Review*, January, 1876.]

No one who has studied the history of science can fail to recognize the fact, that the rate of its progress has been in great degree commensurate with the degree of *freedom from any kind of prepossession* with which scientific inquiry has been conducted. And the chapters of Lord Bacon's "Novum Organon," in which he analyzes and classifies the prejudices that are apt to divert the scientific inquirer from his single-minded pursuit of truth, have rightly been accounted among the most valuable portions of that immortal work. To use the felicitous language of Dr. Thomas Brown, "the temple which Lord Bacon purified was not that of "nature herself, but the temple of the mind; in its innermost "sanctuaries were the idols which he overthrew; and it was not "till these were removed, that truth would deign to unveil herself "to adoration."

Every one, again, who watches the course of educated thought at the present time, must see that it is tending towards the exercise of that trained and organized common sense which we call "scientific method," on subjects to which it is legitimately applicable within the sphere of religious inquiry. Science has been progressively, and in various ways, undermining the old "bases of belief;" and men in almost every religious denomination, animated by no spirit but that of reverent loyalty to truth, are now seriously asking themselves, whether the whole fabric of what is commonly regarded as authoritative revelation must not be carefully re-examined under the searching light of modern criticism, in order that what is sound may be preserved and strengthened, and that the insecurity of some parts may not destroy the stability of the whole.

I notice, further, among even "orthodox" theologians of the present time, indications of a disposition to regard the New Testament miracles rather as encumbrances, than as props, to what is essential in Christianity; of a feeling that they are rather to be explained away,* than adduced as authoritative attestations of the teachings of Jesus;—and of a perception that to attempt to enforce a belief in them on the part of the rising generation, will be either to alienate from the acceptance of those teachings many of the most cultured and most earnest young people of our time, or to reduce their minds to that state of unreasoning subservience to authority, which finds its only logical basis in the Roman Catholic Church. And, moreover, I observe it to be among those, in various religious denominations, who are converging to the conclusion that the "authority" of Christianity most surely consists in the direct appeal it makes to the hearts and consciences of mankind,—who most fully recognize in the life, teaching, and death of Christ, that manifestation of the Divine (*ἀπαύγασμα τῆς δόξης καὶ χαρακτὴρ τῆς ὑποστάσεως αὐτοῦ*) which constitutes him their Master and Lord,—and who most earnestly and constantly aim to fashion their own lives on the model of his, —that there is the greatest readiness to admit that the records of that life are tinged by the prepossessions, and subject to the inaccuracies, to which all human testimony is liable.

It was nobly said thirty years ago † (I believe by Francis Newman) that "every fresh advance of certain knowledge apparently sweeps off a portion of (so-called) religious belief, *but only* "*to leave the true religious element more and more pure; and in*

* Thus theologians of the "philosophic" school argue that miracles are not to be regarded as departures from the Divine order, but are parts of the order originally settled in the Divine mind—as typified by the well-known illustration supplied by Mr. Babbage from his calculating-machine. But this obviously puts altogether on one side the notion of miracles as extraordinary interpositions, involving a more direct personal agency than the ordinary uniformity.

† *Prospective Review*, vol. i. p. 53.

"*proportion to its purity will be its influence for good, and for good* "*only;*" and that "little as many are aware of it, faithlessness is "often betrayed in the struggle to retain in the region of faith that "which is already passing into the region of science, for it implies "doubt of the value of truth." Thoroughly sympathizing with this view,—in no spirit of hostility to what is commonly regarded as revealed truth,—but with a desire to promote the discriminating search for what really constitutes revealed truth,—I offer the following suggestions, arising out of the special studies which have occupied a large part of my life, to the consideration of such as may deem them worthy of attention.

That the whole tendency of recent scientific inquiry has been to strengthen the notion of "continuity" as opposed to "cataclysms" and "interruptions," and to substitute the idea of progressive "evolution" for that of "special creations," cannot but be obvious to every one who is familiar with the progress of inquiry in astronomy, physical geology, palæontology, and biology. But the scientific theist who regards the so-called "laws of nature" as nothing else than man's expressions of so much of the Divine order as it lies within his power to discern, and who looks at the uninterruptedness of this order as the highest evidence of its original perfection, need find (as it seems to me) no abstract difficulty in the conception that the Author of Nature can, if He will, occasionally depart from it. And hence, as I deem it presumptuous to deny that there might be occasions which in His wisdom may require such departure, I am not conscious of any such scientific "prepossession" against miracles, as would prevent me from accepting them as facts, if trustworthy evidence of their reality could be adduced. The question with me, therefore, is simply:—"Have we any adequate historical ground for the "belief that such departure has ever taken place?"

Now it can scarcely be questioned that whilst the scientific probability of uniform sequence has become stronger, the value of testimony in regard to departures from it has been in various ways discredited by modern criticism. It is clear that the old arguments of Lardner, and the modern reproduction of them by Professor Andrews Norton (Boston, N.E.), which in my early days were held as demonstrating the "genuineness of the Gospels," no longer possess their former cogency. For the question has now passed into a phase altogether different from that which it presented a century or two ago. It was then, "Are the nar-"ratives genuine or fictitious? Did the narrators intend to speak "the truth, or were they constructing a tissue of falsehoods? Did "they really witness what they narrate, or were they the dupes of "ingenious story-tellers?" It is now, "Granting that the narrators "wrote what they firmly believed to be true, as having themselves "seen (or thought they had seen) the events they recorded, or as "having heard of them from witnesses whom they had a right to "regard as equally trustworthy with themselves; is *their* belief a "sufficient justification for *ours?* What is the extent of allowance "which we are to make for 'prepossession'—(1) as modifying "their conception of each occurrence at the time, and (2) as "modifying their subsequent remembrance of it? And (3), in "cases in which we have not access to the original records, what "is the amount of allowance which we ought to make for the "accretion of other still less trustworthy narratives around the "original nucleus?"

Circumstances have led me from a very early period to take a great interest in the question of the value of testimony, and to occupy myself a good deal in the inquiry as to what is scientifically termed its "subjective" element. It was my duty for many years to study and to expound systematically to medical students the probative value of different kinds of evidence; and my psychological interest in the curious phenomena which, under the names of mesmerism, odylism, electro-biology, psychic force, and spiritual agency, have been supposed to indicate the existence of some new and mysterious force in nature, led me, through a long series of years, to avail myself of every opportunity of studying them that fell within my reach. The general result of these inquiries has been to force upon me the conviction, that as to all which concerns the "supernatural" (using that term in its generally understood sense, without attempting a logical definition of it), the allowance that has to be made for "prepossession" is so large, as practically to destroy the validity of any testimony which is not submitted to the severest scrutiny according to the strictest scientific methods. Of the manner in which, within my own experience, what seemed the most trustworthy testimony has been completely discredited by the application of such methods, I shall give some examples hereafter.

I would by no means claim for myself or any other scientific man an immunity from idolatrous prepossessions; for we must all be guided in our researches by *some* notion of what we expect to find; and this notion may be very misleading. Thus, when no metal was known that is not several times heavier than water, it was not surprising that Dr. Pearson, as he poised upon his finger the first globule of potassium produced by the battery of Davy, should have exclaimed, "Bless me, how heavy it is!" though, when thrown into water, the metal floated upon it. But while the true disciple of Bacon is on his guard against "idolatry," and is constantly finding himself rudely handled (as Dr. Pearson was) by "the irresistible logic of facts" if he falls into it, the pledged upholder of any religious system can be scarcely other than, in some degree, an "idolater." The real philosopher, says Schiller, is distinguished from the "trader in knowledge" by his "always loving truth better than his system."

Bacon's classification of "idols" is based on the *sources* of our prepossessions; and although his four types graduate insensibly into each other, yet the study of them is very profitable. Sir John Herschel is, I think, less successful when he classifies them as (1) prejudices of opinion and (2) prejudices of sense; because an analysis of any of his "prejudices of sense" shows that it is really a "prejudice of opinion." My first object is to show that we are liable to be affected by our prepossessions at every stage of our mental activity, from our primary reception of impressions from without, to the highest exercise of our reasoning powers; and that the value of the testimony of any individual, therefore, as to any fact whatever, essentially depends upon his freedom from any prepossessions that can affect it.

That our own states of consciousness constitute what are, to each individual, the most certain of all truths—in a philosophical sense (as J. S. Mill says) the only certain truths—will, I suppose, be generally admitted; but there is a wide *hiatus* between this, and the position that every state of consciousness which represents an external object has a real object answering to it. In fact, although we are accustomed to speak of "the evidence of our senses" as worthy of the highest credit, nothing is easier than to show that the evidence of any one sense, without the check afforded by comparison with that of another, is utterly untrustworthy.

I might pile up instances of visual illusion, for example, in which the subject would be ready to affirm without the slightest hesitation that he sees something which greatly differs from the object that actually forms the picture on his retina; his erroneous interpretation of that picture being the result of a prepossession derived from antecedent experience. I could show, too, that the same picture may be interpreted in two different modes: a skeleton-diagram, for example, suggesting two dissimilar solid forms, according as the eyes are fixed on one or another of its angles; and a photograph of a coin or fossil being seen as a cameo or as an intaglio, according as the position of the light affects the interpretation of its lights and shadows. Again, I have before me two pieces of card, A and B, of similar form: when A is placed *above* B, the latter is unhesitatingly pronounced the larger; if their relative positions be reversed, A is pronounced with equal conviction, to be the larger; yet, when one is laid *upon* the other, they are found to be precisely equal in size.

So, again, in those more complex combinations of natural objects which the pictorial artist aims to represent, the different modes in which the very same scene shall be treated by two individuals working at the same time and from the same point of view, show how differently they interpret the same visual picture, according to their original constitution and subsequent training. As Carlyle says, "The eye sees what it brings the power to see."

But mental prepossessions do much more than this; they *produce* sensations having no objective reality. I do not here allude to those "subjective sensations" of physiologists, which depend upon physical affections of nerves in their course, the circulation of poisoned blood in the brain (as in the delirium of fever), and the like; but I refer to the sensations produced by *mental expectancy*, a most fertile source of self-deception. The medical practitioner is familiar with these in the case of "hysterical" subjects; whose pains are as real experiences to them, as if they originated in the parts to which they are referred. And I have no reason to doubt that the "sensitives" of Reichenbach really saw the flames they described as issuing from magnets in the dark,—as a very honest and highly educated gentleman assured me that he did, not only when the magnet was there, but when he believed it to be still there (in the dark), after it had been actually withdrawn. So there are "sensitives" in whom the drawing of a magnet along the arm will produce a sensible *aura* or a pricking pain; and this will be equally excited by the belief that the magnet is being so used, when nothing whatever is done.

Now, the phenomena of which these are simple examples, appear to me to have this physiological signification,—that changes in the cerebrum which answer to the higher mental states, act *downwards* upon the sensorium at its base, in the same manner as changes in the organs of sense act *upwards* upon it; the very same state of the sensorium being producible through the nerves of the *internal* and of the *external* senses, and the very same affection of the sensational consciousness being thus called forth by impressions *ab extra* and *ab intra.* Thus individuals having a strong pictorial memory can reproduce scenes from nature, faces, or pictures, with such vividness that they may be said to see with their "mind's eye" just as distinctly as with their bodily eye; and there is an instance on record (which Mr. Ruskin fully accredits, as well from having seen the two pictures as from his own similar experiences) in which a painter at Cologne accurately reproduced from memory a large altar-piece by Rubens, which had been carried away by the French. Those, again, who possess a strong pictorial imagination, can thus *create* distinct visual images of what they have never seen through their bodily eyes. And although this power of voluntary representation is comparatively rare, yet we are all conscious of the phenomenon as occuring involuntarily in our dreams.

Now, there is a very numerous class of persons who are subject to what may be termed "waking dreams," which they can induce by placing themselves in conditions favourable to reverie;

and the course of these dreams is essentially determined by the individual's prepossessions, brought into play by suggestions conveyed from without. In many who do not spontaneously fall into this state, fixity of the gaze for some minutes is quite sufficient to induce it; and the "mesmeric mania" of Edinburgh in 1851, showed the proportion of such susceptible individuals to be much larger than was previously supposed. Those who have had adequate opportunities of studying these phenomena, find no difficulty in referring to the same category many of the "spiritualistic" performances of the present time, in which we seem to have reproductions of states that were regarded in ancient times, under the influence of religious prepossession, as results of divine inspiration. I have strong reason to believe (from my conviction of the honesty of the individuals who have themselves narrated to me their experiences) that they have really seen, heard, and felt what they describe, where intentional deception was out of the question; that is, that they had the same distinct consciousness, in states of expectant reverie, of seeing, touching, and conversing with the spirits of departed friends, that most of us occasionally have in our dreams. And the difference consists in this—that whilst one, in the exercise of his common sense, dismisses these experiences as the creation of his own brain, having no objective reality, the other, under the influence of his prepossession, accepts them as the results of impressions *ab extra* made upon him by "spiritual" agencies.

The faith anciently placed, by the Heathen as well as the Jewish world, in dreams, visions, trances, etc., has thus its precise parallel in the present day; and it is not a little instructive to find a very intelligent religious body, the Swedenborgians, implicitly accepting as authoritative revelation the visions of a man of great intellectual ability and strong religious spirit, but highly imaginative disposition, the peculiar feature of whose mind it was to dwell upon his own imaginings. These he seems to have so completely separated from his worldly life, that the Swedenborg who believed himself to hold intercourse with the spiritual world, and Swedenborg the mechanician and metallurgist, may almost be regarded as two distinct personalities.

If, then, the high scientific attainments of some of the prominent advocates of "spiritualism," and our confidence in their honesty, be held to require our assent to what they narrate as their experiences, in regard to a class of phenomena which they declare that they have witnessed, but which they cannot reproduce for the satisfaction of other men of science who desire to submit them to the rigorous tests which they regard as necessary to substantiate their validity, then we must, in like manner, accept the records of Swedenborg's revelations as binding on our belief. That they were *true to him* I cannot doubt; and in the same manner, I do not question that Mr. Crookes is thoroughly honest, when he says that he has repeatedly witnessed the "levitation of the human body." But I can regard his statements in no other light, than as evidence of the degree in which certain minds are led by the influence of strong "prepossession," to believe in the creations of their own visual imagination.

All history shows that nothing is so potent as religious enthusiasm, in fostering this tendency; the very state of enthusiasm, in fact, being the "possession" of the mind by fixed ideas, which overbear the teachings of objective experience. These, when directed to great and noble ends, may overcome the obstacles which deter cooler judgments from attempting them; but, on the other hand, may also move not only individuals but great masses of people to extravagances at which sober common sense revolts; as the history of the Flagellants, the dancing mania, and other religious epidemics of the Middle Ages forcibly illustrate. And nothing is more remarkable in the history of these epidemics, than the vividness with which people who were not asleep, saw visions that were obviously inspired by the prevalent religious notions of their times. Thus, some of the dancers saw heaven opened, and the Saviour enthroned with the Virgin Mary; whilst others saw hell yawning before their feet, or felt as if bathed in blood; their frantic leaps being prompted by their eagerness to reach towards the one or to escape from the other.

In the next place, I would briefly direct attention to the influence of prepossessions on those *interpretations* of our sensational experiences, which we are prone to substitute for the statement of the experiences themselves. Of such misinterpretations, the records of science are full; the tendency is one which besets every observer, and to which the most conscientious have frequently yielded; but I do not know any more striking illustrations of it than I could narrate from my own inquiries into mesmerism, spiritualism, etc. The most diverse accounts of the *facts* of a *séance* will be given by a believer and a sceptic. One will declare that a table rose in the air, while another (who had been watching its feet) is confident that it never left the ground; a whole party of believers will affirm that they saw Mr. Home float out of one window and in at another, whilst a single honest sceptic declares that Mr. Home was sitting in his chair all the time. And in this last case we have an example of a fact, of which there is ample illustration, that during the prevalence of an epidemic delusion the honest testimony of any number of individuals on one side, if given under a "prepossession," is of no more weight than that of a single adverse witness—if so much. Thus I think it cannot be doubted by any one who candidly studies the witchcraft trials of two centuries back, that, as a rule, the witnesses really believed what they deposed to as facts; and it further seems pretty clear that in many instances the persons incriminated were themselves "possessed" with the notion of the reality of the occult powers attributed to them. No more instructive lesson can be found, as to the importance of the "subjective" element in human testimony, than is presented in the records of these trials. Thus, Jane Brooks was hung at Chard assizes in 1658, for having bewitched Richard Jones, a sprightly lad of twelve years old; he was seen to rise in the air and pass over a garden wall some thirty yards; and nine people deposed to finding him in open daylight, with his hands flat against a beam at the top of the room, and his body two or three feet from the ground! If this "levitation of the human body," confirmed as it is in modern times by the testimony of Mr. Crookes, Lord Lindsay, and Lord Adair, to say nothing of the dozen witnesses to Mrs. Guppy's descent through the ceiling of a closed and darkened room, has a valid claim on our belief, how are we to stop short of accepting, on the like testimony, *all* the marvels and extravagances of witchcraft? If, on the other hand, we put these witnesses out of court, as rendered untrustworthy by their "prepossession," what credit can we attach to the testimony of any individuals or bodies dominated by a strong religious "prepossession;" that testimony having neither been recorded at the time, nor subjected to the test of judicial examination?

Though I have hitherto spoken of "prepossessions" as ideational states, there are very few in which the emotions do not take a share; and how strongly the influence of these may pervert the representations of actual facts, we best see in that early stage of many forms of monomania, in which there are as yet no fixed delusions, but the occurrences of daily life are wrongly interpreted by the emotional colouring they receive. But we may recognize the same influence in matters which are constantly passing under our observation; and a better illustration of it could scarcely be found than in the following circumstance, mentioned to me as having recently occurred in the practice of a distinguished physician:—The head of a family having been struck down by serious illness, this physician was called in to consult with the ordinary medical attendant; and after examining the patient and conferring with his colleague, he went into the sitting-room where the family were waiting in anxious expectation for his judgment on the case. This he delivered in the cautious form which wise experience dictated:—"The patient's condition is very critical; but I see no reason why he should not recover." One of the daughters screamed, "Dr. —— says Papa will die!" another cried out, in a jubilant tone, "Dr. —— says Papa will get well." If no explanation had been given, the two ladies would have reported the physician's verdict in *precisely opposite terms*, one being under the influence of *fear*, the other of *hope*.

I shall now give a few illustrative examples, from recent experiences, of the contrast between the two views taken of the same phenomena, (1) by such as are led by their "prepossessions" at once to attribute to "occult" influences what they cannot otherwise explain, and (2) by those who, under the guidance of trained and organized common sense, apply themselves in the first instance, to determine whether there be anything in these phenomena which "natural" agencies are *not* competent to account for.

1. When, in 1853, the "table-turning" epidemic had taken so strong a hold of the public mind, that Professor Faraday found himself called upon to explain its supposed mystery, he devised a very simple piece of apparatus for testing the fundamental question, whether there is any evidence that the movements of the table are due to *anything else* than the muscular action of the performers who place their hands upon it. And having demonstrated by its means (1) that the table never went round unless the "indicator" showed that lateral pressure had been exerted in the direction of the movement, whilst (2) it always did go round when the 'indicator' showed that such lateral pressure was adequately exerted, he at once saw that the phenomenon was only another manifestation of the involuntary "ideo-motor" action which had been previously formulated, on other grounds, as a definite physiological principle; and that there was, therefore, not the least evidence of any other agency. Yet it is still asserted that the validity of Faraday's test is completely disproved by the conviction of the performers that they do not exert any such agency; all that this proves being that they are *not conscious* of such exertion—which, to the physiologist, affords no proof whatever that they are not making it.

2. So again Professors Chevreul and Biot, masters of experimental science worthy to be placed in the same rank with Faraday, had been previously applying the same principles and methods to the systematic investigation of the phenomena of the Divining rod and the oscillations of suspended buttons; the former of which were supposed to depend upon some "occult" power on the part of the performer, whilst the latter were attributed to an hypothetical "odylic" force. And they conclusively proved that in both cases the results are brought about (as in table-turning) by the involuntary action of mental expectancy on the muscles of the performer; the phenomena either not occurring at all, or having no constancy whatever, when he neither knows nor guesses *what to expect.*—The following instance of the application to the phenomena of the divining rod, of the very simple test of *closing the eyes*, has lately been sent me by an American friend, who was apparently unaware of its former application by Chevreul and Biot. "An aged clergy-

"man of thorough integrity, has for many years enjoyed the "reputation of being specially skilled in the finding of places to "dig wells by means of the 'divining rod.' His fame has spread "far; and the accounts that are given by him, and of him, must "be to those who place an implicit reliance on human testimony "overwhelmingly convincing. He consented to allow me to "experiment with him, and I found that only a few moments "were required to prove that his fancied gift was a delusion. In "his own yard there was known to be a stream of water running "a few feet below the surface, through a small pipe. As he "marched over and near this, the rod continually pointed "strongly downwards, and several times turned clear over. "These places I marked, and then blindfolded him, and "marched him about until he knew not where he was, taking "him over the same ground over and over again; and although "the rod went down a number of times, *it did not once point to* "*or near the places indicated.*"

3. About twenty-five years ago, when the old phenomena of the oscillations of suspended buttons, developed by Dr. H. Mayo into a pseudo-scientific theory of od-force, were strongly exciting public attention, a medical friend of great intelligence, then residing in the south of France, wrote me long letters giving the results of his surprising experiences, and asking what I regarded as their *rationale.* My reply was simply,—"Shut your eyes, and let some one else observe the oscillations." In a short time I heard from him again, to the effect that his re-investigation of the matter under this condition had satisfied him that there was no other agency concerned than his own involuntary muscular movement, directed by his *mental expectancy* of the results which would ensue.

In the foregoing cases, the honest beliefs of the agents themselves brought about the results; in the following, these beliefs were taken up by the witnesses to the performances of others, in spite of all common-sense probability to the contrary, under the influence of their own strong "prepossessions."

4. At a spiritualistic *séance* at which I was present, at an early stage of the present epidemic, the "medium" pressed down one

side of a large loo table supported on a pedestal springing from three spreading feet, and left it resting on only two of its feet, with its surface at an angle of about 45°. Having been admitted to this *séance* under a promise of non-interference, I waited until its conclusion; and then, going over to the table, *set it up and left it in the same position.* For I had observed, when this was done by the "medium," that the edge of the broad claw of each foot, and the edge of its castor, bore on the ground together, so as to afford a base which, though narrow, was sufficient for the table to rest on, its weight happening to be balanced when thus tilted half over. Several persons of great general intelligence who were present at this *séance* (Mr. Robert Chambers among the rest), assured me that if it had not been for my exposure of this trick, they should have gone away in the belief that the table was sustained by "spiritual" influence, as in no other way could they suppose it to have kept its position against the force of gravity.

5. So strong was the impression made by the rope-tying and other performances of the Davenport Brothers, about twenty years ago, upon those who were already prepossessed in favour of their "spiritualistic" claims, that I was pressed by men of distinguished position to become a member of a committee for their "scientific" investigation. Having a strong prepossession, however, in favour of the common-sense view that these performances were but the tricks of not very clever jugglers, and learning that this inquiry was to take place in a darkened room, and that the members of the committee must form a circle with joined hands, I at once declined to have anything to do with it; on the ground that, to exclude the use of the eyes and hands, which the scientific investigator uses as his chief instruments of research, was to render the inquiry utterly nugatory. Now that the tricks of the Davenport Brothers have been not merely imitated but surpassed by Messrs. Cooke and Maskelyne, I suppose that no truly "rational" person would appeal to them as evidence of "spiritual" agency.

6. During the meeting of the British Association at Belfast in 1874, a lady medium of great repute held spiritualistic *séances*, at which she distributed flowers, affirmed to have been brought

to her then and there by the spirits, fresh from the garden, with the dew of heaven upon them. As there was nothing more in this performance than is done every day by an ordinary conjuror, only the confidence entertained in the good faith of the medium could justify a belief in the "spiritual" transport of the flowers; but this belief, aided by the general "prepossession," had been implicitly accepted by many of the witnesses on such occasions. An inquisitive young gentleman, however, who was staying in the same house, and did not share in this confidence, found a basin-full of these flowers (hollyhocks) in a garret, with a decanter of water beside it; and strongly suspecting that they had been stored there with a view to distribution at the *séance*, and that the dew would be supplied, when wanted, from the decanter, he conveyed into the water a chemical substance (ferrocyanide of potassium), in quantity so small as not to tinge it, and yet to be distinctly recognizable by the proper test. On the subsequent application of this test (a per-salt of iron) to the flowers distributed by the "medium," they were found to give *Prussian blue*. —This is no piece of hearsay, but a statement which I have in the hand of the gentleman himself, with permission to make it public.

But every form of "prepossession" has an involuntary and unsuspected action in modifying the memorial traces of past events, even when they were originally rightly apprehended. A gradual change in our own mode of viewing them will bring us to the conviction that we always so viewed them; as we recently saw in the erroneous account which Earl Russell gave of his action as Foreign Secretary in the negotiations which preceded the Crimean war. His subsequently acquired perception of what he should have done at a particular juncture, wrought him up to the honest belief that he really did it. To few persons of experience in life has it not happened to find their distinct impressions of past events in striking disaccordance with some contemporary narrative, as perhaps given in a letter of their own. An able lawyer told me not long since that he had had occasion to look into a deed which he had not opened for twenty years, but which he could have sworn to contain certain clauses; and to his utter astonishment, the clauses were not to be found in it. His habitual conception of the purpose of the deed had constructed what answered to the actual memorial trace.

Now this constructive process becomes peculiarly obvious, in a comparison of narratives given by the believers in mesmerism, spiritualism, and similar "occult" agencies, when there has been time for the building-up of the edifice,—with contemporary records of the events, made perhaps by the very narrators themselves. Everything which tends to prove the reality of the occult influence, is exaggerated or distorted; everything which would help to explain it away, is quietly (no doubt quite unintentionally) dropped out. And convictions thus come to be honestly entertained, which are in complete disaccordance with the original facts. This source of fallacy was specially noticed by Bacon:—

"When the mind is once pleased with certain things, it draws "all others to consent, and go along with them; and though the "power and number of instances that make for the contrary, are "greater, yet it either attends not to them, or despises them, or "else removes them by a distinction, with a strong and pernicious "prejudice to maintain the authority of the first choice unviolated. "And hence in most cases of superstition, as of astrology, dreams, "omens, judgments, etc., those who find pleasure in such kind "of vanities *always observe where the event answers, but slight and* "*pass by the instances where it fails, which are much the more* "*numerous.*"—NOVUM ORGANON.

Of the manner in which this constructive process will build up a completely ideal representation of a personality (with or without a nucleus of reality), which shall gain implicit acceptance among a whole people, and be currently accepted by the world at large, we have a "pregnant instance" in the William Tell tradition. For the progressive narrowing-down of his claims, which has resulted from the complete discordance between the actions traditionally attributed to him and trustworthy contemporary history, leaves even his personality questionable; while the turning-up of the apple-story in Icelandic sagas and Hindoo myths seems to put it beyond doubt that this, at any rate, is drawn from far older sources. The reality of this process of gradual accretion and modification, in accordance with current ideas in regard to the character of an individual or the bearing of an event, cannot now be doubted by any philosophic student of history. And the degree in which such constiuctions involve ascriptions of supernatural power, can be shown in many instances to depend upon the prevalent notions entertained as to what the individual might be expected to do.

No figure is more prominent in the early ecclesiastical history of Scotland, than that of St. Columba, "the Apostle of the Scoto-Irish," in the sixth century. Having left Ireland, his native country, through having by his fearless independence been brought into collision with its civil powers, and been excommunicated by its church-synods, he migrated to Scotland in the year 563, and acquired by royal donation the island of Iona, which was a peculiarly favourable centre for his evangelizing labours, carried on for more than thirty years among the Picts and Scots, and also among the northern Irish. No fewer than thirty-two separate religious foundations among the Scots, twenty-one among the Picts, and thirty-seven among the Irish, many of which occupied conspicuous places in the monastic history of the earlier Middle Ages, seem to have been planted by himself or his immediate disciples; the most celebrated of all these being the college of the Culdees at Iona, which kept alive the flame of learning during a prolonged period of general ignorance and superstition, and became a centre of religious influence, which extended far beyond the range of its founder's personal labours, and caused his memory to be held in the deepest veneration for centuries afterwards. The point on which I here desire to lay stress, is *the continuity of history*, as trustworthy as any such history can be; the incidents of St. Columba's life having been originally recorded in the contemporary *fasti* of his religious foundation, and transmitted in unbroken succession to Abbot Adamnan, who first compiled a complete *Vita* of his great predecessor, of which there still exists a manuscript copy, whose authenticity there is no reason to doubt, which dates back to the early part of the eighth century, not much more than one hundred years after St. Columba's death. Now, Adamnan's *Vita* credits its subject with the possession of every kind of miraculous power. The saint prophesied events of all kinds, trivial as well as grave, from battles and violent deaths, down to the spilling of an inkhorn, the falling of a book, the omission of a single letter from a writing, and the arrival of guests at the monastery. He cured numbers of people afflicted with inveterate diseases, accorded safety to storm-tossed vessels, himself walked across the sea to his island home, drove demons out of milk-pails, outwitted sorcerers, and gave supernatural powers to domestic implements. Like other saints, he had his visions of angels and apparitions of heavenly light, which comforted and encouraged him at many a trying juncture,—lasting, on one occasion, for three days and nights.

Now it seems to me beyond all reasonable doubt, that St. Columba was one of those men of extraordinary energy of character and earnest religious nature, who have the power of strongly impressing most of those with whom they come into contact, moulding their wills and awakening their religious sympathies, so as to acquire a wonderful influence over them; this being aided by the commanding personal "presence" he is recorded to have possessed. And it is not surprising that when themselves the subjects of what they regarded as "supernatural" power, they should attribute to him the exercise of the same power in other ways. In fact, to their unscientific minds it seemed quite "natural" that he should so exert it; its possession being, in their belief, a normal attribute of his saintship. That he himself believed in his gifts, and that many wonders were actually worked by the concurrent action of his own faith in himself and his followers' faith in him, will not seem unlikely to any one who has carefully studied the action of mental states upon the bodily organism. And that round a nucleus of truth there should have gathered a large accretion of error, under the influence of the mental preconception whose *modus operandi* I have endeavoured to elucidate, is accordant with the teachings of our own recent experience, in such cases as that of Dr. Newton and the Zouave Jacob. In these and similar phenomena, a strong conviction of the possession of the power on the part of the healer seems to be necessary for the excitement of the faith of those operated on; and the healer recognizes, by a kind of intuition, the existence of that faith on the part of the patient. Do not several phrases in the gospel narratives point to the same relations as existing between Jesus and the sufferers who sought his aid? The cure is constantly attributed to the "faith" of the patient; whilst, on the other hand, we are told that Jesus did not do many mighty works in his own country "because of their unbelief," — the very condition which, if these mighty works had been performed by his own will alone, would have been supposed to call forth its exertion, but which is perfectly conformable to our own experience of the wonders of mesmerism, spiritualism, etc. So Paul is spoken of as "steadfastly beholding" the cripple at Lystra, "and seeing that he had faith to be healed."

The potency of influences of the opposite kind upon minds predisposed to them, and through their minds upon their bodies, is shown in the "Obeah practices" still lingering among the negroes of the West Indian colonies, in spite of most stringent legislation. A slow pining away, ending in death, has been the not unfrequent result of the fixed belief, on the part of the victim, that "Obi" has been put upon him by some old man or old woman reputed to possess the injurious power; and I see no reason to doubt that the Obi men or women were firm believers in the occult power attributed to them.

Every medical man of large experience is well aware how strongly the patient's undoubting faith in the efficacy of a particular remedy or mode of treatment assists its action; and where the doctor is himself animated by such a faith, he has the more power of exciting it in others. A simple prediction, without any remedial measure, will sometimes work its own fulfilment. Thus, Sir James Paget tells of a case in which he strongly impressed a woman having a sluggish, non-malignant tumour in the breast, that this tumour would disperse within a month or six weeks; and so it did. He perceived the patient's nature to be one on which the assurance would act favourably, and no one could more earnestly and effectively enforce it.—On the other hand, a fixed belief on the part of the patient that a mortal disease has seized upon the frame, or that a particular operation or system of treatment will prove unsuccessful, seems in numerous instances to have been the real occasion of the fatal result.

Many of the so-called "miracles" of the Romish Church, such as that of the "Holy Thorn" (narrated in the History of the Port Royalists) which stood the test of the most rigid contemporary inquiry, carried on at the prompting of a hostile ecclesiastical party, seem to me fully explicable on the like principle of the action of strongly excited "faith" in producing bodily change, whether beneficial or injurious; and nothing but the fact that this strong excitement was called forth by religious influences, which in all ages have been more potent in arousing it than influences of any other kind, gives the least colour to the assumption of their supernatural character.

I might draw many other illustrations from the lives of the Saints of various periods of the Roman Catholic Church, as chronicled by their contemporaries, many of whom speak of themselves as eye-witnesses of the marvels they relate; thus, the "levitation of the human body"—*i.e.*, the rising from the ground, and the remaining unsupported in the air for a considerable length of time—is one of the miracles attributed to St. Francis d'Assisi. But it will be enough for me to refer to the fact that some of the ablest ecclesiastical historians in the English Church have confessed their inability to see on what grounds—so far as *external evidence* is concerned—we are to reject these, if the testimony of the Biblical narratives is to be accepted as valid evidence of the supernatural occurrences they relate.

But the most remarkable example I have met with in recent times of the "survival" in a whole community of ancient modes of thought on these subjects (the etymological meaning of the term "superstition"), has been very recently made public by a German writer, who has given an account of the population of a corner of Eastern Austria, termed the Bukowina, a large proportion of which are Jews, mostly belonging to the sect of the Chassidim, who are ruled by "Saints" or "Just Ones." "These "saints," says their delineator, "are sly impostors, who take advantage of the fanaticism, superstition, and blind ignorance of "the Chassidim in the most barefaced manner. They heal the "sick by pronouncing magic words, drive out devils, gain lawsuits, "and their curse is supposed to kill whole families, or at least to "reduce them to beggary. Between the 'saint' and 'God' there "is no mediator, for he holds personal intercourse with the Father "of all, and his words are oracles. Woe to those who should "venture to dispute these miracles in the presence of these un-

"reasonable fanatics! They are ready to die for their superstitions "and to kill those who dispute them." *

Now I fail to see what stronger external evidence there is of any of the supernatural occurrences chronicled in the Old Testament, than that which is afforded by the assured conviction of this Jewish community as to what is taking place at the present time under their own eyes. And assuming, as I suppose most of us should be ready to do, that the testimony to these contemporary wonders would break down under the rigorous test of a searching examination, I ask whether we are not equally justified in the assumption that a similar scrutiny, if we had the power to apply it, would in like manner dispose of many of the narratives of old time, either as distortions of real occurrences, or as altogether legendary.

In regard to the New Testament miracles generally, whilst failing to see in what respect the external testimony in their behalf is stronger than it is for the reality of the miracles attributed to St. Columba, I limit myself at present to the following questions :—

First. Whether the "miracles of healing" may not have had a foundation of reality in "natural" agencies perfectly well-known to such as have scientifically studied the action of the mind upon the body. In regard to one form of these supposed miracles—the casting out of devils—I suppose that I need not in these days adduce any argument to disprove the old notion of "demoniacal possession," in the face of the fact that the belief in such "possession" in the case of lunatics, epileptics, etc., and the belief in the powers of "exorcists" to get rid of it, is still as prevalent among Eastern nations as it was in the time of Christ. And I suppose, too, that since travellers have found that the Pool of Bethesda is fed by an intermittent spring, few now seriously believe in the occasional appearance of an "angel" who moved its water; or in the cure of the first among the expectant sick who got himself placed in it, by any other agency than his "faith" in the efficacy of the means. I simply claim the right to a more extended application of the same critical method.

Secondly. Whether we have not a similar right to bring to

* E. Kilian, in *Fraser's Magazine* for December, 1875.

bear on the study of the Gospel narratives, the same *principles* of criticism as guided the early Fathers in their construction of the Canon, with all the enlightenment which we derive from the subsequent history of Christianity, aided by that of other forms of religious belief. The early Christian Fathers were troubled with no doubts as to the reality of miracles in themselves; and they testified to the healing of the sick, the casting out of devils, and even the raising of the dead, as well-known facts of their own time. But they rejected some current narratives of the miraculous which they did not regard as adequately authenticated, and others as considering them puerile. Looking at it not only as our right, but as our duty, to bring the higher critical enlightenment of the present day to bear upon the study of the Gospel records, I ask whether both past and contemporary history do not afford such a body of evidence of a prevalent tendency to exaggeration and distortion, in the representation of actual occurrences in which "supernatural" agencies are supposed to have been concerned, as entitles us, without attempting any detailed analysis, to believe that if we could know *what really did happen*, it would often prove to be something very different from what is narrated.

By such a general admission, we may remove the serious difficulties to which I alluded at the outset—difficulties which must, I think, have been present to the mind of Locke, when he recorded, in the Common-place Book published by Lord King, the remarkable aphorism that "the doctrine proves the miracles, rather than "the miracles the doctrine."

IX.

ON THE DOCTRINE OF HUMAN AUTOMATISM.

[*Contemporary Review*, February, 1875.]

WHAT is the range and limit of the Automatic action of the body of Man, and what clue we gain from modern physiological research as to the manner in which it is controlled and directed by his mind, are the questions I propose to discuss in this paper; and it will, I think, be advantageous to enter upon the discussion historically, by tracing the principal stages in the development of the system of doctrine now generally accepted by physiologists.

Somewhat more than fifty years ago (1821), the publication of the discoveries of Charles Bell gave a new impetus to a study which had previously made but little progress for more than a century. It was by him that the principle was first placed on a valid experimental basis, that every one of the multitudinous fibres of which any single nerve-trunk is composed, runs a distinct course between its central and its peripheral terminations; and that its function consists in establishing a connection, in the one case, between an organ of sense and the central sensorium; or, in the other, between a motor centre and the muscle which it calls into contraction. The fibres of the former class he termed "sensory," and those of the latter "motor;" and he showed that while the ordinary spinal nerves contain fibres of both functions (separated, however, into distinct groups at their roots), there are nerves in the head which are sensory only, and others which are solely motor. It has since been proved, however, that between these two classes of nerve-fibres there is not really any essential difference, each serving, like a telegraph-wire, to convey "molecular motion" (the now fashionable mode of expressing a change of whose nature we really know nothing whatever) in either direction, and its function depending entirely upon its connections. The subsequent progress of inquiry, moreover, has made it clear that such "molecular motion," transmitted from a recipient organ to a nerve-centre, may there excite a motor response without any affection of the consciousness; and hence the "sensory" nerves of Bell are now more generally termed "afferent," or "centripetal."

The "nervous circle," as it was termed by Bell, composed of a sensory nerve, the nerve-centre to which it proceeds, and the motor nerve passing forth from that centre to the muscles, was distinctly recognized by him as furnishing the mechanism of those involuntary movements which are called forth by sensory impressions; as when the passage of a crumb of bread, a drop of water, or a whiff of acrid vapour into the larynx, excites the act of coughing;—the impression transmitted upwards by the sensory nerves to a certain part of the brain (including in this term, for the present, the whole aggregate of nerve-centres contained in the cranial cavity), making itself felt there, and calling forth, through the motor nerves that proceed to the muscles of expiration, a combined movement adapted to get rid of the source of irritation. This is a typical example of what is now termed *reflex action* which may be regarded as the elementary form of nervous activity.

In such a low and almost homogeneous organism as that of the *hydra* (or fresh-water polype), however, every part seems equally capable of receiving impressions and of responding to them by contraction. As there are neither special sense-organs nor special muscles, there are no special nerves; and the movements by which it grasps the prey that may come within its reach, and draws it into its digestive cavity, are no more indicative of consciousness or will, than are those of the muscles of the gullet that carry down into the stomach the food which is brought within their grasp in the act of swallowing, or than the churning action of the stomach itself during the process of digestion. The continuance of these movements in the alimentary canal of higher animals, after it has been taken out of the body, is a clear proof of their purely *automatic* nature; and there is no reason to regard the prehensile actions of the hydra, or other animals of similar grade of organization, in any other light.

But with the development of a special muscular apparatus, and the limitation (with accompanying exaltation) of the sensory endowments of particular parts of the organism, we find a nervous mechanism interposed, the primary office of which is obviously "internuncial" merely. Thus, in the humble ascidian, rooted to one spot during all but its free embryonic stage of existence, and obtaining both its food and the oxygen required for the aeration of its blood by currents sustained by the vibration of the cilia that line its alimentary canal and respiratory sac, an action that resembles coughing is the only sign it gives of any but a purely vegetative existence. The orifice of the dilated pharynx which forms the respiratory sac is fringed with short tentacles, from which nerve-fibres proceed to a ganglionic centre in their neighbourhood; and from this centre we find motor fibres ramifying over the muscular mantle in which the body is inclosed. And thus if the ciliary current should draw inwards a particle of unsuitable size or character, the contact of this with the guardian-tentacles excites a reflex contraction of the muscular sac, whereby a jet of water is squirted out that carries the offending particle to a distance. It is obvious that this act no more represents conscious intention on the part of the ascidian, than the cough of the infant represents a desire to get rid of an uneasy sensation in its throat; in the one case as in the other, the adaptiveness of the action to the purpose it answers is simply that of a piece of mechanism; and we characterize it, therefore, as *automatic.*

It has been shown by Professor Huxley that Descartes, who distinctly recognized the purely mechanical nature of such actions, had made as near an approach as he could do to what we now regard as their true *rationale*, in attributing them to a reflexion of the "animal spirits" in the nerve-centres from the sensory to the motor nerves; and he seems further to have been in advance of his successors in maintaining that the impressions which call forth reflex movements may do so without being consciously felt. It is difficult, however, to ascertain precisely the real meaning of Descartes, as of many writers who succeeded him; for the Latin *sentire* and its derivations obviously cover a very wide range of mental affections, from simple consciousness up to the highest forms of thought and feeling; and it is clear from the illustrations given by Descartes, that he sometimes meant rather *self*-consciousness—that is, the consciousness of one's consciousness—than those simple states of feeling, which, though they can be shown to have *originally* guided our movements, in consequence of their habitual recurrence cease to excite our notice and are not remembered. To this distinction I shall presently have occasion to return.

The next important stage in the progress of neurological inquiry, consisted in the determination and general recognition of the independent endowments of the spinal cord. To those who have been brought up in modern neurological doctrine, it seems scarcely credible that the grossest ignorance should have prevailed up to the end of the first third of the present century, in regard to the *centric* character of this organ; even Bell regarding it as a bundle of nerves—a conductor that brings the nerve-trunks issuing from it into continuity with the brain, which was assumed to be (with the exception of the sympathetic ganglia) the sole centre of the nervous system of Vertebrate animals generally, and of man in particular. And in like manner the knotted ventral nerve-cord of articulated animals was represented by Bell's disciple, George Newport (and also by Professor Grant), as a mere conductor between the cephalic ganglia and the nerve-trunks. Yet Prochaska and Legallois had long before experimentally proved, not only that the spinal cord as a whole is a centre of reflex action quite independent of the brain, but that separated segments of the spinal cord may so act independently of each other. So, in the case of articulated animals, any one who had cut a worm or a centipede into pieces, and had witnessed the continued movements of each segment, might have drawn the inference that these movements were sustained by the independent endowments of the ganglionic centres which the segments severally contained. It had been further proved by Legallois that the respiratory movements continue after the removal of the whole brain proper; the nerve-centre on whose action their continuance depends, being that upward extention of the spinal cord into the cavity of the skull which is known as the medulla oblongata. Yet these facts were so generally ignored in physiological teaching, that, as I can myself remember, they were only vaguely referred to in proof of the persistence of a low degree of consciousness after the loss of the brain.

No one whose recollection goes back as distinctly as mine does, to the publication (in the *Philosophical Transactions* for 1833) of Dr. Marshall Hall's "Researches on the reflex function "of the Medulla Oblongata and Medulla Spinalis," can have a doubt that this memoir has been the basis of all our present more exact knowledge of "reflex action" generally. It is true that its author developed no principle which could not have been found in the writings of Prochaska, more obscurely in those of his predecessor, Unzer, and yet less distinctly and more remotely in those of Descartes. But the ideas of these philosophers, having been in advance of their time, had never been received into the general body of physiological doctrine; and there can be little doubt of the originality of Dr. Marshall Hall's researches, although, by his indignant denial of having been *anticipated* by Prochaska, he provoked the imputation that he had *stolen* his ideas from that author. At any rate, it was by his persistence in calling attention to the demonstrative independence of the spinal cord and medulla oblongata as a centre (or rather series of centres) of nervous power, that the fact came to be universally accepted as a cardinal principle of physiology, and that the occurrence of "reflex action" *without any necessary excitement of consciousness* gradually obtained general recognition. Only those, however, who themselves took part in the controversy, will be likely to remember the strong opposition which the latter part of this doctrine encountered. The *purposive* character of the movements executed by a headless frog, as when its legs make efforts to push away the probe with which its cloaca is being irritated, or when one leg wipes away the acid applied to the surface of the other, was constantly adduced as a proof that the headless trunk *feels* the impression, and makes a conscious effort to get rid of it. And it is not even now possible to meet such an assertion with any direct disproof;

the arguments on the other side being rather of the nature of cumulative probabilities. Thus—(1) as the separated head of the frog will itself show reflex action (the eyelid closing when its edge is irritated), the division of the head from the body would establish two distinct centres of consciousness, or two *egos*, if the performance of reflex action be accepted *per se* as an indication of the persistence of sensibility; while (2) the number of these centres may be further multiplied by dividing the spinal cord in the middle of the back, so that the reflex actions of the fore limbs are performed through the instrumentality of the anterior segment, and those of the hind limbs through the instrumentality of the posterior segment; and (3) cases are of no infrequent occurrence in the human subject, in which, the lower segment of the spinal cord having been entirely cut off by disease or accident from communication with the brain, reflex actions in the legs may be excited by tickling the soles of the feet, or the application to them of a heated plate, without the least consciousness on the part of the patient, either of the application of the excitant, or of the respondent motions it calls forth. And though it was at first urged that this last fact gives no assurance that the endowments of the spinal cord are the same in the frog as they are in man, yet there has been a growing disposition to recognize the uniformity of Nature in this and other particulars, and to accept the facts of human consciousness (or unconsciousness) as affording the best data for the interpretation of such actions of the lower animals as are performed through a demonstrably similar instrumentality.

When once this principle is admitted, it becomes obvious that, however "purposive" may be the character of such actions, their performance from the first, without training or experience, may be regarded as valid evidence that they are determined by nothing else than a physical mechanism. No one doubts this in regard to that rhythmical succession of contractions and dilatations of the auricles and ventricles of the heart, by which the circulation of the blood is kept up; nor in regard to that regular sequence of respiratory movements which serves to maintain the aeration of the blood, alike in the waking state while the attention is completely engrossed elsewhere, and in the states of profound sleep and insensibility. And there are no co-ordinated muscular move ments of which the "purposive" character is more obvious, than it is in the acts of coughing and sucking; the former of which we know experientially to be executed without any conscious intention, and to be capable of being excited in states of the profoundest coma that is compatible with the continuance of ordinary breathing; while the latter, although requiring a still more complex combination of the movements of respiration with those of swallowing, can be shown to be a purely "reflex" act, being at once excited by the impression made on the lips of a new-born mammal, even when, in the case of a puppy or guinea-pig, the whole of the brain-proper has been experimentally removed, or when the human infant has come into the world with its spinal cord and medulla oblongata intact, but without any higher nervous centre.

It was while the doctrine of reflex action without the necessary participation of sensation was thus fighting its way to a place in the general scheme of neuro-physiology, that another very important advance was made by investigations of an entirely different nature, which gave it a cogency and completeness to which it could not otherwise have laid claim;—I refer to the establishment of the essential distinction, alike in structure and in function, between the two forms of nerve-substance that are known in human anatomy as the "grey" and the "white" matter. The determination of this distinction, which is one of even more fundamental importance than that established by Bell between the motor and sensory nerves, was not the work of any one physiologist. It had long been known that the white portion of the brain, the white strands of the spinal cord, and the entire substance of the nerve-trunks, have a fibrous structure; and the advance of histological research (which sprang from the application of the principle of achromatism to the microscope) demonstrated that these fibres were ultimately resolvable into tubules of extreme minuteness. On the other hand, the "grey" matter which forms the convoluted layer of the surface of the cerebrum, but which occupies the interior of the spinal cord and the ganglia of the sympathetic system, as it does of the ganglionic nerve-centres of Invertebrata, was found to be made up of cells or vesicles, certain extensions of which communicate with each other, whilst others become continuous with the fibres of the nerve-trunks. The difference in the relative supply of blood which these two forms of nerve-tissue respectively receive, is not less significant than that of their histological characters; this being especially manifest in the "grey" and the "white" portions of the brain. For, whilst the nerve-cells lie in the midst of a plexus of capillaries so close that no other tissue receives anything approaching to the same quantity of blood in a given space, the vascularity of the tubular component of the brain, spinal cord, and nerve trunks is by no means remarkable. And it is easily proved experimentally that, while an interruption to the circulation of the blood through the brain immediately suspends its functional activity, the conductivity of the nerve-trunks lasts for a considerable time after the general stoppage of the flow of blood through their vessels.

I can myself distinctly recollect the gradual spread of the belief in the physiological distinctness of these two forms of nerve-substance (of which the late Mr. S. Solly was one of the earliest upholders in this country) from a very limited circle to universal acceptance; the tubular being regarded, like the wires of the electric telegraph, as the *conductor* of nerve-force; whilst the vesicular or ganglionic was considered, like the battery which sends the charge, as the *originator* of nerve-force. We now know that this account of the matter is not strictly true; since the vesicular substance may serve also for the transmission, while the fibrous substance may, under certain circumstances, serve also for the origination, of that special form of "molecular motion" which constitutes the characteristic action of the nervous system. But in a broad, general way, the analogy is sufficiently correct; and the recognition of it soon led to important consequences. For Mr. R. D. Grainger showed, by a careful examination of the roots of the spinal nerves, that while some of them are continuous with the fibrous strands of the cord, which thus bring them into continuous connection with the cephalic centres, others lose themselves in its grey or vesicular nucleus, which, serving as their ganglionic centre, is the source of the independent power of the spinal cord; and he further pointed out that the relative proportions of this vesicular matter in the several parts of the spinal cord of different vertebrate animals is closely proportioned to the size of the trunks which proceed from them, and more particularly to the relative importance of the anterior and posterior members as instruments of locomotion. Taking up a suggestion thrown out by Mr. Grainger, I was myself led to re-examine, under this new light, the facts previously ascertained in regard to the structure and actions of the nervous system of invertebrate animals; with the result that these facts seemed to me not only to justify, but to require, the acceptance of the doctrine that every separate ganglion of the ventral cord of insects, centipedes, etc., is an independent centre of reflexion, the function of the cephalic ganglia (which are chiefly, if not entirely, the centres of the nerves of special sense,) being to harmonize and direct their activity. This, again, now seems to be so self-evident a proposition as to need no demonstration; yet it had, like the doctrines already summarized, to fight its way to general recognition; and though accepted by most British physiologists, it seems not to have been known on the Continent until the publication, four years subsequently, of the classical memoir "On the "Nervous and Circulatory Systems of the Myriapoda" (*Philosophical Transactions*, 1843), in which Mr. Newport gave in his adhesion to it.

The application of the doctrine of reflex action to insects gave a definite physiological basis for the doctrine of instinct. All who had carefully studied the remarkable habits of this class of animals, especially those of the social Hymenoptera, had been led to recognize their essentially *automatic* character; as specially indicated (1) by the almost invariable uniformity with which they are performed by all the individuals of the same type; (2) by the perfection with which they are performed from the very commencement of the life of the imago; and (3) by the impossibility, in many cases, of any training or guidance having been derived from parental experience, in the construction of habitations, the collection and storing up of food for the larvæ, and the like. Such actions can only be attributed to an innate or congenital tendency to particular "modes of motion" of the nervous system, dependent upon its mechanical arrangements; and to whatever extent insects learn from their own experience, or have the power of intentionally adapting their ordinary constructive operations to new conditions *—a question

* The account given by Mr. Belt in his *Naturalist in Nicaragua* of the adaptations made by ants, under contingencies brought about by human agency, and but little likely to have arisen under natural conditions, seems

still under discussion—no one, I believe, who has really studied the subject, would hesitate in endorsing the sagacious remark of Macleay, that just as intelligence (or the *intentional* adaption of means to ends) is the essential characteristic of vertebrate animals, culminating (of course) in man, so instinct (or the working-out of results by an *automatic* mechanism) is the essential characteristic of the articulate series, culminating in insects. And it is a curious confirmation of this view, that of all vertebrate animals, those which most strongly display instinctive propensities—modified, however, by intelligence—are birds, which have been appropriately termed "the insects of the vertebrated series."

The nature of Automatism, and the share it takes in the ordinary life of insects, etc., may be recognized in the following examples :—

> If the head of a *Centipede* be cut off whilst it is in motion, the body will continue to move onwards by the action of its legs; and if the body be divided into several pieces, the same will take place in the separate parts. After these movements have come to an end, they may be excited again by irritating any part of the nerve-centres or the cut extremity of the nervous cord. If the body be opposed in its progress by an obstacle over which the propulsive action of its legs can carry it, it mounts over it and moves directly onwards ; but if the obstacle be too high to be thus surmounted, the cut extremity remains forced up against it, the legs still continuing to move. The only difference, therefore, between the crawling of the headless and that of the complete *Centipede*, consists in the direction given to the movements of the latter by the visual sense ; the sight of an obstacle causing it to turn out of the way before reaching it.
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> There is an insect termed the *Mantis*, allied to the crickets and grasshoppers, whose conformation fits it to lie in wait for its prey, rather than to go in search of it. Resting on its two hinder pairs of legs, it lifts up the front of its body, which is furnished with a pair of large and strong legs ending in sharp claws, in readiness to capture any unlucky insect that may come

more indicative of their possession of intelligential power, than anything that had been ascertained by the elaborate observations of Huber.

within their reach; and it is from the resemblance of this attitude to that of prayer, that the *Mantis* has acquired from naturalists the specific name of *religiosa*, and from the peasantry of the South of France, where it abounds, the designation of *prie-Dieu*. Now, if the head be cut off, the body still retains its position, and resists attempts to overthrow it, while the arms close around anything that is introduced between them, and impress their claws upon it. This they will continue to do when the front portion of the body to which they are attached is separated from the rest; while the hinder part will still remain balanced on the four legs that support it, not only resisting any attempt to overthrow it, but recovering its position when disturbed. Here, again, it is obvious that the nerve-centres in the head have only a *directive* action, derived from the guidance afforded by the senses, especially the visual.

While the stimulus to the reflex movements of the legs in the foregoing cases appears to be given by the contact of the extremities with the solid surface whereon they rest, the appropriate impression, in the case of aquatic insects, can only be made by the contact of liquid. Thus the *cephalic ganglia* of the well-known water-beetle, *Dytiscus marginalis*, having been removed, the insect remained motionless so long as it rested on a dry surface; but when cast into water it executed the usual swimming movements with the greatest energy and rapidity, striking all its comrades to one side by its violence, and persisting in these for more than half an hour.

The directing action of the cephalic ganglia would seem, for the reasons already stated, to be not less automatic than the reflex action of the ganglia of the trunk; but whilst we have every reason to regard the latter as *not* involving consciousness, all analogy would indicate that the former cannot exert itself without the excitement of sensation. When we see an insect moving directly towards an object from a distance (as when bees fly straight to honey-yielding or pollen-yielding flowers, or make for the entrance of their hive at the approach of a summer shower), avoiding obstacles placed in its way, escaping from the hand that is coming down to crush, or the net that threatens to capture it; when, also, we see that it possesses organs, which, though framed on a different plan from our eyes, have a sufficient structural parallelism to justify the inference that they too have a visual function, it seems to me that the *onus probandi* lies on those who maintain that the motions of insects can be thus guided without sight of the objects which attract or repel them.

In this, as in other parts of the inquiry, the answer that is probably nearest the truth is that which we receive from our own consciousness when rightly interrogated. It was the sagacity of Hartley that first distinctly worked out the parallel (previously indicated by Descartes) between the *secondary* automatism which man acquires by habit, and the *original* or *primary* automatism of the lower animals. The act of walking, for example, though originally learned by experience under the guidance of sense-impressions, comes to be so completely automatic as to be kept up when once initiated by voluntary direction, not only without any conscious effort, but even without any consciousness of the movements we are performing, until our attention is called to them; so that, as it is credibly asserted, soldiers fatigued by a long march will continue to plod onwards (as Indian punkah-pullers will go on alternately twitching and letting go their cord) in a profound sleep. But whilst the locomotive actions performed in this last condition resemble those of the decapitated centipede, in simply carrying the body forwards without avoidance of obstacles, those of a man who is awake, but whose attention is engrossed by some internal object of contemplation, are obviously guided by impressions received through his visual organs. Thus I have seen John S. Mill making his way along Cheapside at its fullest afternoon tide, threading his way among the foot-passengers with which its narrow pavement was crowded, and neither jostling his fellows nor coming into collision with lamp-posts; and have been assured by him that his mind was then continuously engaged upon his System of Logic (most of which was thought-out in his daily walks between the India office and his residence at Kensington), and that he had so little consciousness of what was taking place around him, as not to recognize his nearest friends among the people he met, until his attention had been recalled to their presence. Most of us, I suppose, have had experiences of the same kind. It has often happened to myself, that, having previously intended to take some special direction, I have found myself in the track which I have been for years accustomed to follow for six days in the week, through having committed myself to the guidance of my *bête* as Xavier de Maistre calls it, whilst my *âme* was otherwise engaged. Now in these and similar cases, *do we see*, or *do we not see* the objects whose impressions upon our retinæ excite those molecular changes in our nerve-centres which direct our muscular action? I find it difficult to conceive that they act except through my consciousness, however faintly and transiently excited; but I would by no means assert it to be impossible. It is very important, however, to bear in mind the distinction between seeing and noticing, as also between hearing and apprehending. That we see and hear a great many things of which we take no distinct cognizance at the time for want of attention to them, is indicated by the fact that the remembrance of them surges up at some subsequent date, not unfrequently in dreams. And it seems to me more philosophical to regard the guiding action of visual impressions as exerted through the consciousness, however faintly it may be awakened, than to assert without a tittle of evidence that a bee does not see the flower or the entrance to its hive towards which it flies in a direct line, or that the chicken does not see the grain or insect at which it pecks. That the sensation may be "surplusage" where it prompts no higher psychical action, and that the physical change would equally take place without it, is doubtless an arguable proposition as regards the actions of animals whose life is purely automatic; but where the like actions (as in the case of man) have had to be learned by experience, it seems to me inconceivable that such experience can be gained except consciously. The child learning to walk, who (as Paley says) is "the greatest posture-master in the world," is vividly conscious of the sense of loss of balance to which he is unaccustomed; and it is under the guidance of that sense that his movements are directed to the recovery of his equilibrium. But by the habitual recurrence of similar experiences, a "mode of motion" comes to be established in his nervous mechanism, which shapes that mechanism (according to the physiological law of nutrition) in accordance with it; and thus the adult, who has acquired the art of shifting his weight from one foot to another, without anything more than a slight and transient disturbance of his equilibrium, ceases to perceive what has become monotonous by the frequency of its repetition; and it is only when his equilibrium happens to be more seriously disturbed by a slip of his foot or a stumble over an unnoticed obstacle, that he becomes aware of the constant control exercised over his automatic movements by this delicate regulating balance.

All these facts distinctly point to a reflex action of the ganglionic centres of the organs of special sense, as the mechanism by which impressions on those organs call forth and direct the instinctive actions of the lower animals; and, as we shall presently see, they harmonize completely with the results of experiments made upon the higher. Whether it be alone the "motion of molecules" (or physical change of any kind) that excites the respondent movement, or whether the sight, sound, smell, or other affection of the consciousness by the object which attracts or repels the insect, be a necessary link in the chain of sequences, is a question which seems to me to have no essential bearing upon the automatism of man; since the appeal to our own experience evokes the unhesitating response, that in him, at any rate (as presumably in the animals that most nearly approach him in structure), the higher forms of activity can only be excited in the first instance through the consciousness, though they too may become automatic by frequent repetition. The essential difference between what we are accustomed to term the instinctive actions of insects, and the simply reflex movements which we have seen to be executed by their headless trunks, or even by segments of those trunks, consists in their greater complexity and variety, and in the special controlling and directing power of the cephalic ganglia; and this may be equally exerted, whether the excitement of sensation (1) be a necessary link in the chain of sequences; or (2) be simply a concomitant, which must occur when the mechanism is in complete working order; or (3), as some maintain, is not really produced by impressions transmitted by the afferent nerves to the cephalic ganglia, any more than it is by the impressions which excite the separated ganglia of the ventral cord to reflex action. The first having been my former opinion, I was led to distinguish the actions automatically excited through the cephalic ganglia as *sensori-motor;*

but I now quite admit that there is much to be said in favour of the second. For the denial of consciousness to insects, however, I cannot see any other argument than that if "molecular motion" be competent to do the work, sensation would be a useless surplusage,—an application of the doctrine of final causes which can scarcely be admitted as having any scientific validity.

The study of the conditions of *instinctive* action having thus landed us in the conclusion of its dependence upon a mechanism of nerves and muscles excited to activity by external impressions, we apply the same method of inquiry to the conditions of that *rational* action with which we credit the higher vertebrates, and of which we trace the dawnings among the lower.

It is now universally acknowledged that the meaning of that complex aggregate of ganglionic centres which makes up the brain of man, can only be rightly understood by a careful study (1) of the comparative structure of the brains of the lower vertebrata, and (2) of the history of embryonic development. And it is the distinct teaching of both alike, that so far from the Cerebrum being the fundamental portion of the brain (as its enormous relative size in man would seem to indicate) it is originally a sort of offset, from that axial cord which constitutes the primary and essential part of the nervous apparatus of vertebrates; the lower part of this axis being formed by the spinal cord, and the upper by the series of ganglionic centres which lie along the floor of the skull, and which represent (in their relation to the sensory and motor nerves of the head) the cephalic ganglia of insects. For in the lowest fishes there is scarcely even a rudiment of the cerebrum, the forward extension of the spinal axis constituting the whole brain. And alike, as it would seem, in all vertebrates, the foundation of the cerebral hemispheres is laid, not in these first-formed "cerebral [or rather cephalic] vesicles," which really represent the higher segments of the axial cord, but in a pair of minute "vesicles of the cerebral hemispheres," which are budded off from the most anterior of these. The proportion which the development of the cerebrum, in the ascending series of vertebrata, bears to that of the axial cord, corresponds so closely with that which reason (so far as we can interpret its manifestations) bears to instinct, as to warrant the conclusion that, since we are justified in assuming that the axial cord (of which the cerebellum seems to be an appendage) furnishes the mechanism of automatic action, the cerebrum is the instrument of the intelligence. And experiment not only bears out this conclusion, but also demonstrates that a great number of actions which man requires long training to be able to perform—which training involves the conscious purposive effort of the Ego—are provided for in the lower animals by the automatic mechanism which they congenitally possess.

Among the lower vertebrates, the frog is the animal whose actions have been most thoroughly studied, and their mechanism most carefully investigated. These actions are for the most part very simple; the habits of the creature leading its natural life being for the most part such as mechanism will readily provide for. That to a very large extent they are purely automatic, can be demonstrated by experiments of the kind already cited. Thus, at the season of sexual excitement, the fore-legs of the male tend to close firmly upon anything that is placed between them (just as mechanically as the fly-trap of the *Dionæa* closes upon the unlucky insect that alights upon it), and will retain that clasp for weeks; and this although the spinal cord has been divided both above and below the segment from which the nerves of the fore-legs are given off. The clasping action may be excited by simply touching the thumb of either fore-foot, which at that season is considerably enlarged and furnished with a peculiar papillary structure; and thus it becomes obvious that this action no more indicates intention, than does the corresponding movement of the fore-legs of the Mantis. There are many other actions performed by the agency of the spinal cord alone, which seem so purposive as to make it difficult for those to regard them in any other light, who have not been led by the considerations previously urged, to recognize the large share which pure automatism has in the life of this animal. If, again, its cerebellum be left in connection with its spinal cord, the cerebrum and optic ganglia having been removed, it will execute all its locomotive movements as well as the complete frog would do, yet only in respondence to some stimulus. Thus if, as it sits upright in the usual attitude of a frog, the skin of its foot be pinched, it will jump; whilst, if thrown into water, it will swim, just like the brainless water-beetle already mentioned.

But if, instead of removing the whole of the brain, we take away (as in Göltz's experiments) only the cerebral hemispheres, leaving the whole axial cord uninjured, the condition of the frog is precisely assimilated to that of the pigeons from which the cerebral hemispheres were removed by Flourens, Magendie, and Longet, with results remarkably similar. Göltz's frog, like Flourens's pigeon, sits unmoved as if profoundly asleep, apparently seeing nothing and hearing nothing; but it will jump when irritated, and shows that its movements are guided (whether consciously or not) by the incidence of light on its eyes; for if a book be placed at some little distance in front, between the frog and the light, it will avoid the book, when excited to jump, by passing to the right hand or the left. And so Flourens's pigeon, when excited to walk by being pushed forwards, would avoid objects that lay in its way; and, according to the observation of Longet, if a lighted candle was made to describe a circle before its eyes, the head of the bird would move in a corresponding manner. Göltz's frog and Flourens's pigeon, moreover, while taking no notice of food, and making no effort to feed themselves, swallow food that is put into their mouths, and may be thus kept alive and vigorous for weeks or months, Göltz's frog croaking whenever a particular part of its back is stroked. The pigeon, moreover, gets upon its legs again when overthrown, and moves its wings in flight if thrown into the air, thus showing that the mechanism of its ordinary actions remains uninjured, though it does not spontaneously exert it. This is proved, in regard to the frog, by the curious observations of Göltz, which Professor Huxley has himself verified:—

"If put on the hand the frog sits there, crouched, perfectly "quiet, and would remain so unless stimulated to action; but if "the hand be inclined very gently and slowly, so that the frog "would naturally slip off, the creature's fore-paws are shifted on to "the edge of the hand, until he can just prevent himself from "falling. If the turning of the hand be slowly continued, he "mounts up with great care and deliberation, putting first one leg "forward and then the other, until he balances himself with per-

"fect precision upon the edge, and if the turning of the hand is "continued, over he goes, through the opposite set of operations, "until he comes to be seated in security upon the back of the "hand."

Even this we are fully justified in attributing to the action of a mechanism: for we are continually ourselves making yet more elaborate adjustments of our muscular movements, to perform some action which—originally voluntary—has come to be "mechanical;" and this under circumstances which forbid the idea that the conscious will in any way directs those adjustments. I have already pointed out this in the case of ordinary walking; and the balancing power of a practised rope-dancer would seem, from the feats which he performs, to be exerted scarcely less automatically. So in that most entertaining and suggestive book, "The Autobiography of Robert Houdin, Conjuror," the author tells us that he early in life trained himself to the performance of a number of his feats of dexterity, whilst reading a book with continuous attention; and that he thus gradually acquired the power of keeping *four* balls in the air, without a moment's distraction of his thoughts. And he further tells us that having a mind, while writing this passage of his memoir, to try to what extent he retained this power, after a disuse of it for thirty years, he found that he could still keep up *three* balls without any interruption of his reading. The purely automatic nature of an action performed under such circumstances, fully justifies our attributing it to a nervo-muscular mechanism; but there are these essential differences between the automatism of Göltz's frog or of Flourens's pigeon, and that of Houdin—that while the one was original, the other was acquired; and that while the one was set going by an external stimulus, the other was put in action by a conscious intention, of which we have every reason to regard the cerebrum as the instrument.

Of these differences it appears to me that Professor Huxley has lost sight, in his application to man of the conclusions he draws from the automatism of animals. In refusing to credit the spinal cord of the frog with the power of conscious self-direction, which a few physiologists still attribute to it, he takes his stand (quite rightly, as I think) upon the facts of human experience;

which show that when any part of the spinal cord has been cut off from the brain by disease or injury, the portion of the body below the point of section loses its sensibility, and that whatever action its muscles may be excited to perform, such action is not only independent of the will, but incapable of being controlled by it. But when he argues from the fact that because certain actions of a frog which appear to be purposive are really automatic, similar actions of man which express the determinations of the conscious Ego really result from the working of an unconscious mechanism, he not only ignores, but distinctly repudiates, the very experience on which he previously built. For even if it could be shown that the spinal cord of man can do all that the same organ does in the frog—if, for example, on the application of an irritant to one of the legs of a paraplegic patient, the other leg were to be raised and crossed, so as to rub it off,—such a fact would give us no right to say that when either this or any other movement is executed in response to a conscious determination of the Ego, such conscious determination has nothing at all to do with it. All that could be legitimately inferred from it would be, that the automatic apparatus is competent to perform this feat, and that when the conscious Ego executes it by what we call the mandate of his will, he uses the automatic apparatus as its instrument.

The doctrine that the Ego puts the body in movement, not (as formerly taught) by its immediate voluntary control over the muscles, but by its power of making the automatic apparatus perform anything that lies within its capacity—whether original or acquired—accords with all the phenomena, physical, as well as psychical; whilst the doctrine of pure automatism, based entirely on the physical, is in direct opposition to the psychical. Let us take the act of coughing as an example; this being, perhaps, the most purpose-like of all the originally automatic actions performed by adult man. We admire the combination of the closure of the glottis with explosive expiration, as perfectly adapted to get rid of any offending matter which has found its way into the air-passages; and at the same time we recognize the fact that this combination is made *for* us and not *by* us, and that, when the stimulus is present in sufficient force, we *must* execute it, however strong may be our desire to restrain it. But our experience also tells us that we can execute the same act by simply *willing* to do so; as, for instance, when we wish to give a signal, to clear our throat, or to cough-down a troublesome speaker. And if I assert, on the basis of every-day experience, that my conscious Ego can direct my automaton to execute this movement, it is surely no answer to say that because my automaton was competent to do it for itself, therefore my conscious Ego really had nothing to do with it. For supposing my air-passages to be free from any irritation, I do not cough unless I will to cough; and my will simply takes the place of the stimulus which the passage of a crumb of bread into my larynx would give. So Göltz's frog and Flourens's pigeon, though capable of performing the ordinary movements of locomotion when excited to do so, remain quiescent in the absence of such excitement, for want of a cerebrum to supply the place of the external stimulus by one proceeding from the conscious Ego. And although my *bête* may have come to be quite as capable as Göltz's frog or Flourens's pigeon, of continuing to walk by itself when my *âme* is asleep or engaged elsewhere, it is none the less under subjection to my *âme* when the latter asserts its prerogative; the automatic movements of my *bête* being then governed by the consciously formed determinations of my Ego.

The higher we ascend in the vertebrate series towards man, the more evident does it become that the ordinary course of action is determined rather by the intentional direction given through the cerebrum to the working of the automatic mechanism, than by its own unconscious operation; in other words, by reason rather than by instinct. And in man we find that everything is left to be learned by experience, save what is imperatively required for the maintenance of life—such as the rhythmical contractions of the heart, the peristaltic movements of the alimentary canal, the acts of swallowing and respiration, their combination in the act of sucking, and the like. Even the tendency to that sudden closure of the lids when danger is threatened to the eyes, which is among the most purely automatic of our protective actions, seems to be an acquired rather than a congenital instinct.

It is the very condition of such acquirement, however, that the human Ego is thus enabled to exercise a rational control over its automatism (as in ordinary walking), which those animals do not possess whose locomotion is purely mechanical; initiating, directing, regulating, and checking its actions, with such directness that many have maintained that because they were voluntary in the first instance, they must always remain so—a position which seems to me as unscientific as the doctrine I have already combated, that because actions adapted to a purpose are performed automatically by a frog, the actions which man executes with a determinate intention are really automatic. The human Ego can even turn to his own account certain parts of his originally automatic mechanism. Thus, although his will does not extend so far into the *penetralia* of his organism, as to enable him to influence the motions of his heart or alimentary canal, and although, if he try ever so hard, he cannot suspend the act of breathing to the extent of asphyxiating himself, he can so regulate his expirations as to make them subservient to those vocal utterances which express, by a mechanism that has to be trained to its work, the thoughts and feelings of his mind.

But when we have been thus led to recognize in the cerebrum, not the original centre of the whole nervous activity of the body, but a superadded organ, in which our sensorial experiences are registered, through the instrumentality of which they give rise to the states of consciousness designated as emotions and ideas, and by whose downward action expression is given to the determinations of the Ego, it may still be plausibly maintained that the whole series of "molecular motions" of which it is the seat, must take place in accordance with certain fixed and definite physical laws; and that it is utterly unscientific to suppose that mind can intervene to modify them.

That there is a mechanism of thought and feeling, the action of which forms part of the life of the body, which gives rise to that succession of thoughts and feelings wherein the life of the mind may be said to consist, and which goes on, when left to itself, according to its original constitution, modified by the influences subsequently brought to bear upon it, can be doubted by no psychologist who is also a physiologist. The cerebrum, as was first pointed out by Dr. Laycock, has a reflex action of its own, analogous to that of the lower centres, but determined as to its nature by the modifications superinduced upon its original mechanism by acquired habit; and this doctrine is but the physiological expression of the Herbartian psychology of *residua*. The response given by this mechanism, whether manifesting itself in bodily or in mental action, is as automatic as the act of walking, or any other sequence of movements which we execute with the like absence of conscious or designed exertion. We cannot help, for example, the recurrence of ideas called up by local or personal associations; nor can we help the feelings of pain or pleasure, of aversion or desire, which are inseparably connected in our minds with these ideas. It would be as unreasonable to say that we *can* help them, as it would be to say that we can prevent ourselves from feeling pain when a pin is run into our flesh, or pleasure in eating a good dinner when we are hungry.

But is this all? Have we *no* power to control and direct this automatic cerebral action, as the cerebral action itself directs and controls the action of the lower centres? Does the body of man constitute *his whole self*, or is there an *Ego* to which that body is in any degree subservient?

To these questions it does not seem to me to be within the capacity of physiology—limiting that term to man's corporeity—to give an answer. If we look at the whole of our mental no less than our bodily activity as dependent upon the reflex action of our cerebrum, we are undoubtedly landed in an automatism, far more varied indeed, but not less bound by the laws of physical causation, than the automatism of the ascidian to which it is now fashionable to trace back our pedigree. But to say that this is the only way in which science permits us to regard it, is (as it seems to me) to disregard that on which all science is based—experience. Surely our own immediate mental experiences are as worthy of confidence, as are deductions drawn from phenomena outside ourselves, which we can only rightly interpret on the basis afforded by those very experiences; the test of the validity of such interpretation being furnished by their conformity to our other immediate experiences. And if we are led by physiological evidence to recognize in the cerebrum a power of directing and controlling the automatism of the axial cord, I do not see on what ground we are to reject the testimony of direct consciousness, that the automatism of the cerebrum is itself directed and controlled by some higher power.

That we can form no conception of the nature of the causal relation between mental and bodily phenomena, is nothing to the purpose—as Professor Huxley himself distinctly admits in regard to the production of sensations and other mental changes by "modes of motion" of the nervous system. But if (to use his own appropriate terms) *neuroses* can give rise to *psychoses*, it is surely quite accordant with the great fundamental principle of interaction to affirm that conversely *psychoses* can give rise to *neuroses*; just as the electricity generated in a voltaic battery by chemical change, can itself produce chemical change. Professor Clifford, indeed, refuses to admit a causal relation either way, giving no other reason for his refusal than his inability to conceive how a "motion of molecules" can be produced in any other mode than by a motion of neighbouring molecules. But I am yet to learn that either in this or any other case, our deductions from experience are to be limited by our ability to supply their *rationale.*

X.

THE LIMITS OF HUMAN AUTOMATISM.

[Preface to the fourth edition of the "Principles of Mental Physiology," 1876.]

SINCE the first issue of the following treatise, the question of "Human Automatism" has largely engaged the attention of that increasing portion of the public mind which interests itself in scientific inquiry. The address of the eminent physicist who occupied the presidential chair at the Belfast meeting of the British Association, embodied a philosophical creed of which it seems a necessary corollary, that all mental as well as bodily activity, being the outcome of the "potentialities" of matter, is subject to physical conditions alone.—The distinguished biologist who brilliantly expounded at the same meeting the Cartesian doctrine that "Animals are Automata," explicitly maintained (in direct opposition to Descartes himself) that Man is only a more complicated and variously endowed automaton: his bodily actions being determined solely by physical causes; the succession of his mental states depending entirely upon the molecular activities of his cerebrum; and the movements he is accustomed to regard as expressing his feelings, or as executing his intentions, having their real origin in brain-changes, of which those feelings and intentions are the mere concomitant "symbols in consciousness." *—Professor Huxley's *pronunciamento* was soon followed by that of an able mathematician, who brought to that profoundly difficult problem of "body and mind" which has exercised the greatest intellects from Aristotle to J. S. Mill, the training of a skilled athlete, who knocks down

* *Fortnightly Review*, November, 1874, p. 577.

with one vigorous blow any opponent unprepared for his peculiar mode of attack. Relying exclusively upon physical experiences, Professor Clifford affirmed without the smallest hesitation,* that as the only thing which can possibly be conceived to influence matter is either the position or the motion of surrounding matter, the statement "that the will influences matter" is simply "nonsense;" an affirmation which assumes that Professor Clifford knows all about matter and its dynamical relations, and therefore has an unquestionable right to say that mankind at large are wrong in the conviction that the movements of their bodies are in any way directed by their minds.

From the confidence with which what are asserted to be the inevitable conclusions of physiological science are now advanced in proof of the doctrine of human automatism, it might be supposed that some new facts of peculiar importance had been discovered, or some more cogent deductions drawn from the facts previously known. But after an attentive re-examination of the whole question, I find nothing in the results of more recent researches to shake the conviction at which I arrived nearly forty years ago,† of the existence of a fundamental distinction, not only between the rational actions of sentient beings guided by experience, and the automatic movements of creatures whose whole life is obviously but the working of a mechanism,— but also between those actions (common to man and intelligent brutes) which are determined by a preponderating attraction towards an object present to the consciousness, and those (peculiar, as I believe, to man) in which there is, at one stage or another, that distinct purposive intervention of the self-conscious Ego which we designate will, whereby the direction of the activity is modified.

What modern research seems to me to have done, is to elucidate the mechanism of automatic action; to define with greater precision the share it takes in the diversified phenomena of animal life, psychical as well as physical; and to introduce a more scientific mode of thought into the physiological part of the inquiry. But in so far as those who profess to be its expositors ignore the funda-

* *Fortnightly Review*, December, 1874, p. 728.

† "On the Voluntary and Instinctive Actions of Living Beings," in the *Edinburgh Medical and Surgical Journal*, No. 132 (1837).

mental facts of consciousness on which Descartes himself built up his philosophical fabric, dwelling exclusively on physical action as the only thing with which science has to do, and repudiating the doctrine (based on the universal experience of mankind) that the mental states which we call volitions and emotions have a causative relation to bodily changes, they appear to me to grasp only one half of the problem, to see only one side of the shield. That the principle of the conservation of energy holds good not less in the living body than in the inorganic world, I was myself among the earliest to maintain.* That in the most powerful muscular effort which can be called forth by the human will, there is no more a *creation* of energy than in an automatic convulsion, I believe as firmly as Professor Clifford. And that the general tendency of modern scientific research is to extend the domain of law to every form of mundane change,—the belief in the uniformity of causation being now assumed as axiomatic in all scientific procedure,—I recognize as fully as Mr. Herbert Spencer. This tendency could not be expressed more forcibly than in the following citation from Mr. H. Sidgwick's recent treatise :—

"The belief that events are determinately related to the state "of things immediately preceding them, is now held by all com-"petent thinkers in respect of all kinds of occurrences except human "volitions. It has steadily grown both intensively and extensively, "both in clearness and certainty of conviction, and in universality "of application, as the human mind has developed and human "experience has been systematized and enlarged. Step by step, in "successive departments of fact, conflicting modes of thought "have receded and faded, until at length they have vanished every-"where, except from this mysterious citadel of will." †

Before inquiring, however, whether there is adequate ground for regarding the human will in this exceptional light, it may be well to consider what basis there is for the assumption that the range of physical causation extends itself from the sphere of matter to that of mind,—in other words, that moral causation and physical causation are convertible terms.

* "On the Mutual Relations of the Vital and Physical Forces," *Philosophical Transactions*, 1850.

† "The Methods of Ethics," p. 47.

It may be fairly urged, on one side, that the tendency of modern scientific investigation has been to show that a very large proportion (if not the whole) of those changes whose succession constitutes our mental life, are determinately related, on the one hand, to the mental states which immediately preceded them, and, on the other, to the material conditions of the bodily organism. The pure metaphysician, who studies the "laws of thought" in the abstract, as if man consisted of mind without body, no more doubts the former, than the physiologist, who works upwards from body to mind, and studies the successions of consciousness as functions of the nervous system, can question the latter. And the psychologist, whose object (to use the words of Mr. Herbert Spencer) is to elucidate "not the connection between internal phenomena, nor "the connection between external phenomena, but the connection "between these two connections," and who studies the relation between psychical phenomena and physical conditions through the whole range of the animal kingdom, interpreting these phenomena by a scientific scrutiny of his own experiences, and applying the knowledge thus gained to the explanation of the actions of organisms whose constitution resembles his own (this inquiry being the special object of the present treatise), finds himself irresistibly brought to the conclusion that automatism * has a very large share in the life of every human being; and is thus naturally led to question whether there is *any* part of man's action which is exempted from the law of physical causation.

The corrective to this view, however, appears to me to be furnished by the intelligent study of that large class of the phenomena of human nature which lies patent to every trained observer in the ordinary course of events. For the more carefully he studies these phenomena, the more clearly is he led to see that, as has been pithily said by Emerson, "*Thoughts rule the World;*" and that, though the spheres of *moral* and *physical* causation impinge (as it were) upon one another, they are in themselves essentially distinct. The influence of a great idea conceived by a

* In the term "Automatism," as used here and elsewhere, I include not merely those *bodily* but those *mental* activities, which *are determinately related to* (or, in other words, *are caused by*) previous bodily or mental activities, to the exclusion of all *choice* or *self-direction* on the part of the Ego.

thinker in his closet, in dominating the action of an entire nation, is utterly disproportioned to any conceivable play of molecular forces that can be excited by the physical agency of the thinker in putting his idea into speech or writing. The moral power of the "thoughts that breathe, and words that burn" in the utterances of the poet, cannot be correlated, like the mechanical energy exerted by his muscles in the writing of his verse, with the quantity of food he may have consumed in their production. And the new direction that may be given to the whole course of two lives, by the faintest expression of emotion in a tone, a look, or a touch, cannot be brought to any common measure, either with those muscular contractions, or with those molecular changes in nervous matter, which are the physical causes of its manifestation.

But to this it may be replied that, even when we look at human action from its mental side, without any regard to physical antecedents, we cannot help recognizing in it the principle of causation by character and circumstances; and that without the power of prediction which we derive from organized experience, as is well stated by Mr. Sidgwick (*op. cit.* p. 48), social life would be impossible. But while every one admits the existence of uniformities in human action which constitute the basis of our social fabric, every one also admits that the closest observation of these uniformities, and the most sagacious analysis of their conditions, does not justify anything more than a "forecast" of the course of action, either of individuals or of communities, in any given contingency. "Who would have thought that he would have done such a "thing?" is our frequent exclamation in regard to some one of whom we considered that we had a most intimate knowledge: that "the unexpected [in politics] is what always happens," has passed into a proverb. It is, of course, open for the automatist to assert that the element of uncertainty here arises, as in the case of weather-forecasts, from the complexity of the conditions, and from our imperfect acquaintance with them; and he might fairly urge, on general grounds, that if we could grasp the whole of the antecedents, and measure the potency of each, no "unconditioned" or self-originating element would be found to have interfered with the regular sequence of cause and effect. But he has no right whatever to *assume* this. The whole history of science shows that the investigation of "residual phenomena" has been a most fertile means of discovery in regard to agencies not previously suspected. And until it shall have been *proved* that there are no human actions which cannot be accounted for by "unconditional "sequence," such an assumption cannot be admitted as an adequate disproof of the testimony borne by human consciousness to the opposite effect. "It is impossible for me to think," says Mr. Sidgwick (*op. cit.* p. 51), "in the moment of deliberate "volition, that my volition is completely determined by my formed "character and the motives acting upon it. The opposite con- "viction is so strong as to be absolutely unshaken by the evidence "brought against it. I cannot believe it to be illusory. . . . No "amount of experience of the sway of motives even tends to make "me distrust my intuitive consciousness, that in resolving after "deliberation I exercise free choice as to which of the motives "acting on me shall prevail. Nothing short of absolute proof that "this consciousness is erroneous, could overcome the force with "which it announces itself as certain; and I cannot perceive that "such proof has been given."

It is alleged, indeed, that the belief entertained by all men—except philosophers—in their own freedom of choice (within certain limits) between different modes of action, is an illusion of ignorant "common sense," which, like the vulgar belief that the sun moves round the earth, is utterly dispelled by the light of science. But the two beliefs rest upon an entirely different basis. The latter, like other erroneous beliefs which arise in the exercise of our senses, is an *inference* from the facts of consciousness, which a more enlarged experience (such as that afforded by almost every railway-journey) shows to be untenable: the former is the *immediate affirmation* of consciousness itself, the assurance of which, its constant recurrence under a great variety of conditions only serves to confirm.

The direct testimony of consciousness as to any one of its primal cognitions, must be held, as it seems to me, of higher account than the deductions of reason from data afforded by other cognitions; constituting, in fact, a "base of verification" to which all our logical triangulation must be worked back, if we desire to test its validity. And no fact of consciousness as to which mankind in general is in accord, can be disproved, save by the contradiction afforded by some other primary cognition of superior validity. For, as has been truly said by John S. Mill, "feeling "and thought are much more real than anything else; they are "the only things which we directly know to be real." * We know nothing about matter, as Berkeley demonstrated, except by inference from the manner in which its states affect our consciousness; "itself we do not perceive; we are not conscious of it." And hence those so-called "experiences," on the basis afforded by which the whole fabric of physical science is built up, being really nothing else than "assumptions to account for our sensations" (Mill), can only be accepted as valid, in so far as they accord with those primal cognitions which we cannot dissociate from our own consciousness of personal agency. Thus, for example, when Professor Clifford affirms (*loc. cit.*) that no interaction can possibly take place between bodily and mental states, the physical facts going along by themselves, and the mental facts going along by themselves, on two utterly different platforms,—he calls upon us to receive as the indubitable teaching of science, the result of a process of reasoning based upon one set of experiences alone; notwithstanding that this is completely contradicted by another set, which, as appealing much more directly to our own consciousness, has a stronger claim upon our acceptance. For all mankind —except philosophers of Professor Clifford's school—accept it as a fact, "based on the normal experience of healthy men," that, running a pin into one's flesh is the cause of that mental state which we call pain (Huxley, *op. cit.* p. 574); a certain *neurosis*, or molecular change in the nervous system, producing a corresponding *psychosis*, or affection of the consciousness. And, conversely, since all mankind—except the followers of Professors Huxley and Clifford—accept it as a fact, "based on the normal experience of healthy men," that the state of mind which we term volition is the cause of the muscular movement that gives expression to it—a *psychosis* producing the *neurosis* which calls forth muscular contraction—I cannot see that this conviction can be nullified by any inference drawn from an order of facts that is capable of an entirely different interpretation. The doctrine propounded by Professor

* "Posthumous Essays," p. 202.

Huxley in his Belfast lecture, that the feeling we call volition is not the cause of the voluntary act, but the "symbol in consciousness" of that state of the brain which is the immediate cause of that act (like the blowing of the steam-whistle, which signals, but does not cause, the starting of the locomotive), and that the strongest volition has therefore no power in itself to call forth a movement, seems to me to find its best answer in the explicit statement which he himself put forth not many years previously, that "the belief that our volition counts for something as a condition "in the course of events," is one which "can be verified experi-"mentally as often as we like to try," and therefore "stands upon "the strongest foundation upon which any belief can rest, and "forms one of our highest truths." *

When we come to examine the reasons latterly assigned by Professor Huxley for giving up this assured belief, we find them mainly based on the fact that certain actions which would be ordinarily accounted volitional (as being initiated by an intentional effort) in man, can be performed under circumstances which strongly indicate a purely automatic causation.

Thus it has been shown by Göltz, that a frog from which the cerebrum has been removed, and which (according to ordinary physiological doctrine) has consequently lost the power of voluntary movement, will jump when irritated, the direction of this movement being affected by the incidence of light upon its eyes; though making no effort to feed itself, it will swallow food put into its mouth, and may thus be kept alive for weeks or months; and will utter its croak when a particular part of its back is stroked. But further, although, when put on the hand, the frog sits there crouched, perfectly quiet, and would remain so unless stimulated to action, yet (says Professor Huxley) "if "the hand be inclined very gently and slowly, so that the frog "would naturally slip off, the creature's forepaws are shifted on to "the edge of the hand until he can just prevent himself from "falling. If the turning of the hand be continued, he mounts "up with great care and deliberation, putting first one leg forward, "and then the other, until he balances himself with perfect pre-"cision upon the edge, and in the turning of the hand over he

* "Lay Sermons," p. 160.

"goes through the opposite set of operations, until he comes to "be seated in security upon the back of the hand."—(*Fortnightly Review*, Nov. 1874, p. 567).

Now, that Man is himself continually making yet more elaborate adjustments of his muscular movements, under circumstances which forbid the idea that they are in any way directed by his conscious will, is expressly shown in various parts of the present work. Some of these actions, as coughing and sucking, are originally or *primarily* automatic; and can be experimentally shown not to depend upon cerebral instrumentality, except when performed in obedience to a volitional mandate. Others, as walking erect, are originally performed under the conscious purposive direction of the mind; but, when they have once become habitual, they may be repeated involuntarily, and even unconsciously, by a *secondary* or acquired automatism, the mechanism of which has constructed itself in virtue of the tendency of the nervous system to *grow to* the mode in which it is habitually exercised. And this is equally true of those more special activities which have been acquired by "training,"—such as rope-dancing, music-playing, juggling with balls, etc.; for these may be performed (as we are accustomed truly enough to say) "mechanically" by any individual by whom they have been so habitually repeated as to have become a "second nature."

Of this general principle, of which numerous examples will hereafter come before the reader, the following singularly curious illustration, which I have lately received from a trustworthy source (a clergyman in the north of England), may be here presented:—

"While I was a student in Dublin University, I was at an "evening party at which a lady was asked to play for dancing. "Unfortunately she had taken far too much at supper; and was, "in fact, after she had begun to play, so drunk as to be totally "unable to rise off the stool. I was standing near the piano, "and saw her eyes close, her head fall forward, and give every "manifestation of sleep except snore aloud. But her playing "went on in perfect time; and, in fact, the difficulty was, when "she had ended a waltz or quadrille, *to make her stop;* for when "she was shaken out of sleep, it was evidently her intention to "go on the whole night. To set her going again, it was only "necessary to place her hands on the keys, and she would begin "a new quadrille, soon again relapsing into sleep, and yet con- "tinuing to play well. I was studying a deep course of meta- "physics at the time, for my degree in those subjects in Trinity "College; and the case made a great impression on my mind. "I could not account for it on any of my then principles; but I "see it perfectly now."

I have recently learned, too, that it is no uncommon experience in telegraph offices, for transmitters of messages, when they have been for some time in the service, to work the instruments without conscious thought of what they are doing. "They read the words," says my informant, "pass them through "their minds, and transfer them to the sending part of the "apparatus, just as unconsciously and automatically as Wheat- "stone's transmitter does. I have often found myself," he continues, "indulging in trains of thought, or even listening to a "conversation that might be going on near me, and yet continued "to 'receive' and 'send' just as if I was giving my whole "attention to the work; and when I came to see the messages "afterwards, I knew that they had passed through my hands "only by the handwriting. Once, indeed, when on night duty, "I became completely unconscious whilst sending a long and "monotonous 'group' message, consisting entirely of figures, "and woke up bewildered, and had to ask the receiving station "'after what?' before I could proceed. Some clerks believe "that the work is done more accurately when done auto- "matically; but I scarcely think this justified by experience."

However strange these statements may seem, they find their parallel in our own familiar experience. For almost every one who has been much in the habit of reading aloud, is well aware that he may continue to do this with perfect articulation, punctuation, emphasis, and intonation, while his mind is so completely engrossed by some entirely different subject, that, until his attention is recalled to it, he is no more aware that he is reading, or conscious of the guidance he has been receiving from his visual sense, than is the philosopher of the pursuance of his walk whilst his whole mind is given to the solution of some knotty problem.

The only difference between the case of the reader-aloud and that of the telegraph-clerk, is that the words whose visual pictures have fallen on the retina, are expressed in the one case by acts of vocalization, in the other by a special kind of finger-language. So, the case of the musical performer who continued to play quadrilles in her sleep, is analogous to that of the ambulatory thinker; a previously acquired succession of movements, once initiated, going on without conscious direction; each movement being suggested by that which preceded it, and itself suggesting the next.

The same explanation seems to me to be legitimately applicable to the case of the French sergeant, on which great stress is laid by Professor Huxley (*loc. cit.* p. 568) as indicating that what we are accustomed to call voluntary action in ourselves is really automatic. For, as a consequence of a wound in the head received at Gravelotte, this man frequently passed spontaneously into a state closely resembling that of the artificially-induced hypnotism, whose phenomena are described in the latter part of this treatise. The essential peculiarity of this state is the suspension of the directing and controlling power of the Will; so that the whole course of action is determined automatically by suggestion. And its phenomena, so far from affording any evidence that the same is the case in our normal state, and that what we call Will is only the "symbol in consciousness" of a material change which would equally take place without it, seem to me to testify exactly the contrary. For we cannot help recognizing a marked difference between the *normal* and the *abnormal* states of such subjects; and, as I think I have demonstrated in my discussion of these and of allied states, that difference essentially consists in the suspension in the latter state of that volitional power, which in the former directs and controls the successions of thought and action. And on the recognition of this difference will depend our appreciation of the relative moral "responsibility" of the subjects of these states, for the same actions performed in the normal and in the abnormal conditions respectively. Thus we should hold the French sergeant fully "responsible" for any theft he might commit when in full possession of his wits; and yet for the very same action performed in his automatic state, we should be ready to admit the excuse that he had no power of self-control (p. 302).

Thus, as it seems to me, the cases cited by Professor Huxley are readily explicable by the principle of *secondary* or *acquired* automatism first explicitly laid down by Hartley; this taking the place in man (save as regards such actions as breathing and sucking, which are essential to the life of the infant) of those which are *primary* or *original* among the lower animals. And I hold it to be the legitimate inference from the fact that certain actions of the frog, resembling those which man might execute volitionally under like circumstances, are performed automatically, that a provision exists in the inherited structure of the frog, for doing that which man only learns to do by intentional "training,"—an inference which all physiological study tends to confirm. For the fullest recognition of automatism in the performances of Göltz's frog does not in the least invalidate the testimony of my own consciousness, that when, being called on to balance my body under some unaccustomed circumstances (as in crossing a stream on a narrow plank, or over a series of stepping-stones), I give my whole attention to the act, the movements of my body are executed under my intentional direction. Again, the fact that various actions have become so familiar to me by habit as to be performed automatically, affords no real contradiction to the testimony of my own conciousness, that when I was first trained (or was training myself) to execute them, my will issued the mandates which were carried into effect by my muscles. I cannot believe that a piece of delicate handiwork, such as a minute dissection, or the painting of a miniature—requiring constant visual guidance, and trained exactness of muscular response—can be executed without a distinct volitional direction of each movement. And I find myself quite unable to conceive that when I am consciously attempting, whether by speech or by writing, to excite in the minds of my readers the ideas which are present to my own consciousness at the moment, it is *not* my mind which is putting my lips or my hand in motion, but that (as Professor Huxley maintains) it is my body which is moving *of itself*, and simply keeping my mind informed of its movements.

If this doctrine were true, not only of particular cases, but of human life generally, it is obvious that its stream would flow on exactly as it does, if we had no consciousness at all of what we are about; that the actions and reactions of the "ideagenous molecules" would do the work of the philosopher, even if they never generated ideas in his mind; that he would give forth its results in books or lectures, not from any intention or desire that his books should be read and his lectures heard, so as to bring the thoughts of other minds into relation with his own, but simply because certain molecular motions in his brain call forth the movements of speech or writing; and that, in like manner, the noblest works of genius—the master-pieces of the poet, the artist, and the musician—would none the less be produced, if the "symbols in consciousness" were never evoked in their producers' nature, and would prove none the less attractive to other automata, if the molecular movements of their brains should be equally incapable of exciting either intellectual or emotional activity; such activity being, to use a legal phrase, mere "surplusage." To myself this seems like a *reductio ad absurdum.* For although I maintain in the present treatise that an automatic action may take place in the cerebrum, which, without any intervention of consciousness, may evolve products usually accounted mental, yet in all such cases *the action takes place on the lines previously laid down by volitional direction;* being exactly parallel, in the case of cerebral action, to that secondary or acquired automatism, by which particular kinds of movement, originally acquired by "training," come to be performed "mechanically."

I fail to find, then, in any of the modern developments either of physical or physiological science, any adequate grounds for abandoning the position maintained in the following treatise, as to the direction and control to which the automatic activity of man is subject in proportion to the development of his volitional power,—that is, the power exerted by the Ego not only with *a distinct purpose*, but with a *consciousness of effort*, the strength of which is the mark and measure of its exercise.

The direct testimony of consciousness, in regard not only to the existence of this volitional power, but also to the self-determination of the Ego in the exercise of it, is borne out by numerous other considerations of various degrees of cogency, more or less intimately related to each other; the aggregate of which, like that of the mutually-supporting outworks round a citadel, adds enormously to the strength of the position, though each independently might be inefficient for its defence.

1. It is supported by the very existence of the idea symbolized in the word *choice;* an idea which we could not entertain, if we did not find something answerable to it in our own subjective experience. For in external nature there is nothing that can be truly termed "choice." If a piece of iron be brought within the sphere of attraction of two magnets placed on opposite sides of it, one near but feeble, the other strong but remote, we feel assured that it will be drawn towards the one which makes the stronger pull upon it; and we take its motion in one or the other direction, as the indication of the superior tractive force of the magnet towards which it tends. To use the word "choice" in such a case—to say that the iron *chooses* towards which of the magnets it shall move,—would be felt by every one a misapplication of the term. The same would be the case as regards any other action determined by physical causation. And yet on the determinist doctrine, if I am attracted by the temptation of an immediate but immoral pleasure, and am deterred from it either by a sense of duty or by the fear of the remote consequences of the sin, I have no more "choice" as to the course I shall take, than has the piece of iron that is attracted in opposite directions by two magnets. Now my contention is, not merely that I *have* a choice, but that the very existence of an idea which can be derived from no other source than human experience, confirms the testimony of my own consciousness to that effect.* And the like confirmation is afforded by the familiar reply, "I have *no choice*," in cases in which we feel it to be a *necessity* (whether physical or moral) that we should take a particular line of action.

That in making our choice, and in acting upon it, we are determined by the "preponderance of motives," I do not call in question; the self-determining power of the will seeming to me

* The case seems to me exactly parallel to that of the notion of force, which is based on our own *consciousness of effort* in originating or in resisting motion.

to be exerted in modifying the preponderance which the motives *per se* would determine. The affirmation that our actions are determined by the strongest motives, appears to me, indeed, a mere truism; being only another mode of saying that the motive which prevails is the strongest. For we have no other test of the relative strength of motives, than that which is afforded by our experience of their action in each individual case. If we put into a balance two bodies of known densities, we can predict, by the comparison of their dimensions, which will preponderate. But, if the density of one or both is unknown, we can only determine which is the heavier by seeing which scale goes down. And so we can have no other measure of the relative strength of motives of different orders, than that which is afforded by their respective effects in the determination of the conduct. Now, all experience shows that motives which may exert a preponderating influence at one moment, are comparatively powerless at another; on the other hand, motives whose influence at one moment is scarcely felt, may come to acquire a force that makes them far outweigh those which at first overbalanced them. This is especially apparent when we exert our volitional power of "self-control" to check the immediate action which is prompted by some automatic impulse; time being thus gained for the excited feeling to subside, and for the "second thoughts" of the higher reason to make themselves heard.* And a further reflection on our own mental experiences will satisfy us, that these variations in the relative strength of motives mainly arise from the degree of attention that we give to each respectively. An excited feeling which would soon die out if left to itself, will retain its potency, or even gain augmented force, if we allow ourselves to brood over it; whilst, on the other hand, the power of those remoter considerations which deliberation suggests, increases in proportion as they are dwelt on. And just as in the case of the two magnets, we may reverse their relative attractions by changing their respective distances from the iron between them, so can each Ego who has acquired the power of directing his own course of thought and

* It is not always, however, that "second thoughts are best." For the immediate impulse may be a *benevolent* one, and the "second thoughts" *deliberately selfish.*

feeling, alter the relative potency of different motives or sets of motives, by *determinately directing his attention* to those which would draw him in one direction, and by partially or completely *excluding* those of an opposite tendency from his mental view.

If it be urged by the Automatist that this fixation of the Ego's attention on one set of motives to the exclusion of the other, is really due to the superior strength of the motive (supplied by his previously formed character) which leads him to *desire* so to fix it, I reply that no experience of which I am conscious is more real to me, than that if I did not *make an effort* to keep my attention fixed, the *desire* alone would fail to do it. I am further conscious that a great deal more is "taken out of me" (to use an expressive colloquialism) by the prolongation of such a struggle, than by a far larger measure of undistracted mental action. And I ask, "Why, on the automatist theory, should this be?"—To myself it seems clear that it is in the control he thus acquires over the automatism of his nature, that Man's *freedom of choice* essentially consists; whilst, on the other hand, it is in virtue of his want of power to gain a complete control, that his *freedom is limited.*

This view seems to me to find its strongest support in the experience of those who have been most largely and most successfully engaged in the education of the young. For, as I have had abundant opportunities of learning, they watch for the dawn of this power of reflection and deliberation in the child, endeavour to strengthen his feeble resolution by judicious encouragement, lead him to reflect upon the consequences of his misdoing to himself or to others, and give additional force to his sense of duty by earnest appeals to it, so as to sustain him in a conflict to which he is as yet unequal if left to himself; but at the same time they make him feel that he must not always expect such help, and that it rests with himself, by habitually fixing his attention upon what his reason and his moral sense tell him he *ought* to do, to be able to *will* to do it against his inclination.

No experience is so remarkable in its bearing on this question, as that of the philanthropic men and women who have taken the largest and most efficient share in the work of juvenile reformation. For they have to deal with a class of boys and girls, who have grown up to a most unmanageable age, in habits of entire unrestrainedness of thought and feeling, and in no more restrainedness of action than has been imposed on them by external coercion or by fear of punishment. These young "reprobates" have not the least idea of self-control, or of doing anything else than that which their inclinations prompt; their notions of "right" are all based upon limited self-interest; and they hold everything to be "wrong" which interferes with what they conceive to be their own "rights." Now the first lesson that has to be taught them is that of obedience to discipline, for which punishment has often to be used as a motive. But in proportion as the habit of *self*-control is acquired, appeals to the better nature come to have a force superior to that of mere coercion: and the greatest success is attained when that controlling power is *spontaneously* exerted under the direction of the *ought* or *ought not.* So, in the cultivation of the dormant moral sense, the first teaching goes to show that what the pupil considers his [or her] "rights" are some one else's "wrongs;" and the golden rule is enforced by the practical applications which are found most suitable to impress it on each individual nature. Thus a foundation is laid for the development of that higher moral sense, on which the principle of religious obligation is most securely based. But the result of the most successful effort in this direction is only considered to have been attained, when the subject of it has been awakened to a full consciousness of possessing a power *within himself* to resist temptation and to act as duty directs; which power it rests with himself to exert, and for the non-exercise of which he is responsible.*

Of course it will be replied by the automatist, that all such "training" is part of the external influences which go to the formation of the character; and that its efficacy depends upon the degree in which the sense of duty can be thus developed by judicious culture into efficient predominance. But I affirm it to be a matter of notorious experience, that it is the reiteration of the assurance that the child or juvenile offender *can* govern his temper, if he will try hard enough; that he *can* overcome a difficulty, if he will summon courage to make a vigorous effort; that he *can* choose and act upon the right, in spite of strong

* My information on this subject is mainly derived from my sister, Mary Carpenter; than whom no one can speak with a greater weight of authority.

temptation to do wrong, by *determinately keeping before his mind* the motives and sanctions of duty,—which constitutes the most effectual means of calling forth that power of "self-control," which the most enlightened writers of antiquity, and the most successful of modern educators, concur in regarding as the most valuable result alike of moral and of intellectual discipline.—To the consistent Automatist, who denies the existence in the Ego of any self-determining power, and who puts his whole trust in the motives brought to bear from without, it seems to me that the word *try* can really have no more meaning than the word *choice*.

2. That the self-consciousness of freedom involved in the very idea of *choice* is not illusory, is further indicated by the universal existence of a *moral consciousness* absolutely inconsistent with the notion of automatism. The conception of freedom, as Mr. Sidgwick remarks (*op. cit.* p. 50), "is, so to say, the pivot "upon which our moral sentiments naturally play." Our feelings of approval and disapproval in regard to human conduct, are of an order quite different from those we entertain in regard to any kind of mechanical action. I have no moral approbation for a chronometer whose perfect time-keeping gives the true place of a ship at sea, or the true longitude of a transit-station; such as I have for the maker of that chronometer, whom I know to have put forth his utmost skill in its construction, careless of advantage to himself, but thinking only of the human lives he helps to save, or the accuracy of the scientific researches in which he thus bears an honourable part. Nor have I any moral disapproval for a watch whose stopping or bad-going causes me to incur serious detriment by missing a railway-train; such as I have for the workman whose carelessness in putting that watch together proves to be the occasion of my misfortune. Yet, upon the automatist theory, neither of these human agents could *help* doing exactly what he did; and I am therefore alike unreasonable in blaming the man who has caused me injury, and in commending the man who has done good service. So, again, our feelings, in regard to the actions of brutes, or of human beings whose brute condition seems to justify us in considering them as Automata, are

very different from those with which we view the like actions of men whom we regard as possessing a self-regulating power.* We should never think of blaming a wasp for stinging us, or a poisonous snake for biting us; neither do we esteem a bee deserving of credit for its industry in laying up honey for our use, or deem the silk-worm an object of gratitude for the toilsome ingenuity with which it spins the cocoon whose thread furnishes the material of our most beautiful fabrics;—each of these creatures doing that which it is its "nature" to do, and having no power to do otherwise. We make the like allowance for young children, or even for "children of a larger growth," in whom the moral sense and the power of self-control have not yet been developed; as we do also for the insane, who are either deficient in the power of self-direction, or whose will is overborne by some uncontrollable impulse. We hold them "not responsible" for any injury they may do us; and justify the discipline to which we subject them, as alike needful for the welfare of society at large, and likely to be beneficial to themselves. But we view in a very different light the acts of simple recklessness, still more those of deliberate selfishness, and yet more again those of treacherous and unmanly brutality, that are committed by men who knowing better have preferred the worse; acting on the suggestions of slothful folly, or the cool calculations of self-interest, or the fierce impulses of malignant passion, without regard to the sufferings which their misdeeds may bring upon others.

When, for example, a man throws down stones from a house-top without looking to see who is below, or fires a pistol in a crowded thoroughfare without care as to who may be in the line of the bullet, not only does the law regard him as fully "responsible" for any injury that may be caused by his act (holding him guilty of murder if death ensues), but public feeling sanctions

* See the "Psychologie Naturelle" of M. Prosper Despine; in which the mental mechanism of crime is studied from nature, under the guidance of views as to the relation between the automatism of Man's nature and the controlling power of the will, which essentially correspond with those set forth in the present work. A large proportion of criminal offenders, according to M. Despine, are so devoid of moral sense, that they must be accounted "moral idiots;" and in many more, that sense is temporarily overborne by a passion which the subject of it has never been trained to control.

the infliction of severe punishment, although he had not *intended* to do harm to any one; and this because he *could have helped* doing what he did, and must have *wilfully shut his eyes* to its possible or probable consequences.—So, when a man deliberately plans to blow up a house or a ship, at the sacrifice of scores or (it may be) of hundreds of human lives, for the sake of gaining a few scores or hundreds of pounds by a fraudulent policy of insurance, the primary instincts of humanity would protest against his being punished with a view merely to the prevention of similar crimes and to his own reformation, and every one feels that he "richly deserves" the heaviest penalty of the law.* And we have no terms of reprobation strong enough for the cowardly ferocity of a Nana Sahib; who gratified his hatred of the British to whom he had previously professed to be a friend, by the brutal murder of the defenceless women and children who had trusted themselves to his protection; and who, if he had been taken "red-hand," would assuredly have been deemed by the world in general a fitting object of "retributive justice."

But, as has been pithily remarked, if vice and virtue are products like sugar and vitriol, the laws of whose production science may be expected to discover, "it will be as irrational to feel indigna- "tion at base and cowardly actions, as it would be to feel angry "about the chemical affinities." And the like may be said of the irrationality, on the automatist hypothesis, of the moral approval we feel for acts of noble self-sacrifice;—such as that of the steersman of the burning ship, who held his place at the wheel, so as to run the ship towards shore, though the fire beneath was roasting the soles of his feet;—or that of the handful of brave men who blew open the gate of Delhi, the stronghold of the Indian mutineers, in the face of what seemed certain annihilation;—or that of the six hundred soldiers who kept their stations on the deck of the sinking *Birkenhead*, while the women and children were being lowered into the boats. Could we entertain that feeling, if we really believed the men whose deeds and sufferings we hold among our most precious memories, to be nothing more than well-regulated

* I here allude not merely to the recent Bremerhaven explosion, but to a case in which the blowing up of a pile of building that contained two hundred people, was attempted in Glasgow, fortunately without success, when I was studying in Edinburgh about forty years since.

machines? One of the most admirable sayings of Fred. W. Robertson has always seemed to me to be his reply to the remonstrance addressed to him by one of his churchwardens, as to the displeasing effect of the outspokenness of his preaching upon some of the principal supporters of his church. "I don't "care," he said; meaning, of course, "I must preach as my own "sense of duty prompts me."—"You know what 'don't care' "came to?" said the remonstrator.—"Yes, sir," replied Robertson, "it came to Calvary." That the sympathetic thrill which every true Christian disciple must feel when he realizes the full force of these pregnant words, is the illusion of an unenlightened nature, which the revelations of science will dispel by proving their utterer to have been an automaton whose choice between duty and self-interest was determined solely by "circumstances," may be the conclusion of the unimpassioned closet-philosopher; but the experience of all who, like Robertson, make the sublimest of all acts of self-sacrifice the rule and guide of their own lives, recognizes in such sacrifice a moral power far transcending in probative value any logical deduction of the intellect.

3. I find the embodiment of that moral consciousness in all language and literature; for whatever may be the judgment of ethical philosophers as to the nature and source of the fundamental distinction between *right* and *wrong*, and whatever may be the direction given to that notion by the Νόμος by which the judgment of each individual is shaped as to *what* is right and *what* is wrong, the sense in which these terms are universally accepted is based on the idea of a *self*-determining capability to *do* the right and to *avoid* the wrong.* This seems to me perfectly clear, when

* It is not a little instructive to find the moral intuitions of men like Professor Clifford rising up to assert themselves against their philosophy. In his lecture on "Right and Wrong" (*Fortnightly Review*, December, 1875), it is distinctly affirmed not only that there is a moral sense or conscience, which is "the whole aggregate of our feelings about right or wrong, regarded "as tending to make us do the right actions and avoid the wrong ones," but, that there are feelings of moral approval and disapproval which imply "choice;" that "a particular motive is made to prevail by the fixing the attention upon "that class of remembered things which calls up the motive," and that in so far as this act of directing the attention is voluntary, "I am responsible because "I made the choice;" and that "within certain limits I am responsible for "what I am now, because within certain limits I have made myself." In all

we compare this acceptation with the sense we attach to the very same words when applied (figuratively) to a piece of pure mechanism. If I say that my watch goes "right," I do not assign to it any moral credit, but merely mean that it keeps time well. And if I say that it goes "wrong," I do not speak of it as an object of blame, but merely mean that it wants regulating.

If the "wrong" movement of the self-acting points of a railway gives such a direction to the train which passes over them as causes a terrible sacrifice of life, we do not imply by our use of the word the moral criminality with which we charge a pointsman whose drunken carelessness has brought about a similar calamity. The machine *could not* help acting as it did; we assume that the pointsman *could*. If the machine proves to have been ill-constructed, or to have got out of order by neglect, we blame the man whom we believe to have been in fault; but if its working was deranged by a snow-storm of unprecedented violence, we cannot say that any one is chargeable with moral "wrong." So, if the pointsman can excuse himself by showing that he had been on duty for eight-and-forty hours continuously, and did not know what he was about, we shift the blame on the directors who wrongly overtaxed his brain; whilst, if it turns out that his inattention was due, neither to drunkenness nor to over-fatigue, but to sudden illness, we cannot say that any one was in fault. But, on the automatist theory, the pointsman could no more help getting drunk, than, when drunk, he could help neglecting his work; and the railway-directors could no more help keeping the pointsman on duty for forty-eight hours, than he could help the bewilderment which was caused by this overstrain of his power. And, neither the drunken pointsman nor the reckless directors were any more morally responsible for the loss of life, in the one case, than were the self-acting points in the other: each being a machine whose movements were determined by the law of its construction and the conditions in which it was placed; and the term "wrong," as applied to the action of the man, having no other meaning than it has when

this he seems to me implicitly to recognize that direction of bodily action by the mind of the Ego, which in his previous lecture he distinctly denied (*ante*, p. 290); and, whilst still upholding the principle of uniformity of sequence, to surrender all that essentially constitutes automatism.

applied to the working of the self-acting points.—The moral consciousness of mankind protests against such an identification.

So, again, I am unable to attach any definite import to such words as ἐγκράτεια, σωφροσύνη, *continentia*, or *temperantia*,—to see any meaning in the ancient proverb that "he that is slow to anger "is better than the mighty, and he that ruleth his spirit than he "that taketh a city,"—or to feel any admiration for the hero who "has gained that greatest of all victories, the victory over himself," if the course of action results from no other agency than either physical or mental automatism, and no independent power be put forth by the Ego in determining it. And if I felt obliged to accept that doctrine as scientific truth, I should look to its honest and consistent application to the training of the young as the greatest of social calamities. For I can imagine nothing more paralyzing to every virtuous effort, more withering to every noble aspiration, than that our children should be brought up in the belief that their characters are entirely formed *for* them by "heredity" and "environments;" that they *must* do whatever their respective characters impel them to do; that they have no other power of resisting temptations to evil, than such as may spontaneously arise from the knowledge they have acquired of what they ought or ought not to do; that if this motive proves too weak, they can do nothing *of themselves* to intensify and strengthen it; that the notion of "summoning their resolution," or "bracing themselves for the conflict," is altogether a delusion; that, in fine, they are in the position of a man who is floating down-stream in a boat without oars, towards a dangerous cataract, and can only be rescued by the interposition of some *Deus ex machinâ.*—How the perception of this, as the logical outcome of the doctrine of automatism, weighed "like an incubus" upon the spirit of John Stuart Mill, when he first fully awoke to it, he has himself told us in his Autobiography (p. 169). "I felt," he says, "as if I was scientifically "proved to be the helpless slave of antecedent circumstances; as "if my character and that of all others had been formed for us by "agencies beyond our control, and was wholly out of our own "power." And it is not a little curious that, while continuing to advocate as scientific truth the determination of human conduct by the formed character of each individual, and while excluding any interference, at the final stage, with the strict sequence of cause and effect, he implicitly admitted the independence or unconditioned agency of the Ego in the formation of his character. "I saw," he says, "that though our character is formed by circum-"stances, our own desire can do much to shape those circum-"stances; and that what is really inspiriting and ennobling in the "doctrine of free-will, is the conviction that *we have real power over* "*the formation of our own character;* that our will, by influencing "some of our circumstances, can modify our future habits and "capacities of willing." I can attach no other meaning to this remarkable passage (the teaching of which is more fully developed in chap. i. of Book VI. of the "System of Logic"), than that it recognizes a factor in the formation of our characters, which is something else than "heredity *plus* environments." For I can scarcely suppose J. S. Mill not to have seen that if a man's desires are themselves the results of antecedent "circumstances," the incubus of hopeless slavery to those circumstances can no more be removed by any desires for self-improvement which *ex hypothesi* arise out of them, than a weight which bears down on a man's shoulders can be lifted off by its own pressure. And any one who reads in De Quincey's "Confessions" the graphic narrative of his miserable experiences from the abuse of opium, will see how ineffectual are the strongest *desires*, without the *will* to carry them into effect.

4. It may be confidently stated as a result of universal experience, that our "capacity of willing," that is, of giving a preponderance to the motive on which we elect to act, depends, *first*, upon our conviction that we really have such a self-determining power, and, *secondly*, upon our habitual exercise of it. The case, which is unfortunately but too common, of a man who habitually gives way to the desire for alcoholic excitement, and is ruining himself and his family by his self-abandonment, will bring into distinct view the practical bearing of the antagonistic doctrines.

The automatism of his nature (purely physical so far as the bodily craving for alcohol is concerned, but including, in most cases, some play of social instincts) furnishes an aggregate of powerful attractions to the present gratification. On the other side is an aggregate of moral deterrents, which, when the attention is fixed upon them in the absence of the attractive object, have a decided preponderance, so far as the *desires* are concerned. The slave of intemperance is often ready to cry out, "O wretched "man that I am, who shall deliver me from the body of this "death?"—and he proves his sincerity by his readiness to take every indirect precaution that does not interfere with his personal liberty. But when the temptation recurs, the force of the attraction is intensified by its actual presence; the direct sensory presentation makes a more vivid impression than the ideal representation of the deterrent motives; and the balance, which previously turned against the indulgence, now preponderates in favour of it. What, then, is it within the power of the Ego to do? On the automatist theory, *nothing*. For not only is he unable to call to his aid any motive which does not spontaneously arise, but he cannot make any alteration in the relative strength of the motives which are actually present to his consciousness. He says, to himself and to others, "I could not help yielding;" and automatism sanctions the plea. Society may be justified in imposing on him either restraint or punishment, alike for its own security and for his welfare; but no consistent automatist can regard him as an object of the *moral reprobation* which we instinctively feel for the self-degraded sot; and experience shows that the system of external repression almost invariably loses its potency as a deterrent, as soon as the restraining influence is withdrawn.

Now, although I hold it beyond question that a state *may* be induced by habitual alcoholic indulgence, in which the unhappy subject of it loses all power of resistance, I affirm it to be "the normal experience of healthy men," that the ordinary toper *has* such a power in the earlier stages of his decadence, and that he is justly held culpable for not exerting it. This power is exercised in the determinate fixation of the Ego's attention on the deterrent motives which he knows *ought* to prevail, and in the determinate withdrawal of his mental vision from the attraction which he knows *ought not* to prevail; so that the intensification of the former, and the weakening of the latter give to the claims of duty a preponderating force in the regulation of the conduct. The deliverance of the universal experience of mankind upon this point, seems to me to take a rank equal to that of our common-sense decision in regard to the reality of an external world. And it is confirmed by the superior efficacy of our appeal to the better nature of the individual we are endeavouring to rescue, when this is backed by the assurance that he *has* the power of escape from the enslavement which he feels to be gradually closing in upon him, if he will but resolutely exert it. We say to him:—"You *can* conquer, if you *will.* And it rests "with *yourself* to will. You have every possible motive of the "highest kind on the one side, and nothing but the attraction of "a selfish indulgence on the other. Be a man, and not a beast. "Exert the power which you know and feel yourself to possess; "keep your thoughts and affections steadily fixed upon the right; "avoid the first step in the downward path; and when the "moment of unexpected temptation comes, make a vigorous "effort, determine to succeed, and you will come off victorious. "And when you have once done so, you will feel a more assured "conviction that you *can* do so again; each victory will make the "next easier to you; and, by steady perseverance, you will re-"acquire that power of self-direction which will enable you to "keep straight without an effort."—I appeal to the experience of such as have had to deal with these sad cases, whether this is not the more effective method.

Whatever allowances Society may be ready to make for individual cases—such, for instance, as that of Hartley Coleridge, who was the victim of a strong hereditary predisposition, accompanied by a constitutional weakness of will,—it recognizes as a fixed conviction, and consistently acts upon that conviction, that the incipient drunkard *has* a power over himself; that *he can not only abstain if he chooses*, but that *he can choose to abstain* because he knows that he *ought* to do so; and that when, by voluntarily giving way to his propensity, he brings himself into a condition in which he is no more responsible for his actions than a lunatic, he is not thereby exempted from the penalty that may attach to them, but must be held responsible for having knowingly and deliberately brought himself into the condition of irresponsibility.

On the automatist theory, a drunkard who deserts a comfortable home for the tap-room (I make large allowance for those who have *un*comfortable homes), who neglects an attached wife and loving children for the society of profligates, and who, with ample means of higher enjoyment, surrenders himself without a struggle to the allurement of sensual pleasure, and at last renders himself amenable to the law by fatal outrage on the patient wife who has long borne with his brutality, is no more a subject of moral reprobation than poor Hartley Coleridge; who, when he strayed from the loving care of his friends, would be found in the parlour of some rural public-house, delighting the rustics with his wonderful stories, and indulging to his heart's content in the unlimited beer which the publican was only too glad to allow him. When, on the other hand, the subject of a strong hereditary alcoholic craving maintains a daily conflict with his tempter, uses every means he can think of to avoid or weaken its seductions, puts forth all his energy in resisting them, and, through occasional failures, comes off on the whole victorious, the consistent automatist can have no other approbation to bestow upon him, than that which he would accord to a self-governing steam-engine or a compensation-balance watch.

5. Further, the existence of the ideas currently attached to the words *duty* and *responsibility*, is an evidence of the acceptance by Mankind at large, of the belief that every normally-constituted individual has a power of *choice* and *self-regulation*,—"ought" necessarily implying "can." And this evidence is not invalidated by the discrepancy which must always exist between *legal* and *moral* responsibility. For the law, looking mainly to the protection of society, necessarily deals rather with acts than with motives; and punishments must often be inflicted with a deterrent view, which we may not regard the criminal as having morally deserved.

Thus, in the rescue of the Fenian conspirators at Manchester, the men who made the attack on the prison-van which involved the death of police-sergeant Brett, were doubtless animated by what they deemed noble and patriotic motives. They had no ill-will towards Brett individually; but, as the Judge laid it down in his charge to the Grand Jury, they were all guilty of murder, as being concerned in the common design of using dangerous violence towards any police who might resist their efforts in procuring the rescue of the prisoners. The man Allen, who fired the fatal shot, seems to have done so in the full knowledge that the sacrifice of his own life would be the consequence:— "I will free you, Colonel," he is reported to have said, "if I swing "for it." If the same thing had been done to rescue an escaped slave, or to retake a ship captured by pirates or mutineers, or by an enemy in war, it would have been accounted a glorious act of heroism. But it can scarcely be doubted that the infliction of capital punishment on the ringleaders in this outrage was necessary to maintain the supremacy of law and order.— The same may be said of the execution of Orsini for his attempt on the life of the Emperor Louis Napoleon. Orsini, it is now well known, was simply the instrument of the Carbonari Society to which the Emperor had belonged in the earlier part of his life, for inflicting the condign punishment decreed by its laws, as the penalty incurred by any of its members who failed to do everything in his power for the liberation of Italy. The Emperor, having been formally tried and condemned for his inaction, was decreed worthy of death, according to the oath which he had himself taken; and lots were cast to select the individual who should be charged with the execution of the sentence. The lot fell upon Orsini, who was summoned from Birmingham for the purpose; and the summons was one (as he hinted to his friends there) which he felt that he must obey, though at the risk of his own life. It is clear that the Emperor felt no personal ill-will against him, and regarded his execution as a political necessity; the publication in the *Moniteur* of the will in which Orsini bequeathed to the Emperor the liberation of Italy and the charge of his children, being understood at the time by well-informed politicians as an acceptance, on the Emperor's part, of both legacies, of which acceptance the liberation of Italy has been the direct or indirect consequence. It is difficult to see in what respect Orsini's act of self-sacrifice, under what we may deem a mistaken sense of duty, was less noble than that of other patriots whom the world holds in honour

Omniscience alone can rightly assign the *moral* responsibility of each individual for his several acts; the degree of that responsibility being determined (as in the cases cited under the last head) by the proportion which his will or self-regulating power bears to the strength of the dominant motives by which he is urged in each case. This ratio, as already shown, will be a "general resultant" of the whole previous course of life; every exercise of the will increasing its vigour and controlling efficiency, while every weak concession to a dominant passion tends to make the individual its slave. And thus a man (or woman) may come at last so far to have lost the power of self-control, as to be unable to resist a temptation to what is known to be wrong, and to be therefore morally irresponsible for the particular act; but such an individual, like the drunkard in the commission of violence, is *responsible for his irresponsibility*, because he has wilfully abnegated his power of self-control, by habitually yielding to temptations which he knows that he ought to have resisted.

The moral judgments which *we* form of the actions of other men, are necessarily as imperfect as our predictions of their conduct; since no one can fully estimate the relative potency of heredity and environments, on the one side, and of the sense of duty and capacity of willing, on the other: and the consciousness of our own weakness in resisting the temptations which we feel most attractive to ourselves, should lead us to make large allowance for the frailties and shortcomings of others. There are too many, who, as old Butler pithily said—

"Compound for sins they are inclined to,
"By damning those they have no mind to."

Kindly allowance for the offender ("considering thyself, lest thou "also be tempted") is perfectly consistent with reprobation of the offence. And thus the "charity" which "beareth all things, "believeth all things, hopeth all things, endureth all things," is in strict accordance with the results of psychological inquiry into the influences which form the character and determine the relative potency of motives.

It seems to me (as to Mr. Sidgwick, *op. cit.*, p. 50) quite clear that on the automatist or determinist theory, such words as "ought," "duty," "responsibility," have to be used, if used at all, in new significations. The welfare of that aggregate of automata which we call society, may require that every individual automaton shall be prevented from doing what is injurious to it; and punishment for offences actually committed may be reasonably inflicted as a deterrent from the repetition of such offences by the individual or by others. But if the individual has *in himself* no power either to do the right or to avoid the wrong, and if the potency of that aggregate of feelings about actions as being "right or wrong" which is termed conscience, entirely depends upon "circumstances" over which he neither has, nor ever has had any control, I fail to see in what other sense he should be held "responsible" for doing what he knows that he "ought not" to have done, or for doing what he knows that he "ought" to have done, than a steam-engine, which breaks away from its "governor" in consequence of a sudden increase of steam-pressure, or which comes to a stop through the bursting of its steam-pipe, can be accounted responsible for the damage thence arising.

The idea of "responsibility," on the other hand, which is entertained by mankind at large, rests upon the assumption, not only that each Ego has a conscience which recognizes a distinction between right and wrong, and which (according to the training it has received) decides *what* is right and *what* is wrong in each individual case, but also that he has a volitional power which enables him to intensify his sense of "duty" by fixing his attention upon it, and thus gives it a potency in determining his conduct which it might not have otherwise possessed. That this power is a part of the Ego's "formed character," and that it can only be exerted within certain limits, is fully admitted on the doctrine I advocate; but the responsibility of the Ego is shifted backwards to the share he has had in the formation of his character and in the determination of those limits. And here, again, the results of scientific investigation are in complete harmony with the precepts of the greatest of all religious teachers. For no one can study these with care, without perceiving that Jesus and Paul addressed themselves rather to the formation of the character than to the laying down rules for conduct; that they endeavoured rather to cultivate the dispositions which should lead to right action, than to fix rigid lines of duty, the enforcement of which under other circumstances might be not only unsuitable but actually mischievous; and that they not only most fully recognized the power of each individual to direct the habitual course of his thoughts, to cherish his nobler affections, and to repress his sensual inclinations, but made the possession of that power the basis of the entire system of Christian morality.

That system has been found to harmonize with the experience of the best and wisest of our race; which has proved its capability of strengthening every virtuous effort, of giving force to every noble aspiration, of aiding the resistance to the allurements of self-interest, and of keeping at bay the stronger temptations of vicious indulgence. The tendency of the automatist philosophy, on the other hand, which represents man as nothing but "a part "of the great series of causes and effects, which, in unbroken "continuity, composes that which is, and has been, and shall be "—the sum of existence," * seems to me to be no less certainly towards the discouragement of all *determinate effort*, either for individual self-improvement, or for the general welfare of the race. For though it fully recognizes, as factors in human action, the most elevated as well as the most degraded classes of motives, and gives all the encouragement to the culture of the one and to the repression of the other that faith in the uniformity of causation can afford, yet by refusing to the Ego any capability of *himself* modifying the potency of those factors, it dries up the source of that sense of independence which springs from the conviction that man's "volition counts for something as a condition in the "course of events," and leaves him a mere instrument in the hands of an inexorable fate.

To myself it seems as if nothing was wanting either in my own self-consciousness, or in what I know of the conscious experiences of other men, to establish the existence of the "self-"determining power" for which I contend. I cannot conceive of any kind of evidence of its existence more cogent than that which I already possess. And feeling assured that the sources of my belief in it lie deep down in the nature of every normally-constituted human being, I cannot anticipate the time when that

* Prof. Huxley in *Fortnightly Review*, Nov., 1874, p. 577.

belief will be eliminated from the thought of mankind; when the words "ought," "duty," "responsibility," "choice," "self-control," and the like, will cease to have the meaning we at present attach to them;—and when we shall really treat each other as automata who cannot help doing whatever our "heredity" and "environments" necessitate.

XI.

THE DEEP SEA AND ITS CONTENTS.

[*Nineteenth Century*, April, 1880.]

When, in June 1871, I placed before Mr. Goschen, then First Lord of the Admiralty, the scheme I had formed for a Scientific Circumnavigation Expedition, I stated as its general object "the "extension to the three great oceanic areas—the Atlantic, the "Indian and Southern, and the Pacific—of the physical and "biological exploration of the Deep Sea, which has been ten-"tatively prosecuted by my colleagues and myself, during a few "months of each of the last three years, on the eastern margin of "the North Atlantic, and in the neighbouring portion of the "Mediterranean." Those researches had been regarded by the scientific public—not of this country only, but of the whole civilized world—as of extraordinary interest; not only for the new facts that they had brought into view and the old fallacies which they had exploded, but for the new ideas they had introduced into various departments of scientific thought. And I felt myself justified in expressing the confident belief "that the wider exten-"sion and systematic prosecution of them will be fruitful in such "a rich harvest of discovery as has been rarely reaped in any "scientific inquiry."

The "Challenger Expedition," thus originated, was fitted out in the most complete manner, everything being done which skill and experience could suggest to make it a complete success. A ship was selected whose size and construction rendered her peculiarly suitable for the work; she was placed under the command of Captain (now Sir George) Nares, than whom no more highly qualified head could have been chosen. In the work of the ship he had the zealous co-operation of a selected staff of naval officers, whilst for the direction of the scientific work the expedition had the advantage of the services of Professor (now Sir) Wyville Thomson, with five assistants, each of whom had already shown special proficiency in the particular department committed to his charge.

The expedition left Sheerness on the 7th of December, 1872, and returned to Spithead on the 24th of May, 1876; having altogether traversed a distance of nearly *seventy thousand* nautical miles or (nearly *four times* the earth's equatorial circumference), and having, at intervals as nearly uniform as possible, established 362 observing stations along the course traversed. This course was, for various reasons, anything but a direct one. In the first year the Atlantic was crossed and recrossed three times each way; and a diversion was made from Bermuda to Halifax, and back again, for the special purpose of examining the phenomena of the Gulf Stream. This first part of the voyage terminated at the Cape of Good Hope, from which a fresh start was made for Kerguelen's Land, on which Captain Nares was directed to report in regard to the sites most suitable for the observation of the approaching transit of Venus. Thence the *Challenger* proceeded due south towards the antarctic ice-barrier: and, after making the desired observations along its margin, she proceeded to Melbourne, Sydney, and New Zealand. The next portion of her voyage was devoted to an examination of the western part of the great Pacific area, with a diversion into the adjacent part of the Malay Archipelago; and it was when proceeding almost due north from New Guinea to Japan that her deepest sounding (the deepest *trustworthy* sounding yet made) of 4,475 fathoms—26,850 feet, or more than *five miles*—was obtained. From Japan her course was shaped almost due east, keeping near the parallel of 38° north as far as the meridian of the Sandwich Islands, so as to traverse about two-thirds of the North Pacific; and then, taking a southern direction, she proceeded first to that group, and thence across the equator to Tahiti, thus making a north and south course through the tropical Pacific. From Tahiti she proceeded south-east towards Cape Horn, with a detour to Valparaiso; and after passing through the Straits of Magellan, touching at the Falkland Islands, and putting in at Monte Video, she proceeded eastward halfway across the South Atlantic, to complete the east and west section partly taken in the first year of the voyage on the parallel of the Cape. Changing her course to the north, she ran a north and south line as far as the equator, in the meridian of Madeira; and then, turning north-west, and keeping at some distance from the African coast, got into the middle line of the North Atlantic, which she followed past the Azores; after which she bore up for home.

At each of the observing stations a sounding was taken for the determination of the exact *depth;* the *bottom-temperature* was accurately ascertained; a sample of *bottom-water* was obtained for chemical and physical examination; and a sample of the *bottom* itself was brought up, averaging from one ounce to one pound in weight. At most of the stations, *serial temperatures* also were taken; *i.e.* the temperature of the waters at several different *depths* between the surface and the bottom was determined, so as to enable "sections" to be constructed, giving what may be called the *thermal stratification* of the entire mass of ocean-water along the different lines traversed during the voyage, and samples of sea-water were also obtained from different depths. At most of the stations a fair sample of the *bottom-fauna* was procured by means of the dredge or trawl: while the *swimming animals* of the surface and of intermediate depths were captured by the use of a "tow-net," adjusted to sweep through the waters in any desired plane. And while the direction and rate of any *surface-current* were everywhere determined by methods which the skilful navigator can now use with great precision, attempts were made to determine *the direction and rate of movement* of the water at different depths, wherever there was any special reason for doing so. In addition to all this, which constituted the proper work of the expedition, meteorological and magnetic observations were also regularly taken and recorded.

The vast mass of accurate information, and of materials from which accurate information may be obtained, which has thus been collected in regard to the Physics of the Ocean, affords a body of data for scientific discussion of which, when it shall have been fully published, advantage will doubtless be eagerly taken by the various inquirers into the different branches of this subject who are at present anxiously waiting for it. And, in like manner, the enormous collection of marine animals that has been most carefully made along the whole of the *Challenger's* course, and at various depths from the surface down to more than four miles—the locality and depth from which every specimen was obtained having been accurately recorded—attests the entire success of the Biological portion of the *Challenger's* work. But here, again, however great the amount of work done, much more remains to do, in the "working up" of this most valuable material. It has been distributed among Naturalists of the highest competence in their respective departments, each of whom will report separately upon his own subject. And only when all these separate reports shall have been published, which cannot be for some years, will it be possible to give a general *résumé* of the zoological results of the expedition. But in the study of the *bottom-deposits* more progress has been made; and Mr. Murray—one of the *Challenger* scientific staff, who was specially charged with this department during the voyage—has already arrived at some results of such remarkable interest as fully to justify the belief I had expressed to Mr. Goschen, "that the key to the interpretation of much of the past "history of our globe is at present lying at the bottom of the sea, "waiting only to be brought up."

I have been so often asked, "What has the *Challenger* expedi-"tion done for science?" that, notwithstanding what I have shown to be the impossibility of at present giving more than a very inadequate idea of the results of its work, I shall now endeavour briefly to show what light these results have thrown on a few *general questions* of great interest; some of which were first opened up in our previous deep-sea explorations, while on others not apparently related to it the *Challenger* researches have been found to cast an unexpected light.

The question which naturally takes the first place in order is that of the *depth and configuration of the Ocean basins*, as to which little had been previously learned with certainty, except in the case of the North Atlantic, which had been carefully sounded along certain lines with a view to the laying of telegraph cables. The first systematic survey of this kind brought out a set of facts which were then supposed to be exceptional, but which the soundings of the *Challenger*, taken in connection with those of the United States ship *Tuscarora* and the German *Gazelle*, have shown to be general; viz. (1) that the bottom sinks very gradually from the coast of Ireland, westward, for a hundred miles or more; (2) that then, not far beyond the hundred-fathom line, it falls so rapidly that depths of from 1200 to 1500 fathoms are met with at only a short distance further west; (3) that after a further descent to a depth of more than 2000 fathoms, the bottom becomes a slightly undulating plain, whose gradients are so low as to show scarcely any perceptible alteration of depth in a section in which the same scales are used for vertical heights and horizontal distances; * and (4) that on the American side as on the British this plain is bordered by a very steep slope, leading up quickly to a bottom not much exceeding 100 fathoms in depth, which shallows gradually to the coast-line of America. Nothing seems to have struck the *Challenger* surveyors more than the extraordinary *flatness* (except in the neighbourhood of land) of that depressed portion of the earth's crust which forms the floor of the great oceanic area; the result of one day's sounding enabling a tolerably safe guess to be formed as to the depth to be encountered on the following day; and thus, if the bottom of the mid-ocean were laid dry, an observer standing on any spot of it would find himself surrounded by a plain only comparable to that of the North American prairies or the South American pampas.

Thus our notions of the so-called "ocean basins" are found to require considerable modification; and it becomes obvious that, putting aside the oceanic islands which rise from the bottom of the sea, as mountain-peaks and ridges rise from the general surface of the land, the proper oceanic area is a portion of the crust of the earth which is depressed with tolerable uniformity some thousands of feet below the land area, whilst the bands of

* Sections drawn (as usual) with a *vertical* scale enormously in excess of the horizontal altogether misrepresent the real character of the oceanic sea-bed.

shallow bottom which usually border the existing coast-lines are to be regarded as submerged portions of the adjacent land-platforms. The form of the depressed area which lodges the water of the deep ocean is rather, indeed, to be likened to that of a flat waiter or tea-tray, surrounded by an elevated and steeply sloping rim, than to that of the basin with which it is commonly compared. And it further becomes obvious that the *real* border of any oceanic area may be very different from the *ostensible* border formed by the existing coast-line.

Of this difference between the shallow waters covering submerged land, and the sea that fills the real ocean basins, we have nowhere a more remarkable example than that which is presented to us in the seas which girdle the British Islands. These are all so shallow that their bed is undoubtedly to be regarded as a continuation of the European continental platform, an elevation of the north-western corner of which, to the amount of only 100 fathoms, would reunite Great Britain to Denmark, Holland, Belgium, and France, and would bring it into continuity with Ireland, the Hebrides, and the Shetland and Orkney Islands. Not only would the whole of the British Channel be laid dry by such an elevation, but the whole of the North Sea also, with the exception of a narrow deeper channel that lies outside the fiords of Norway. Again, the coast-line of Ireland would be extended seawards to about 100 miles west of Galway, and that of the Western Hebrides to beyond St. Kilda; but a little further west, the sea-bed shows the abrupt depression already spoken of as marking the commencement of the real Atlantic area. A like rapid descent has been traced outside the hundred-fathom line in the Bay of Biscay (a considerable part of which would be converted into dry land by an elevation of that amount), and along the western coast of Spain and Portugal, where, however, it takes place much nearer the existing land-border. The soundings of the United States ship *Tuscarora* in the North Pacific have shown that a like condition exists along the western coast of North America; a submerged portion of its continental platform, covered by comparatively shallow water, forming a belt of variable breadth outside the existing coast-line, and the sea-bed then descending so rapidly as distinctly to mark the real border of the vast Pacific depression. And as similar features present themseves elsewhere, it may be stated as a general fact that *the great continental platforms usually rise very abruptly from the margins of the real oceanic depressed areas.*

On the other hand, a *depression* of the existing land of northern Europe to the same or even half that amount would cause very extensive areas of what is now dry land to be overflowed by sea; the higher tracts and mountainous regions alone remaining as representatives of the continental platform to which the submerged portions equally belong. This, as every geologist knows, has been, not once only, but many times, the former condition of Europe; and finds a singular parallelism in the present condition of that great continental platform of which the peninsula and islands of Malaya are the most elevated portions. For the Yellow Sea, which forms the existing boundary of south-eastern Asia, is everywhere so shallow that an elevation of 100 fathoms would convert it into land, while half that elevation would lay dry many of the channels between the Malay Islands, so as to bring them into continuity not only with each other but with the continent of Asia. And Mr. Wallace's admirable researches on the zoology of this region have shown that such continuity undoubtedly existed at no remote period, its mammalian fauna being essentially Asiatic. On the other hand, a like elevation would bring Papua into land-continuity with Australia; with which, in like manner, the intimacy of its zoological relations shows it to have been in former connection. The Indo-Malay province is separated from the Papuo-Australian province by a strait which, though narrow, is so much deeper than the channels which intervene between the separate members of either group that it would still remain as a fissure of considerable depth, even if the elevation of the two parts of the great area it divides were sufficient to raise most of each into dry land. And thus we may view the whole area extending from south-eastern Asia to South Australia as a vast land-platform (partly submerged), of which the great fissure that divides it into two distinct zoological provinces may be considered as corresponding with the great break made by the Mediterranean in the continuity between Europe and Africa, and that made by the Gulf of Mexico and the Caribbean Sea in the continuity between North and

South America. There is generally a very marked contrast in elevation between the slightly submerged portions of this land-platform and the deep sea-floors in its neighbourhood, the descent from the former to the latter being very abrupt.

Now these parts remarkably confirm the doctrine long since propounded by the distinguished American geologist Professor Dana, when reasoning out the probable succession of events during the original consolidation of the earth's crust, and its subsequent shrinkage upon the gradually contracting mass within—that these elevated areas now forming the Continental platforms, and the depressed areas that constitute the existing Ocean-floors *were formed as such in the first instance*, and have remained unchanged in their general relations from that time to the present, notwithstanding the vast disturbances that have been produced in each by the progressive contraction of the earth's crust. For this general contraction, coupled with the unequal bearing of the different parts of the crust upon one another, has been the chief agency in determining the evolution of the earth's surface-features; producing local upheavals and subsidences alike in the elevated and depressed areas; so that lofty mountains and deep troughs have been formed, with plications and contortions of their component strata; metamorphism of various kinds has been produced, and volcanic action, with earthquake phenomena involving extensive dislocations of the crust, has been repeated through successive geological periods, mostly along particular lines or in special areas, without making any considerable alteration in the position of the great Continent, or in the real borders of the Oceanic areas, though the amount of the continental areas that might be above water, and the position of their coast-lines, might vary greatly from time to time.

This idea of the general permanence of what we used to call the great "ocean basins" had, in fact, struck me forcibly, as soon as the soundings of the *Challenger* and *Tuscarora*, in the Pacific, enabled me to work out the enormous disproportion between the mass of land above the sea-level and the volume of the waters beneath it. At the end of our first (*Lightning*) cruise in 1868, my colleague, Professor Wyville Thomson, had pointed out to me that there is no adequate reason for supposing that the present bed of the North Atlantic has ever been raised into dry land since the termination of the Cretaceous epoch, which was marked by the elevation of the chalk formations of Europe and Asia on the one side, and of North America on the other, into dry land; and that the persistence of a considerable number of cretaceous types in its marine fauna justifies the conclusion that the deep sea-bed of this ocean has not undergone any essential change of condition through the whole of the Tertiary period. This conclusion I unhesitatingly indorsed; and though the announcement of it rather startled some of our geological Nestors, it has come to be generally accepted by the younger generation as by no means improbable. Subsequent reflection upon the disproportion to which I have just referred, though from imperfect data I at first *under*-estimated it, disposed me to extend the same view to the ocean basins generally; and happening at the same time to become acquainted with the doctrines which had been advanced by Professor Dana (then little known in this country), I was strongly impressed by their accordance—this being the more remarkable on account of the entire difference of the data and lines of reasoning which led Professor Dana and myself to the same conclusion.*

We are now able to form an estimate of the relative masses of Land and Sea which is probably not far from the truth. The *area* of the existing land is to that of the sea as about 1 to $2\frac{3}{4}$, or as 4 : 11; so that if the entire surface of the globe were divided into fifteen equal parts, the land would occupy only four of these, or rather more than a quarter, whilst the sea would cover eleven, or rather less than three-quarters. But the average *height* of the whole land of the globe above the sea-level certainly does not exceed 1000 feet, that of Asia and Africa being somewhat above that amount, while that of America (North and South), Europe, and Australia is considerably below it. On the other hand, the average *depth* of the ocean-floors is now known to be at least $2\frac{1}{2}$ miles, and may be taken (for the convenience of round number) at 13,000 feet. Thus the average depth of the ocean being 13 times as much as the average height of the

* See my article "Atlantic," in the ninth edition of the *Encyclopædia Britannica.*

land, and the area of the sea $2\frac{3}{4}$ times that of the land, *the total volume of the ocean-water is* ($2\frac{3}{4} \times 13$) *just* 36 *times that of the land above the sea-level.*

Now this disproportion appears to me to render it extremely improbable that any such geological "see-saw" as may have produced successive alternations of land and water between the several parts of the same continental platform can have ever produced an exchange between any continental platform and an ocean-floor such as was assumed by Sir Charles Lyell to have taken place over and over again in geological time.* For even supposing all the existing land of the globe to sink down to the sea-level, this subsidence would be balanced by the elevation of only *one thirty-sixth* part of the existing ocean-floor from its present average depth to the same level. Or, again, let the great island-continent of Australia (whose area is about one-seventeenth of the total land-area of the globe) be supposed to subside to the depth of the average sea-bed, so as to be altogether lost sight of not only by the surface navigator but by the deep-sea surveyor, and a compensatory elevation to take place in the existing land area, this, if limited to an area of the size of Australia (which is about equal to that of the whole of Europe), *would raise it all to nearly the height of Mont Blanc;* whilst, if spread over the entire land area of the globe, *it would nearly double its present average elevation.*

Now we have no reason whatever to believe that *vertical* upheavals or subsidences have ever taken place over extensive areas to anything like such amounts, which have their parallels only in the elevation of lofty mountain chains, or in the complementary formation of deep troughs now filled by sedimentary deposit originating in the degradation of the neighbouring land; which local disturbances (as Professor Dana has shown) have been effected by the *lateral* or *horizontal* thrust engendered during the shrinkage of the globe in cooling. Moreover, the contours of the oceanic area, so far as they have been yet determined by the *Challenger* and other soundings, give no sanction whatever to the notion of the existence of any submerged continental platform. On the contrary, the *Challenger* observations enable it to be affirmed with high probability that the islands which are met

* See chap. xii. of his *Principles of Geology.*

with in the real oceanic area (as distinguished from those which, like the British Isles, are really outlying parts of the slightly sunken corner of the platform which rises into continental land in their vicinity; or which, like the great islands of the Malayan Archipelago, are the "survivals" of a continental platform more deeply submerged) are all of Volcanic origin, having been projected upwards from beneath, instead of having gone down from above. This may be stated with confidence in regard to all those which consist of inorganic rocks; and since it is equally true of those coral islands whose rock basis shows itself above the surface, the same may be fairly presumed in regard to the submerged peaks on which those "atolls" rest, above whose level platforms no rocky base now rises. These volcanic vents are generally found on upward bulgings of median portions of the depressed ocean-floors; whilst, on the other hand, the volcanoes which rise from the elevated land-platforms are for the most part thrown up near their oceanic margins; and Professor Dana gives mechanical reasons for both these classes of facts, deduced from consideration of the mode in which the horizontal thrust will be exerted in the two areas respectively. The "crumpling" of the elevated portions of the crust which throws up mountain ridges, produces at the same time equivalent depressions, and these will be filled by sea-water if it has access to them, as is the case with the enormously deep pit-holes found in various parts of the Malayan area; or with fresh waters where, being cut off from the sea, they are surrounded by a mountainous region affording a large supply of it, as in deep lake-basins of Switzerland; or they may remain almost empty for want of water, like the deeply depressed valley of the Jordan; or may be partly filled, like the Caspian. And thus the distribution of land and water over different parts of the Continental platforms may have been greatly changed from time to time, and groups or chains of islands may have been raised and again submerged in the Oceanic area, without making any such essential changes in the Map of the World as Sir Charles Lyell supposed to have taken place over and over again.

Now this view of the permanence of the great original division of the crust of the earth into elevated and depressed areas, and of the non-conversion of any considerable part of a continental platform into a deep sea-bed, or of a deep sea-bed into a continental platform, has received a most unexpected and explicit confirmation from the study of the *deposits* at present being formed on the Oceanic sea-bed, of which a sample was brought up in every sounding taken by the *Challenger*, whilst larger collections of them were made by the trawl and the dredge. For such deposits as are obviously formed by the disintegration of ordinary land-masses were, as a rule, only found in the comparatively shallow waters in the near neighbourhood of those masses, the almost universal absence of the ordinary *siliceous sand* of our shores being a most noteworthy fact. Indeed, the exception served to prove the rule; for it was only when the *Challenger's* course lay parallel to the coast of Africa, some two or three hundred miles to the westward of it, that the soundings gave evidence of its presence; and that this sand had been *blown* over the sea-surface from the Sahara was indicated by its deposit as a fine dust on the ship's deck: but deposits of volcanic origin were met with in unexpected abundance, the most common being a *red clay*, first found on the deepest areas of the Atlantic, the source of which was for some time a question of great perplexity to the scientific staff of the *Challenger*, from its presenting itself at such a distance from any land that it could not be supposed to have been brought down (as the clay deposits of shore-waters are) by continental rivers. The clue to the solution of the difficulty was furnished by the unexpected capture, in the "tow-net," of a considerable number of floating masses of pumice-stone, whilst the trawl frequently brought up bushels of such, varying in size from that of a pea to that of a football. Now pumice is formed of ordinary lava which has been raised (like dough) into a spongy condition by the liberation of gases in its substances, and it contains a considerable proportion of feldspar, which affords the material of clay; and as the clay deposits were found to contain fragments of pumice in various stages of disintegration, the probability of their volcanic origin seems so strong as to justify its full acceptance. Mr. Murray thinks it likely that not only all the pieces of pumice which float on the surface, but those spread over the sea-bottom, have been ejected from *land*-volcanoes; some of them, perhaps, having fallen into the sea in the first instance, but the greater number having been washed down by rain and rivers. After floating for a longer or shorter time, so as to be carried about by winds and currents, perhaps to very considerable distances, they would become water-logged and sink to the bottom, and there undergo gradual disintegration. They were always found in greatest abundance in the neighbourhood of volcanic centres, such as the Azores and the Philippines; and within their areas, again, were found tufaceous deposits—dust and ashes which had been carried by the winds blowing over the craters. But there were also occasionally found, at several hundred miles' distance from any land, small pieces of obsidian and basaltic lavas, whose presence there could only be accounted for by *submarine* volcanic action.

In association with the clays there were found remarkable deposits of *manganese*, sometimes incrusting corals, etc., with a coating of greater or less thickness, but more generally forming nodular concretions, varying in size from little pellets to several pounds in weight, which were usually found to include organic bodies, such as sharks' teeth or whales' ear-bones. The following summary of this curious class of facts is given in Lord George Campbell's "Log-letters":—

"In some regions everything at the bottom, even the bottom "itself, would appear to be overlaid by and impregnated with this "substance. Sharks' teeth of all sizes (many gigantic, one was "four inches across the base) are frequent, and are sometimes sur-"rounded by concentric layers of manganese of nearly an inch in "thickness. A siliceous sponge, bits of pumice, radiolaria and "globigerinæ, and lumps of clay, have all been found forming the "nuclei of these nodules. We have caught in one haul, where "there has been no reason to suppose that the trawl has sunk "more than two inches in the clay, over 600 sharks' teeth, 100 "ear-bones of whales, and fifty fragments of other bones, some "embedded in manganese an inch thick, some with only just a "trace of manganese on them, and some with no trace at all. "These sharks' teeth are all *fossil* teeth, the same as are found "in great quantities in Tertiary formations, particularly in Swiss "Miocene deposits.*

* The writer does not seem aware of the extraordinary abundance of similar sharks' teeth and whales' ear-bones in the so-called "coprolite pits" of our Suffolk crag.

"As we have every reason to believe that this aggregation of "the manganese is a very slow process, the occurrence of these "teeth and bones, some embedded deeply, and some not at all, in "the same surface-layers, argues strongly in favour of an extremely "slow rate of deposition. On the other hand, the occurrence of "sharks' teeth in shore deposits is extremely rare, and in the "organic oozes slightly less so"—p. 495.

This deposit of manganese seems, like that of the red clay, traceable to a volcanic source:—

"Wherever we have pumice containing much magnetite, "olivine, augite, or hornblende, and these apparently undergoing "decomposition and alteration, or where we have great showers "of volcanic ash, there also is manganese in the greatest abund-"ance. The correspondence between the distribution of these "two may therefore be regarded as very significant of the origin "of the latter. Manganese is as frequent as iron in lavas; and in "magnetite and in some varieties of hornblende and augite it par-"tially replaces peroxide of iron. It is therefore probable that the "manganese, as we find it, is one of the secondary products arising "from the decomposition of volcanic minerals, that decomposition "being caused by the carbonic acid and oxygen of ocean-waters." —*Log-letters*, p. 495.

These deep-sea deposits of manganese differ in mineral structure and composition from any of the known ores of that metal; and the conditions under which they are being formed constitute a problem of very great interest, to which, as to other points of this inquiry, a most distinguished Continental petrologist, the Abbé Renard, is now giving the most careful attention, with the full expectation of being able to throw great light upon the mode of production of many minerals whose origin has been hitherto unaccounted for.

But there is yet another form of inorganic deposit whose character is even more remarkable:—

"In the midst of the clay from the bottom," says Professor Geikie, "Mr. Murray found numerous minute spherical granules "of native iron, which, as he suggests, are almost certainly of "*meteoric* origin—fragments of those falling stars which, coming to "us from planetary space, burst into fragments when they rush "into the denser layers of our atmosphere. In tracts where the "growth of silt upon the sea-floor is excessively tardy, the fine "particles scattered by the dissipation of these meteorites may "remain in appreciable quantity. It is not needful to suppose "that meteorites have disappeared over these ocean-depths more "numerously than over other parts of the earth's surface. The "iron granules have no doubt been as plentifully showered down "elsewhere, though they cannot be so readily detected in accumu-"lating sediment. I know no recent discovery in physical geo-"graphy more calculated to impress deeply the imagination than "the testimony of this meteoric iron from the most distant abysses "of the ocean. To be told that mud gathers on the floor of those "abysses at an extremely slow rate conveys but a vague notion of "the tardiness of the process. But to learn that it gathers so "slowly that the very star-dust which falls from outer space forms "an appreciable part of it, brings home to us, as hardly anything "else could do, the idea of undisturbed and excessively slow "accumulation."—*Lecture on Geographical Evolution*, p. 7.

Next to the volcanic clays, the *globigerina-ooze* (which had been brought up by the hundredweight in the *Lightning* and *Porcupine* dredgings) proved to be the most abundant oceanic deposit. Not only from the completeness of their minute shells in the surface-layer, but also from the fact that a large proportion of these shells were occupied by their sarcodic bodies in an apparently fresh condition, we had concluded that the Globigerinæ live on the bottoms on which their remains accumulate. But since, in nearly all but the coldest parts of the oceanic area traversed by the *Challenger*, they were collected in abundance by the "tow-net" drawn through the waters at or beneath the surface, Sir Wyville Thompson and some of his associates have come to the conclusion that they pass their whole lives in the surface stratum, their subsidence to the bottom only taking place after their death. I have myself, however, remained of the opinion that they subside during life, when the addition of new chambers has come to an end, and the further exudation of carbonate of lime has been applied to the thickening of the walls of the old; and that they continue to live on the bottom, continually adding to the thickness of their shells. And in this I have the satisfaction of finding myself supported by Mr. H. B. Brady, into whose most competent charge the Foraminifera of the *Challenger* have been given for "working up." For the result of a series of most careful comparisons between the Globigerinæ brought up from any bottom and those captured floating in the upper waters of the same region, shows that the shells of the former so greatly exceed those of the latter in size and massiveness as to make it certain that they continued to live and grow after their subsidence.

The careful examination in which Mr. Murray has been engaged of the *calcareous* deposits (resembling chalk in process of formation), chiefly consisting of globigerina-ooze, but also containing the disintegrated remains of free-swimming Pteropod molluscs, as well as of shells and corals that have lived on the bottom, has led him to the remarkable conclusion that in their descent from the upper waters towards the deeper sea-bottoms the thin shells of the Globigerinæ and the yet more delicate pteropod shells are again dissolved, by the agency of the carbonic acid that is held in larger proportion in those abyssal waters. And thus it was that on the deepest parts of the Oceanic area, though Globigerinæ were captured by the tow-net in the same abundance as elsewhere, their remains were entirely wanting on the bottom beneath. At intermediate depths the ooze and the red clay would often be found mixed, in proportions that seemed related to the depth. But in the shallower waters not sufficiently charged with carbonic acid to exert any solvent powers, the organic deposit prevailed almost to the exclusion of the inorganic. This, then, seems to have been the condition of the marine area in which the old Chalk was deposited; a variety of considerations pointing to the conclusion that the sea-bottom whereon accumulated the foraminiferal ooze of which it is almost entirely composed, was of no considerable depth.

But the surface-waters are also inhabited by microscopic organisms whose skeletons are composed, not of carbonate of lime, but of *silex*; and of these, some—the Diatoms—are vegetable, whilst others—the Radiolarians—are animals of about the same simplicity as the Foraminifera. The Diatoms abound in those colder seas which are not prolific in Foraminifera; often accumulating in such numbers as to form green bands that attract the notice of both Arctic and Antarctic voyagers. And their exquisitely sculptured cases, accumulating on the bottom, form a siliceous "Diatom-ooze," which takes the place in higher latitudes of the white calcareous mud, resulting from the disintegration of foraminiferal shells. The foraminiferal ooze, moreover, generally contains, in larger or smaller proportion, the beautiful siliceous skeletons of Radiolaria; and sometimes these were found to predominate to such a degree that the ooze mainly consisted of them, in which case it was designated as radiolarian. As siliceous skeletons are not—like calcareous—dissolved by deep-sea water, those which fall down from the surface even upon the deepest bottoms rest there unchanged; and thus it happens that they are found diffused through the red-clay deposits, and, at the greatest depths, sometimes almost entirely replace them. Some of these minute organisms were almost everywhere captured alive in the tow-net; but, like the Diatoms, they commonly aggregate in patches or bands, and this to such a degree as to colour the sea-surface, the hue of their animal substance being usually red or reddish-brown. Such patches are often seen in the neighbourhood of the Shetlands, where they are designated by the fishermen as "herring food."

Thus, then, if we compare (1) the deposits now going on upon the deep Oceanic sea-bed, (2) the sediments at present in course of deposition in the shallower bottoms nearer land, and (3) the materials of the sedimentary rocks of all geological periods, we see that whilst there is a close correspondence between the second and the third, the first differs so completely—in most particulars—from both the others as to be utterly beyond the range of comparison with them; the chief exception being presented by those calcareous sediments which correspond with the various Limestone formations intercalated among the sandstones and clays that have had their origin in the degradation of the pre-existing land. We now know for certain that the sands and clays washed off the land—whether by the action of ice or river-waters on its surface, or by the wearing away of its margin by the waves of the sea—sink to the sea-bottom long before they reach the deeper abysses; *not the least trace of such sediments having been anywhere found at a distance from the continental platforms.* And thus the study of the deposits on the Oceanic sea-bed has fully confirmed the conclusion drawn from the present configuration of the earth's surface, as to the general persistence of those original inequalities which have served as the bases of the existing continents, and the floors of the great ocean basins.

In the masterly lecture on "Geographical Evolution" recently given by Professor Geikie before the Royal Geographical Society, the importance of these results, as affording the key to the interpretation of much of the past history of the earth, is most fully brought out. "For," he unhesitatingly asserts, with all the authority of a vast geological experience, "from the earliest geo-"logical times the great area of deposit has been, as it still is, *the* "*marginal belt of sea-floor skirting the land.* It is there that nature "has always strewn 'the dust of continents to be.' The decay of "old rocks has been unceasingly in progress on the land, and the "building up of new rocks has been as unceasingly going on "underneath the adjoining sea. The two phenomena are the "complementary sides of one process, which *belongs to the terres-* "*trial and shallow oceanic parts of the earth's surface, and not to the* "*wide and deep ocean basins.*" "No part of the results obtained "by the *Challenger* expedition," he goes on to say, "has a pro-"founder interest for geologists and geographers than the proof "they furnish that the floor of the ocean-basins has no real analogy "among the sedimentary formations which form most of the frame-"work of the land." And after dwelling on the chief facts I have already brought together, he thus sums up :—

"From all this evidence we may legitimately conclude that "the present land of the globe, though composed in great measure "of marine formations, has never lain under the deep sea, but "that its site must always have been near land. Even its thick "marine limestones are the deposits of comparatively shallow "water. Whether or not any trace of aboriginal land may now "be discoverable, the characters of the most unequivocally marine "formations bear emphatic testimony to the proximity of a terres-"trial surface. The present continental ridges have probably "always existed in some form; and as a corollary we may infer "that *the present deep ocean-basins likewise date from the remotest* "*geological antiquity.*"

No part of the *Challenger's* work has been more thoroughly and successfully carried out than the determination of the *thermal stratification*, or vertical distribution of temperature in the different parts of the Oceanic area; an inquiry first prosecuted with trustworthy thermometers ("protected" to resist pressure) in the *Porcupine* expeditions of 1869 and 1870. This determination was effected by "serial" temperature-soundings; thermometers attached to a sounding-line being let down to depths progressively increasing by 10 fathoms down to 200, and below this to depths progressively increasing by 100 fathoms to the bottom. It is in the upper stratum of 200 fathoms that the most rapid reduction of temperature usually shows itself; the further reduction beneath this stratum taking place at a progressively diminishing rate, until from 1500 fathoms downwards to the bottom at any depth there is usually very little change.

The Temperature-soundings of the *Challenger*, supplemented by other more limited explorations of the same kind, have clearly brought out this most unexpected result, that the low bottom-temperatures previously observed represent,—not, as has been supposed, the overflowing of the sea-bed by "Polar currents" of limited breadth and inconsiderable thickness, overlaid by a vast mass of comparatively warm water,—but the reduction of nearly the whole body of oceanic water, in every basin except that of the North Atlantic (to whose exceptional character I shall presently advert), to a temperature which averages but a very few degrees above 32° Fahr., that of its deepest stratum being sometimes even a degree or two *below* the freezing-point of fresh water; while the heating influence of the solar rays is limited to a very small depth beneath the surface.

Thus in the South Atlantic, in which a sounding taken near 37° S. lat. gave a depth of 2900 fathoms and a bottom-temperature beneath 32° Fahr., the lowest stratum, consisting of *absolutely glacial water*, was found to have the enormous thickness of 1000 fathoms: this was overlaid by another stratum of 1000 fathoms, in which the temperature rose slowly from 32° at its lower to 36½° at its upper surface; and this, again, by another of about 500 fathoms, which showed a further rise at its upper surface to 40°, the rate of elevation from below upwards being no more than about 0.7° for every 100 fathoms. Thus it is only in the uppermost layer of about *four hundred fathoms* (less than one-seventh of the whole) that the temperature exceeds 40°; and the regularity of the rise of the thermometer, from 40° at its base to the summer surface-temperature of 70°, at the rate of about 7½° for every 100 fathoms, justifies our regarding the plane of 40° as the limit of the depth at which the solar rays here exert any direct heating influence.

On her passage southwards towards the Antarctic ice-barrier, the *Challenger* found the progressive reduction of surface-temperature to correspond with the progressive thinning of the warm superficial layer in a manner which clearly showed that the thermal condition of the southern ocean is entirely dominated by the flow into it of the great mass of glacial water which has been cooled down in the Antarctic area, and that it is, so to speak, a vast *reservoir of cold*, the outflow from which keeps down the temperature of every part of the oceanic area in free communication with it. This we see best in the Pacific, whose vast basin is almost entirely filled by water of glacial or sub-glacial coldness, on the surface of which in the intertropical region there floats a layer whose temperature rises rapidly from its lower limit of 40° to 80° at the surface, and whose thickness is nowhere more than *one fifth* of the whole depth. This exceptional stratum, which clearly derives its heat from the direct action of the solar rays upon its surface, progressively thins away in either hemisphere as it is traced from the tropic to the parallel of 55°, where it disappears altogether, except in the course of the Kuro Siwo, or gulf-stream of the Pacific, which slants northwards from Japan towards Behring's Strait. That the cold of the great mass of glacial and sub-glacial water which everywhere underlies it, and which rises to the surface beyond its northern and southern borders, is due to an underflow from the Antarctic area, is distinctly indicated by the absolute continuity of the same glacial temperature throughout the deepest stratum—all the way from the southern ocean to the Aleutian Islands, the bottom-temperatures at depths of 2000 fathoms or more not differing as much as 1° Fahr., whilst the thermal stratification of the whole superincumbent mass up to within 500 fathoms of the surface shows a similar uniformity.

The thermal condition of the North Atlantic, however, is very different. Putting aside the extraordinarily low temperature of $29\frac{1}{2}^{\circ}$ revealed by the *Porcupine* temperature-soundings in the stratum occupying the deeper part of the channel of 500 fathoms between the Faroe and the Shetland Islands, which has been since proved to be a southward extension of the true Arctic basin, no lower bottom-temperature than 35° had been anywhere met with in our earlier work, while we had found the thickness of the warm stratum ranging from 40° upwards to range from 800 to 900 fathoms. This want of a truly *glacial* understratum I attributed to the limitation of the communication between the deeper parts of the Arctic and North Atlantic basins, preventing the coldest water of the former from flowing out into the latter. And this explanation has been borne out by the subsequent temperature-soundings of the *Valorous*, which have shown the existence of a ridge between Greenland and Iceland, lying at a depth which allows water of 35° to pass over it, while keeping back the deeper stratum of Arctic water. I had further predicted than an Antarctic underflow would probably be found to range to the north of the Equator, where it would be recognized by the reduction of the bottom-temperature below 35°: and this prediction was verified in the first temperature-section carried by the *Challenger* obliquely across the Atlantic to St. Thomas's, the bottom-temperature there falling a degree, and showing a still further reduction as it was subsequently traced southwards to the Equator, where it fell nearly to 32°.

But, further, I had ventured the prediction that the meeting of the Arctic and Antarctic underflows under the Equator would cause an uprising of cold water from the bottom towards the surface, so that the plane of 40° would be found nearer the surface in the neighbourhood of the line than either to the north or to the south of it; and it was a great surprise to many on board the *Challenger* to find, as they first approached the Equator from the Tropic of Cancer, the plane of 40° rapidly rising from a depth of 700 fathoms towards the surface, though the temperature of that surface-stratum was itself becoming higher and higher until water of 40° was found at a depth of less than 300 fathoms, descending again to about 400 as the *Challenger's* course was laid towards the Tropic of Capricorn. This anomaly had been remarked by Lenz fifty years previously: but the valuable series of temperature-observations which he took in Kotzebue's second voyage was strangely overlooked by those who ranked as the highest authorities on the physics of the earth, until recently disinterred by Professor Prestwich.

Not only is the stratum of above 40° Fahr. exceptionally deep in the North Atlantic, but it is exceptionally warm, especially on its western side, where a stratum of water having a temperature above 60° Fahr. was found by the *Challenger* to range to a depth of nearly 400 fathoms. Taking all circumstances into account, I entertain no doubt that Sir Wyville Thomson is right in regarding this stratum as the reflux of the northern division of the great Equatorial Current, from the coast of the West India Islands and of the peninsula of Florida, added to that of the Gulf Stream proper. In consequence of the evaporation produced by its prolonged exposure to the tropical sun, this water contains such an excess of salt as, in spite of its high temperature, to be specifically heavier than the colder water which would otherwise occupy its place in the basin, and consequently substitutes itself for the latter by gravitation, to a depth of several hundred fathoms. Thus it conveys the solar heat downwards in such a manner as to make the North Atlantic between the parallels of 20° and 40° a great reservoir of *warmth*, the importance of which will presently become apparent.

The *Challenger* investigations have now, I think, afforded the requisite data for the final solution of a question which has been long under discussion—what, namely, the Gulf Stream (or Florida Current) *does*, and what it *does not*, for the amelioration of the climate of North-western Europe. All the best hydrographers, both of this country and of the United States, agree in the conclusion that the Florida current dies out in the mid-Atlantic, losing all the attributes by which it had been previously distinguished—its movement, its excess of warmth, and its peculiarly deep colour; and that it then degenerates into a mere surface-drift, the rate and direction of which depend entirely upon the prevalent winds. But, on the other hand, most conclusive proof has been obtained by the systematic comparisons of sea and air temperatures along the western coasts of North-western Europe that the amelioration of its winter climate is due to the afflux of water of a temperature considerably higher than that of the air. It has been urged with conclusive force by Admiral Irminger (of the Danish Navy) that nothing else can account for the openness of the fiords and harbours of the indented coast of Norway, even beyond the North Cape, through the whole winter; whilst the opposite coast of East Greenland, ranging, like it, between the parallels of 60° (that of the Pentland Firth) and 72° N., is so blocked with ice throughout the year as only to be approachable in exceptional summers. And this view has derived full confirmation from the observations systematically carried on under the direction of Professor Möhn of Christiania (the able director of the Meteorological Department of Norway), which have shown how completely dependent the temperature of the coast-line is upon that of the sea which laves it. For while the temperature of the air is generally much below the freezing-point during the winter months, that of the water is always considerably above it; the average excess at Fruholm, near the North Cape, being as much as 14½° Fahr. And it has been further shown by Professor Möhn that not only the coast-temperature of Norway during the winter, but its inland climate, is affected in a very marked manner by this afflux of warm water; for the "isocheimals," or lines of mean winter-temperature, instead of corresponding with the parallels of latitude, lie parallel to the coast-line.

How, then, are these phenomena to be explained? If the *vis a tergo* of the Gulf Stream has spent itself in the mid-Atlantic, what force brings this afflux of warm water to our shores, and carries it on to the north-east, along the coast of Norway, and even past the North Cape to Spitzbergen and Nova Zembla? And how does it happen that the water that laves our north-western shores in winter is not only so much warmer than the air which rests upon it, but continues to preserve a notable portion of that warmth, at least as far as the North Cape, notwithstanding that as it flows northwards its temperature is more and more in excess of that of the atmosphere above it?

It is obvious that the continual outflow of the deeper stratum of Polar water, of which we have evidence in the constant maintenance of the glacial temperature, not only of the sea-bottom, but of the great mass of the water contained in the vast oceanic basin, cannot be maintained without a continual indraught of the upper stratum towards the Poles; this, as its temperature is progressively lowered, decreases in volume and increases in specific gravity; and as the lower stratum flows away under the excess of pressure, the upper stratum, now cooled down nearly to the freezing-point of salt water, will sink into its place, making way for a new indraught above. The two Polar underflows, on the other hand, meeting at or near the Equator, will there tend to rise towards the surface, replacing the water which has been draughted away towards either Pole; and thus a constant "vertical circulation" must be kept up by opposition of temperature alone, analogous to that which takes place in the pipes of the hot-water apparatus by which large buildings are now commonly warmed. The only essential difference between the two cases is, that whilst the *primum mobile* in the latter is the heat applied to the bottom of the boiler, making the warmed water ascend by the reduction of its specific gravity due to its expansion, the moving power in the former is the cold applied to the surface of the Polar water, making it descend by the increase of specific gravity due to the diminution in its bulk as its temperature is lowered.

This doctrine was first distinctly promulgated nearly forty years ago by the eminent physicist Lenz, on the basis of the temperature-observations he had made in Kotzebue's second voyage more than ten years previously; these having satisfied him of two facts—first, the general diffusion of a glacial temperature over the ocean-bottom, which he rightly interpreted as dependent on an underflow of Polar water; and, second, the near approach of cold water to the surface under the Equator than either on the north or on the south of it, which he considered to indicate an uprising of that Polar water from below, where the two underflows meet. But, though accepted by Pouillet and other distinguished physicists, this doctrine, with the observations by which it was supported was entirely lost sight of until independently advanced by myself as the only feasible explanation of the Poleward movement of the whole upper stratum of North Atlantic water, and of the southward outflow of glacial water from the Arctic basin, of which the *Porcupine* temperature-soundings seemed to afford conclusive evidence.

My explanation, though contested by Mr. Croll, and not accepted by Sir Wyville Thomson, has been explicitly adopted by a large number of eminent physicists, both British and Continental, among whom I may specially mention Professor Möhn of Christiania, who had previously maintained the dependence of the remarkable climatic condition of Norway on the north-east extension of the true Gulf Stream. Immediately on receiving the report in which I had demonstrated the inadequacy of the Florida current to propel as far as the coast of Norway the vast body of warm water required to keep its harbours open, and had shown the dependence of the north-east movement of the warm upper stratum to the depth of 500 fathoms (which I had myself first recognized in the *Porcupine*), on the Poleward indraught that forms the necessary complement of the outward glacial underflow, Professor Möhn not only expressed to me his entire concurrence in both views, but communicated to me a remarkable example he had himself met with of a similiar vertical circulation on a smaller scale. It is to the remarkable thickness of this Poleward flow that its surface-layer owes its power of so long resisting the cooling effect of the atmosphere which overlies it; so that, as it flows along the coast of Norway towards the North Cape, its temperature even in winter sustains so much smaller a reduction than that of the atmosphere as to give it an excess which constantly increases with its northing. But though its surface-temperature is so little reduced, the thickness of this warm stratum is undergoing progressive diminution as its deeper layers successively go up to replace those which have been chilled and have gone down; so that beyond the North Cape the surface-temperature rapidly falls with the eastward movement of this flow along the northern shores of Europe and Asia; and all trace of heat imported from the south-west at last dies out.

As the superheating of the upper stratum of the mid-Atlantic is dependent on the influx of Gulf Stream and other water exceptionally warmed in the Equatorial Current, the *thermal effect* of its north-east flow is mainly dependent upon the Gulf Stream and its adjuncts, while its *movement* is kept up by the Polar indraught.

Thus neither the general Oceanic Circulation nor the Gulf Stream could alone produce the result which is due to their conjoint action. The Gulf Stream water, without the Polar indraught, would remain in the mid-Atlantic; and the Polar indraught, without Gulf Stream water to feed it, would be almost as destitute of thermal power as it is in the South Atlantic.

The transient visit of the *Challenger* to the Antarctic ice-barrier gave her scientific staff the opportunity of examining the structure of the southern icebergs, which altogether differs from that of the icebergs with which our northern navigators are familiar; these last being now universally regarded as *glaciers*, which have descended the seaward valleys of Greenland and Labrador, and have floated away when no longer supported by solid base; and the information they have gathered is of considerable interest, as helping us to form a more definite conception of the condition of our own part of the globe during the glacial epoch. A number of independent considerations now lead almost irresistibly to the conclusion that the icebergs of the Antarctic are for the most part detached portions of a vast *ice-sheet*, covering a land surface—either continuous, or broken up into an archipelago of islands—which occupies the principal part of the vast circumpolar area, estimated at about four and a half millions of square miles, or nearly double the area of Australia. Of this ice-sheet, the edge forms the great southern "ice-barrier," which presents itself, wherever it has been approached sufficiently near to be distinctly visible, as a continuous ice-cliff, rising from 200 to 250 feet above the sea-level.

The icebergs of the Antarctic Sea are, as a rule, distinguished by their tabular form, and by the great uniformity of their height; this, in bergs which show least signs of change since their first detachment from the parent mass, seldom varies much from 200 feet above the sea-line. The tabular surface of the typical berg is nearly flat, and parallel with the sea-line; its shape usually approaches the rectangular, and it is bounded all round by nearly perpendicular cliffs. From a comparison of the specific gravity of berg-ice with that of sea-water, it appears that the quantity of ice beneath the surface required to float that which is elevated above it must be about nine times as great; in other words, supposing that a berg had the regular shape of a box, its entire depth from its upper surface to its base must be ten times its height above the sea-level. Consequently, if the latter be 200 feet, the entire height of the mass would be 2000 feet, which might thus be assumed to be the thickness of the ice-sheet from whose margin it was detached. This estimate must not be accepted, however, as other than approximative. The dimensions of these bergs vary greatly. Those seen from the *Challenger* were generally from one to three miles long; but single bergs are reported of seven or even ten miles in length; and an enormous mass of floating ice, probably composed of a chain of bergs locked together, forming a hook 60 miles long by 40 broad, and inclosing a bay 40 miles in breadth, was passed in 1854 by twenty-one merchant ships, in a latitude corresponding to that of the northern coast of Portugal.

The upper part of the ice-cliff that forms the exposed face of the bergs is of a pale blue, which gradually deepens in colour towards the base. When looked at closely, it is seen to be traversed by a delicate horizontal ruling of faint blue lines separated by dead-white interspaces. These lines preserve a very marked parallelism, but become gradually closer and closer from above downwards, their distance being a foot or even more at the top of the berg, but not more than two or three inches near the surface of the water, where the interspaces lose their dead whiteness, and become hyaline or bluish. There can be no doubt that this stratification is due to successive accumulations of snow upon a nearly level surface, the spaces between the principal blue lines probably representing approximately the snow-accumulations of successive seasons. The direct radiant heat of the sun is very considerable even in these latitudes, so that the immediate surface of the snow is melted in the middle of every clear day; and the water, percolating into the subjacent layers, freezes again at night. The frequent repetition of this process will convert a very considerable thickness of snow into ice; the blue transparent lamellæ being the most compact, whilst the intervening white veins are rendered semi-opaque by the presence of air-cells. And it is obviously the compression which these undergo that causes the approximation of the blue lines, and the change to a greater compactness and transparence in the intervening layers, towards the bottom of the cliff. Slight irregularities in the general parallelism of the stratification, and the occasional thinning-out of particular lamellæ, were easily accounted for by the drifting of the snow-layers of the surface, before they had become consolidated. And although there are various cases in which the strata had been changed from their original horizontality to various degrees of inclination, sometimes also being traversed by "faults," and occasionally even twisted and contorted, these might all be accounted for by forces acting subsequently to the detachment of the bergs. For their plane of flotation is liable to alteration by changes of form due to unequal melting, and the separation of large masses either above or below the surface; and "dislocations" of various kinds will be produced by collisions and lateral thrusts, when bergs are impelled against each other by the wind. Sir Wyville Thomas and Mr. Moseley entirely agree in the statement that they could nowhere trace any such "structure" as is produced in a land-glacier during its movement down a valley, by the curvature and contraction of its rocky borders, and the inequalities of the bottom over which it moves. And the presumption is altogether very strong that these vast masses have originally formed part of a great ice-sheet, formed by the cumulative pressure of successive snow-falls over a land area of no great elevation; which flows downwards from its highest level in the direction of least resistance, that is to say from the Polar centre towards the continually disintegrating margin, progressively diminishing in thickness as it extends itself peripherally. Thus gradually moving seawards, the ice-sheet will at last pass the margin of the land, but will continue to rest upon the gradually descending sea-bed, flowing down its gentle slope until lifted by its own buoyancy (like a vessel or launch), when vast masses will break off and float away.

Although the observers of the *Challenger* did not see either masses of rock, stones, or even gravel upon any of the icebergs they approached, Wilkes and Ross saw many such: and the "soundings" of the *Challenger* were found to consist of such comminuted clays and sands as would be the result of the abrasion of rocky surfaces over which the ice-sheet had moved; while the dredge brought up a considerable quantity of land *débris*—

chiefly basaltic pebbles about the meridian of 80° E., and further to the eastward pebbles and larger fragments of metamorphic rocks. It was probably from the valleys of the great volcanic range that the rock-masses came which were observed on bergs by Wilkes and Ross; one of which, clearly of volcanic origin, weighed many tons. That the southern circumpolar area is chiefly land, and not water, seems to be further indicated by the absence of any such low temperature of the deeper water as Sir George Nares ascertained to exist beneath the "palæocrystic" ice of high northern latitudes. For the thermometers lowered through borings in that ice gave 28° Fahr. at all depths, this being the lowest temperature at which sea-water can remain unfrozen under ordinary circumstances. On the other hand, the bottom temperatures taken in the *Challenger* in closest proximity to the Antarctic ice-barrier nowhere proved to be lower than the temperature of surface-stratum which was cooled by the melting of the berg-ice, thus indicating the absence of any supply of yet colder water from a source nearer the Pole.

Thus the antarctic "ice-barrier" is to be regarded as the margin of a Polar "ice-cap," whose thickness at its edge is probably about 2000 feet, nine tenths of it lying beneath the water-line. This margin is not permanent, but is continually wasting away like the terminal portion of a land-glacier—not, however, by liquefaction, but by disruption—and is as continually renewed by the spreading out of the piled-up ice of the area within. What may be the thickness of the "ice-cap" nearer its Polar centre we have at present no means of knowing; but it must doubtless be kept down by the facility of downward flow in almost every direction towards its periphery of 10,000 miles.

In regard to the *animal life* of the deep sea, the *Challenger* researches do not seem likely to yield any new *general result* of striking interest. Our previous work had shown that a depth of three miles, a pressure of three tons on the square inch, an entire absence of sunlight, and a temperature below 32°, might be sustained by a considerable number and variety of animal types; and this conclusion has been fully confirmed and widely extended. Many specimens have been brought up alive from depths exceeding four miles, at which the pressure was four tons on the square inch, considerably exceeding that exerted by the hydraulic presses used for packing Manchester goods. Even the "protected" thermometers specially constructed for deep-sea sounding were frequently crushed; and a sealed glass tube containing air, having been lowered (within a copper case) to a depth of 2,000 fathoms, was reduced to a fine powder almost like snow by what Sir Wyville Thomson ingeniously characterized as an *im*plosion, the pressure having apparently been resisted until it could no longer be borne, and the whole having been then disintegrated at the same moment. The *rationale* of the resistance afforded by soft-bodied animals to a pressure which thus affects hard glass is simply that they contain no air, but consist of solids and liquids only; and that since their constituent parts are not subject to more than a very trifling change of bulk, while the equality of the pressure in every direction will prevent any change in their form, there is really nothing to interfere with the ordinary performance of their vital functions.

The entire absence of solar light, which constitutes another most important peculiarity in the conditions of deep-sea life, would seem at first sight to be an absolute bar to its maintenance. Experimental evidence has not yet, I believe, been obtained of the direct penetration of the solar rays to more than 100 fathoms; but as I dredged slow-growing red calcareous Algæ (true *corallines*) in the Mediterranean at a depth of 150 fathoms (at, or below, which Edward Forbes also would seem to have met with them), the actinic, if not the luminous, rays must probably penetrate to that range. Below what Edward Forbes termed the coralline zone, it would seem impossible that any other type of vegetable life can be sustained, than such as has the capacity of the fungi for growing in the dark, living, like them, upon material supplied by the decomposition of organic compounds. Such lowly plants have been found by Professor P. M. Duncan in corals dredged from more than 1000 fathoms' depth.

Upon what, then, do deep-sea animals feed? In the early stage of this inquiry it was ascertained by Dr. Frankland that the samples of water procured by the *Porcupine* not only at considerable distances from land, but also from bottoms exceeding 500 fathoms' depth, contained so much organic matter *not* in a decomposing state that animals having a large absorbent surface, and requiring but a small proportion of solids in their food, might be sustained by simple imbibition. And an adequate provision for the continual restoration of such material to the ocean-waters seemed to be made by the surface-vegetation which fringes almost every sea-margin, and which occasionally extends itself over large tracts in the open ocean, as, notably, in the Sargasso Sea. But the *Challenger* researches have thrown a new light on this question, by showing that the animals of the deep sea are largely dependent for their food upon the minute organisms and the *débris* of larger ones which are continually falling to the bottom from the upper waters.

"This *débris* (says Mr. Moseley) is no doubt mainly derived "from the surface Pelagic flora and fauna, but is also to a large "extent composed of refuse of various kinds washed down by "rivers, or floated out to sea from shores, and sunken to the "bottom when water-logged. The dead Pelagic animals must fall "as a constant rain of food upon the habitation of their deep-sea "dependants. Maury, speaking of the surface Foraminifera, "wrote, 'The sea, like the snow-cloud, with its flakes in a calm, "'is always letting fall upon its bed showers of microscopic shells.' "It might be supposed that these shells and other surface-"animals would consume so long a time in dropping to the "bottom in great depths, that their soft tissues would be decom-"posed, and that they would have ceased to be serviceable as "food by the time they reached the ocean bed. Such, however, "is not the case, partly because the salt water of the sea exercises "a strongly preservative effect on animal tissues, partly because "the time required for sinking is in reality not very great."—*Notes by a Naturalist*, p. 582.

Of this Mr. Moseley assured himself by an experimental test, which indicated that the dead body of a floating salpa might sink to a depth of 2000 fathoms in little more than four days, whilst its body might remain for a month so far undecomposed as to be serviceable as food to deep-sea animals. As land was neared, moreover, many interesting proofs were obtained of the feeding of deep-sea animals on *débris* derived from the neighbouring shores.

"Thus, off the coast of New South Wales we dredged from 400 "fathoms a large sea-urchin which had its stomach full of pieces "of a sea-grass (Zostera) derived from the coast above. Again, "we dredged from between the New Hebrides and Australia, "from 1400 fathoms, a piece of wood and half a dozen examples "of a large palm-fruit as large as an orange. In one of these fruits, "which had hard woody external coats, the albumen of the fruit "was still preserved, perfectly fresh in appearance, and white, "like that of a ripe cocoa-nut. The hollows of the fruits were "occupied by two molluscs; the husks and albumen were bored by "a teredo-like mollusc; and the fibres of the husks had among "them small nematoid worms.—p. 583.

Branches of trees, also, and leaves of shrubs, in a water-logged condition, were occasionally brought up in the dredge from great depths; and their occurrence, as Mr. Moseley remarks, is of importance, not only to the naturalist, as showing that deep-sea animals may draw large supplies of food from such sources, but also to the geologist, as indicating the manner in which specimens of land vegetation may have been imbedded in deposits formed at great depths.

The entire absence of sunlight on the deep-sea bottom seems to have the same effect as the darkness of caves, in reducing to a rudimentary condition the eyes of such of their inhabitants as fish and crustacea, which ordinarily enjoy visual power; and many of these are provided with enormously long and delicate feelers or hairs, in order that they may feel their way about with these, just as a blind man does with his stick. But other deep-sea animals have enormously large eyes, enabling them to make the best of the little light there is in the depths, which is probably derived (as suggested in the report of the *Porcupine* dredgings) from the *phosphorescence* emitted by many deep-sea animals, especially a certain kind of zoophytes. "It seems certain," says Mr. Moseley, "that the deep sea must be lighted here and there by greater or "smaller patches of luminous alcyonarians, with wide intervals, "probably, of total darkness intervening; and very possibly the "animals with eyes congregate round these sources of light." It is remarkable that with such poverty of light there should be such richness of *colour* among deep-sea animals. Although most deep-sea fish are of a dull black colour, and some white as if bleached, deep-sea crustaceans, echinoderms, and zoophytes usually exhibit more colour than the corresponding forms that inhabit shallow water. Thus the deep-sea shrimps, which were obtained in very great abundance, were commonly of an intensely bright scarlet; deep-sea holothurians are often of a deep purple; and many deep-sea corals have their soft structures tinged with a madder colouring-matter resembling that which occurs in surface-swimming jelly-fish.

As was to be expected from the results of the *Lightning* and *Porcupine* dredgings, the more extended explorations of the *Challenger* have shown that there still live on the sea-depths a number of animal forms which were supposed, until thus found, to be extinct, existing only as fossils. And large numbers of interesting new genera and species of known families of animals were obtained; whilst many forms which had been previously accounted of extreme rarity have proved to be really common, having a wide geographical range, and occurring in large numbers in particular spots. This is the case, for example, with the beautiful *Pentacrinus*, a survivor from the old Liassic times, of which the living specimens preserved in all the museums of the world could a few years ago have been counted on the fingers, all of them having been brought up on fishing-lines from the neighbourhood of the West India Islands. As many as twenty specimens of a new species of this most interesting type, however, had been brought up from a depth of 800 fathoms in one of the *Porcupine* dredgings off the coast of Portugal. The *Challenger* made a large collection, including several new species, from various localities. And yet more recently the dredgings of Professor Alexander Agassiz in the Gulf of Mexico have shown how thickly many parts of the sea-bed are covered with these "lily stars" mounted upon their long wavy stalks.

Those, however, who had expected results of greater zoological and palæontological importance from these explorations must confess to some disappointment:—

"Most enthusiastic representations (says Mr. Moseley) were "held by many naturalists, and such were especially put forward "by the late Professor Agassiz, who had hopes of finding almost "all important fossil forms existing in life and vigour at great "depths. Such hopes were doomed to disappointment; but "even to the last, every cuttle-fish which came up in our deep-"sea net was squeezed to see if it had a Belemnite's bone in its "back, and Trilobites were eagerly looked out for. . . . We "picked up no missing links to fill up the gaps of the great zoo-"logical family tree. The results of the *Challenger's* voyage have "gone to prove that the missing links are to be sought out rather "by more careful investigation of the structure of animals already "partially known, than by hunting for entirely new ones in the "deep sea."—*Notes by a Naturalist*, p. 587.

The work which has been already done by Mr. Moseley himself in this direction, contained in the memoirs he has presented to the Royal and the Linnæan Society, is of first-rate value. And if the whole, or even any considerable part, of the vast *Challenger* collection shall be worked out by the various specialists among whom it has been distributed, with anything like the same completeness and ability, it cannot be questioned that the series of volumes in which the scientific results of this voyage will be em-embodied will far surpass in interest and importance those reports of previous Circumnavigation Expeditions which are accounted models of their class.

XII.

THE FORCE BEHIND NATURE.

[*The Modern Review*, January, 1880.]

SOME thirty years ago, I enjoyed opportunities of discussing with John Stuart Mill (whose younger brother had been for twelve months an inmate of my house) many questions of philosophy in which we both felt the deepest interest. Among these was the Doctrine of Causation set forth in his recently published "System of Logic:"—"We may define the cause of a phenomenon to be "the antecedent, or the concurrence of antecedents, on which it "is invariably and unconditionally consequent." I pointed out to my friend that when this assemblage of antecedents is analyzed, it is uniformly found resolvable into two categories, which may be distinguished as the *dynamical* and the *material;* the former supplying the *force* or *power* to which the change must be attributed, whilst the latter affords the *conditions* under which that power is exerted. Thus, I urged, when a man falls from a ladder *because* (as is commonly said) of the breaking of the rung on which his foot was resting, the real or *dynamical* cause of his fall is the force of gravity, or attraction of the earth, which pulls him to the ground when his foot is no longer supported; the loss of support being only the *material condition* or *collocation*, which allowed the force previously acting as *pressure* on the rung, to produce the downward *motion* of the man who stood upon it.

To this Mr. Mill's reply was, that the distinction is one of metaphysics, not of logic. I ventured, however, to press on him that to whichever department of philosophy this point is to be referred, is is one of fundamental importance; that, assuming experience as the basis of our knowledge, we recognize the downward tendency of every body heavier than air, by our sense of muscular tension in lifting it from the ground, or in resisting its descent towards the earth; and that our cognition of *force* through this form of sensation, being thus quite as immediate and direct as our cognition of *motion* through the visual sense, ought to be equally taken account of.

The promulgation, about the same time, of the doctrine of the "Correlation of the Physical Forces" by Professor (now Sir William) Grove, and the researches of Mr. Joule on the "Mechanical Equivalent of Heat," seemed to me to bring this view of *dynamical* causation into yet greater importance; by showing that what is true of that form of force which produces or resists mechanical (or what is now distinguished as *molar*) motion, may be legitimately extended to those other forms which are manifested in the *molecular* changes that express themselves in chemical action, or impress us with the sensations of heat, light, etc. Partaking of the general ignorance at that time prevalent in this country of the doctrine of "Conservation of Energy," already promulgated in Germany by Mayer and Helmholtz, I myself endeavoured to carry Professor Grove's principle into the domain of biology; by showing that what physiologists had been accustomed to call vital force, may be regarded as having the same "correlation" with the various forms of physical force as they have with each other.* And in the introduction to the fourth edition of my "Human Physiology" (published in 1853), I thus explicitly defined my position:—

When this assemblage of antecedents is analyzed, it is uniformly found that they may be resolved into two categories, which may be distinguished as the *dynamical* and the *material*, the former supplying the *force* or *power* to which the change must be attributed, whilst the latter afford the *conditions* under which that power is exerted. Thus in a steam-engine we see the dynamical agency of heat made to produce mechanical power by the mode in which it is applied: first, to impart a mutual repulsion to the particles of water; and then, by means

* "On the Mutual Relations of the Vital and Physical Forces," in Philos. Transact., 1850.

of that mutual repulsion, to give motion to the various solid parts of which the machine is composed. And thus, if asked what is the cause of the movement of the steam-engine, we distinguish in our reply between the *dynamical* condition supplied by the heat, and the *material* condition (or assemblage of conditions) afforded by the "collocation" of the boiler, cylinder, piston, valves, etc. . . . In like manner, if we inquire into the cause of the germination of a seed—which has been brought to the surface of the earth, after remaining dormant through having been buried deep beneath the soil for (it may be) thousands of years—we are told that the phenomenon depends upon warmth, moisture, and oxygen; but out of these we single warmth as the *dynamical* condition, whilst the oxygen and the water, with the organized structure of the seed itself, and the organic compounds which are stored up in its substance, constitute the *material.*

The subsequent general recognition by the scientific world of the "correlation" between the forces of nature (under whatever form expressed) has thus given a breadth of foundation to the dynamical doctrine of causation which it previously lacked; and the doctrine having been afterwards formally developed by Professor Bain, was summarized by J. S. Mill in the later editions of his "Logic," almost in the very terms in which I had originally propounded it to him in conversation, and had publicly expressed it in the extract just cited:—"The chief practical conclusion "drawn by Professor Bain, bearing on causation, is that we must "distinguish in the assemblage of conditions which constitutes "the cause of a phenomenon, two elements: one, the presence "of a force; the other, the collocation or position of objects "which is required in order that the force may undergo the par- "ticular transmutation which constitutes the phenomenon." * Mr. Mill himself still preferred, however, to express the principle in terms of motion, rather than in terms of force:—"If the "effect, or any part of the effect, to be accounted for consists in "putting matter in motion, then any of the objects present which "has lost motion has contributed to the effect; and this is the "true meaning of the proposition that the cause is that one of

* "System of Logic" (eighth edition), vol. i. p. 406.

"the antecedents which exerts active force." As this mode of expressing the facts is sanctioned by high authorities at the present time, it may be well for me to explain more fully the basis of my original contention, that our cognition of *force* is quite as immediate and direct as our cognition of *motion;* in fact (as I think I shall be able to prove), even more fundamental, inasmuch as our cognition of matter itself is in great degree dependent upon it.

It has been recently well said that "all true science involves "both the knowledge of Nature and the knowledge of Man; it "includes the study of mind, as well as of matter. A philo-"sopher may pursue either, but he can have no complete know-"ledge of what he investigates, without borrowing from the other "department of investigation." * Many of the nature-philosophers who affirm that we have no knowledge of anything but the matter and motion which lie within the range of "experience," show themselves very imperfectly acquainted with what "experience" really means; unhesitatingly ranking as actual objective facts their own mental interpretations of the sensory impressions they receive from external objects. Many metaphysicians, on the other hand, have reasoned as if our concern were with mental operations alone, and as if the abstractions in which they deal had an existence *per se*, without any relation to the phenomena of nature. But among the ablest thinkers of the present time, there seems to be now a pretty general recognition of the necessity for the replacement of the abstract definitions of metaphysics—so far, at least, as they relate to the external world —by psychological expressions of the modes in which the human *ego* is affected by its changes. Thus the ordinary metaphysical definition of "matter" is that which possesses "extension." But for this definition to convey any definite idea to our minds, we must know what "extension" means; and this, we are told, is the "occupation of space." Now, the conception of "space," in the opinion of most psychologists, is ordinarily derived from our interpretation of *visual* sensations; and yet these may be altogether deceptive. When we look at a window from a short

* "Natural Theology of the Doctrine of the Forces." By Professor Benjamin Martin, of the University of the City of New York.

distance, we cannot tell by the use of our eyes alone whether the space included by its frame is void, or is occupied by a perfectly transparent and colourless glass. A glass globe is held up in front of it, and we cannot tell by looking at it whether it is empty, or is filled with pure water or some other transparent colourless liquid. And we can take no cognizance by our vision of the atmosphere which surrounds us, unless its transparence is interfered with by mist or fog.—Clearly, then, our visual sense cannot *per se* furnish us with a satisfactory definition of matter.*

Now that we have got rid of the fiction of "imponderables," we might fall back on a definition of matter—in use before that fiction was invented—as that which possesses "ponderosity" or weight. But what is weight? The downward tendency, it may be replied, in virtue of which all unsupported bodies fall to the earth. But what is this "tendency?" We might *see* any number of bodies falling to the ground, and might frame a correct law of their motion, without having the remotest conception of their possessing that downward *pressure*, which we at once recognize when we take a lump of lead or iron into our hands; and it is obviously on our cognition of this pressure, that our idea of weight or ponderosity is based. Now the instrumentality through which we take cognizance of it seems to me to be threefold. In the *first* place, we have the sense of simple pressure on the tactile surface; as when, the hand passively resting on a table, a weight is laid upon it. *Secondly*, we recognize it by the sense of *tension* which we experience when a weight is attached to a pendent limb, and which we refer to the muscles and ligaments which are thus put on the stretch; or when, the hand resting on the top of a cylinder of glass placed over an air-pump, the air is exhausted from beneath, so as to make us *feel* the downward "pressure of

* According to Professor Bain, the conception of space is essentially based on the sense of muscular tension which, according to him, we experience in the ordinary movements of our eyes. But I am satisfied that this is physiologically erroneous. These movements are ordinarily guided, as Professor Alison long ago contended, and as Professor Helmholtz and I myself have since experimentally proved, by the visual, not by the muscular sense; and it is only when we put the muscles to an unusual strain—as when our visual axes converge on an object brought nearer and nearer to the eyes, or when we entirely exclude light from the retina, that we experience any sense of tension in their muscles.

the atmosphere." In these two cases, the mind is the passive recipient of the sensory impressions. But, *thirdly*, when we determinately lift a weight or hold it suspended by our hands, we experience, in addition to the sense of pressure and the sense of tension, *a sense of effort*, which we recognize as an *immediate* revelation of consciousness, not referrible to any physical impression, but of the same kind as that which we experience in a purely mental act, such as the fixation of the attention. And a little consideration will, I think, make it clear that it is on this "sense of effort" in resisting downward pressure, that our cognition of weight is essentially based.

For, in the *first* place, the *continuance* of a moderate pressure on the cutaneous surface, like other sensory impressions that become habitual, soon ceases to affect us sensorially for we cognosce rather the *changes* in the states of our sense organs, than the states themselves. Or, again, we may suffer under a temporary or permanent paralysis of the cutaneous sense, that may prevent our feeling the contact of the body we are lifting or supporting; and yet, recognizing its downward pressure in other ways, we can put our muscles into action to antagonize it. But, *secondly*, this paralysis may extend to the muscular sense, so that the feeling of muscular tension is wanting, as well as that of contact-pressure; and yet none the less can a weight be lifted or sustained by a conscious effort, provided that the deficiency of the guiding sensations ordinarily derived from the muscle itself is supplied by the sight. A woman whose arm is sensorially but not motorially paralyzed, can hold up her child as long as she looks at it; and a man affected with the like paralysis of his legs, can stand and walk while looking at his feet. But, *thirdly*, since the *mental sense of effort* is experienced in every determinate exercise of our muscular power, and is, as all experience teaches, a necessary condition of that exercise; since, again, it is proportioned to the exertion we put forth, and continues as long as that exertion is sustained—it is in this, and not in the cutaneous or muscular impressions, which are (so to speak) accidental, that as (it seems to me) we find the real basis of our cognition of the "ponderosity" of matter.

But "ponderosity" cannot be considered an essential property of matter, being merely the "accident" of the earth's attraction for bodies lying within its range. This attraction varies with the distance of a body from the centre of the earth; and a body occupying the common centre of gravity of the earth and sun would be equally drawn towards both, and would consequently have no "weight." We must, therefore, seek a satisfactory definition of matter elsewhere; and we find the clue to it in the consideration that the sense of effort we experience in antagonizing the downward pressure of a body, is but a particular case of our more general cognition of *resistance*. When we project our hand against a hard and fixed solid body, our consciousness of its resistance to our pressure is exactly that which we experience when we try to raise a weight that we have not strength to lift; whilst if that solid be either yielding in its parts or movable as a whole, we measure its resistance, as in lifting a weight, by our sense of the effort necessary to overcome it. When we move our hand through a liquid, we are conscious of a resistance to its motion, which is greater or less according to the "viscosity" of the liquid. And when we move our open hand through air at rest, we are still conscious of a resistance, our sense of it being augmented by an extension of the surface moved, as in the act of fanning; whilst if the air is in motion, we feel its pressure on the sail of a boat by the "pull" of the sheet we hold in our hand, or on the sails of a windmill by the rotation it imparts, the *force* of which we can estimate by the *effort* we must put forth to resist it. Attenuate any kind of air or gas as we may, its resistance can still be made apparent by the like communication of its own motion to solid bodies. Thus, in Mr. Crookes's wonderful radiometer, a set of vanes poised on a pivot within a globe of glass exhausted to *a millionth* of its ordinary gaseous contents, is whirled round by the movement excited in the molecules of that residual millionth, either by the heat of the radiant beam falling on the surface of the globe, or by the passage of an electric current across its interior; and the mechanical force required to impart that motion can be measured with precision, by bringing it into comparison with some other force (as that of gravity) of which we can take immediate cognizance. And thus, as Herbert Spencer remarks, by the decomposition of our knowledge of any form of matter into simpler and simpler components, we must come at last to the simplest, to the ultimate material, to the substratum; and this we find in the *impression of resistance* we receive through what we may call our "force-sense." *

Such being the teachings alike of general and of scientific experience, I cannot but feel surprised that any persons claiming the title of philosophers should affirm that we *know* nothing except matter and motion, and that force is a creation of our own imagination. One might suppose such persons to be either destitute of the "force-sense," or to have based their philosophical system upon the movements of the heavenly bodies which they can only *see*, instead of upon those mundane phenomena in the cognition of which they can bring their *hands* to the assistance of their eyes. How essential this assistance is to the formation of correct conceptions of the solid forms and relative positions of the objects around us, is known to every one who has studied the physiology of the senses. Should we not think it absurd on the part of any one who possesses in the use of his hands the means of detecting the error of his visual perceptions, if he were to base a superstructure of reasoning—still more to found a whole system of philosophy—upon the latter alone? Yet such appears to me to be the position of those who deny our direct cognition of force.

Let us suppose (if possible) a man who had enjoyed the full use of his eyes, but whose limbs had been completely paralyzed from infancy, looking on at a game of billiards. He would see a succession of motions connected by regular sequence—the motion of the arm of the player, the stroke of the cue, the roll of the ball, its contact with another ball, the movement of the second ball, the change of direction or the entire stop of the first, the rebound of balls from the cushion in altered directions, and so on. And he might frame a statement in "terms of motion" of all that passes before his eyes, thinking this all he can know.—But suppose the limbs of such a man to be suddenly endowed with the ordinary

* Herbert Spencer considers the cognition of resistance to be essentially derived from the sense of muscular tension. I have already expressed my reason for now dissenting from this view, which I myself formerly held.

powers of sensation and movement; let him take the cue into his hands and himself strike the ball; let him hold his hand on the table so that the rolling ball shall strike it and make him feel its impact; let him hold the second ball and feel the shock imparted to it by the stroke of the first. Can any one deny that he would thus acquire a dynamical conception linking together the whole succession of phenomena, which he was previously quite incapable of forming; that this dynamical conception is quite as directly based upon the experience derived through his "force-sense," as his kinetic expression was upon that derived through his visual sense; and that this cognition of the force producing the motions is, therefore, fully as much entitled to be introduced into a logical doctrine of causation, as the visual cognition of the motions themselves? If it be replied that we have no proof that the movement of the ball we strike is produced by the force which we consciously exert in striking it, I simply reply that we have as much proof of it as we have of anything which rests upon universal experience, and which we can verify experimentally as often as we choose to try—quite as much as we have of the existence of anything whatever that is external to ourselves.

Let us take, again, the simple case of magnetic attraction. A man who knows nothing of magnetism sees a piece of iron brought within a certain distance of what looks like a horse-shoe bar of the same metal, suddenly jump towards its approximated ends; and might, as before, correctly express the fact in "terms of motion." But let him take the piece of iron in his hands, so as to feel the "pull" upon it when brought sufficiently near the magnet, and he then becomes conscious, through his force-sense, of a *power* of which he was before utterly ignorant.

Thus, as it seems to me, an analysis of those *psychical* experiences, on which all our cognitions of the *physical* universe around us are really based, irresistibly lands us in the conclusion that, as Herbert Spencer expresses it, "All the sensations through which "the external world is known to us, are explicable by us only as "resulting from certain forms of force;" the direct derivation of our conception of force from our own experience of muscular tension (or as I should myself say, from our own sense of effort) being "a fact which no metaphysical quibbling can set aside."

In the words of the able American writer I have already quoted, "The conception of force is one of those universal ideas which "belong of necessity to the intellectual furniture of every human "mind." By no one has the principle for which I am contending, been more clearly and more authoritatively expressed than by Sir John Herschel, a philosopher who united to his wonderful grasp of Nature-phenomena a profound insight into the action of the mind of man in the interpretation of them:—

"Whatever attempts have been made by metaphysical writers "to reason away the connection of cause and effect, and fritter "it down into the unsatisfactory relation of habitual [uncon- "ditional] sequence, it is certain that the conception of some "more real and intimate connection is quite as strongly impressed "upon the human mind as that of the existence of an external "world, the vindication of whose reality has, strange to say, been "regarded as an achievement of no common merit in the annals "of this branch of philosophy. It is our own immediate con- "sciousness of *effort*, when we exert force to put matter in "motion or to oppose and neutralize force, which gives us this "internal conviction of *power* and *causation*, so far as it relates "to the material world."—Treatise on "Astronomy" in Lardner's *Cyclopædia*, p. 232.

Man's position as the "Interpreter of Nature" may be not inaptly likened (as it seems to me) to that of an intelligent observer of the working of a cotton-factory, with whose mechanical arrangements he is entirely unacquainted, and of whose moving power he knows nothing whatever. He is taken into a vast apartment,* in which he is at first utterly bewildered by the number and variety of the movements going on around him; but, by directing his attention to the several machines, *seriatim*, he is able to arrive at a *classification* of them, according to the *kind of work* which each does. Thus he finds one set *carding* the cotton-wool supplied to it, so that its confused tangle gives place to a parallel laying of the fibres. He would see another taking up the bundles of carded wool, and *drawing* them out

* In one of the flax-spinning mills belonging to the Marshalls of Leeds, the whole of the work is done on one floor, covering (I believe) two acres of ground, instead of in the usual building of several stories.

(after repeated doublings to secure uniformity) into a long soft cord. This cord he would then trace into the *roving* machine, which, by a continuation of the drawing process, further reduces its thickness, at the same time giving it a slight twist to increase its tenacity, so that it admits of being then wound upon bobbins. Thence he would trace the cord into the *spinning* machine, which at the same time stretches and twists the cord, producing from it a yarn whose fineness might vary considerably in different machines. Finally, he would see the spun yarn carried, some as weft and some as woof, into the *power-loom*, from which it emerges as woven cloth—the final resultant of the whole series of operations.

Concentrating now his attention upon any one of these machines, he studies its wheels, levers, and other moving parts, and tries to comprehend their several actions and the bearing of these upon each other. By long and scrutinizing observation he masters the whole series of sequences, and traces the distribution of motion from a single large axis, through the hundreds (it may be) of separate pieces of the machine directly or indirectly connected with it; and he might thus frame a description of the working of the machine, which might be perfectly correct so far as it goes, and which yet would be defective in one most essential particular—the statement of the *force* or *power* by which it is moved. For, so far as mere visual observation could teach him, the machine might be self-moving; and he might thus attribute to each kind an *inherent power* of carding, roving, drawing, spinning, or weaving, as the case might be.

Carrying his observations further, and noticing that one or another of these machines comes to a standstill, but resumes its motion after an interval, he may include this occasional suspension also in his general expression; but, perplexed by the want of any regularity in its intervals, he will seek some further explanation. Continuing his patient watch, he will see that the stoppage of the machine follows the pulling of a handle by the man in attendance upon it, and that when the handle is pulled the other way, the machine goes on again; and thus he will be led to introduce a certain position of this handle as one of the antecedent conditions of the machine's action. Still pursuing his inquiries, he finds out that the axes of the several machines are all in mechanical relation with one great longitudinal shaft, being connected with it either by continuous bands passing round pulleys, or by trains of wheelwork: and at last he discovers the important fact, that the movement of the handle which stops the machine breaks the continuity of that relation, shifting a strap from a "fast" to a "loose" pulley, or throwing the wheelwork "out of gear;" while the converse movement, which restores that continuity, is followed by the renewed action of the machine, which goes on until the continuity is again broken. Thus he will be led to regard its maintenance as essential to the working of the machine; but nothing that he has yet learned explains to him *why* it is essential. He has only got at the *material collocation* which his educated vision enables him to recognize; and for anything he knows to the contrary, the change in that collocation may be *in itself* adequate to determine the result.

But let him lay hold of the band which stretches between the main shaft and the axis of one machine, or attempt to stay with his hand the rotation of the train of wheels which connects it with another,—he then at once becomes conscious, through his "force-sense," of the *power* which the band or the wheelwork is the instrument of conveying; and as he finds that the "pull" upon his hand is just the same whether the machine is in motion or not, provided that the band or wheel remains in mechanical connection with the main shaft, he comes to the conviction that the *source* of the power is in the shaft, and that, so far from any one of the machines having an inherent power of movement, its motion entirely depends upon the force supplied to it from the shaft. And when, under the guidance of this conception, he again examines the *working* of the several kinds of machine, he finds that while the *power* is the same for all, the diversity in their respective products is traceable to the diversity in their construction—that is, to the *material collocations* through which the one moving force exerts itself in action.

But having thus acquired the notion of *moving power*, and having satisfied himself of the derivation of the force that gives motion to each of the entire aggregate of machines, from one main shaft, our inquirer finds himself again posed. Has this shaft itself an inherent power of motion; or does it derive that power from any ulterior source? He sees the shaft apparently terminate in the two end-walls of the building; and, finding no evidence of its connection with anything else, he may feel himself drawn towards the conclusion that it moves *of itself*—that is, by the "potency" of its own material constitution. But before adopting this *rationale*, he sees all the machines stop at once, and finds that the shaft also has ceased to revolve. Here is a new and startling phenomenon. After pondering on it for an hour, and carefully looking out for an explanation, he sees the shaft and its connected machines resume their motion, and yet is certain that no agency visible to him has had any concern in that renewal. By continued watching, he finds this suspension and renewal to be periodical, so that he can frame a law that shall express them in terms of *time*. Thus he might give a complete *phenomenal* account of the action of the shaft, which should be perfectly consistent with the assumption of its "inherent potency," and which might be sufficiently satisfactory to his mind to justify him in believing that there is no more to be learned about it. But not wishing to leave anything uninvestigated, he goes round to *the other side of the wall*. There he finds that one end of the shaft comes through it, and is in mechanical connection with either a steam-engine or a water-wheel; and by watching what occurs when its motion is checked and renewed, he sees that the Engineer shuts off, or turns on, either the steam generated in the boiler of the steam-engine, or the descending water whose motion drives the wheel.

I shall not weary the patience of such readers as may have followed me thus far, by tracing out in like detail the further steps of the inquiry; but shall land them in the final conclusion now accepted by every man of science—that the power exerted in both these cases is drawn from solar radiation: the fall of the water which gives motion to the water-wheel, being merely the return of that which has been pumped up as vapour by the sun's heat; whilst the combustion of coal from which steam-power is derived, reproduces, as active force or "energy," the sunshine that exerted itself during the carboniferous period in dissociating carbonic acid and water into the hydrocarbons of coal and the oxygen of the atmosphere, whose recombination gives forth heat and light. And if we look still further back for the source of the sun's radiant energy, we should find it, perhaps, in the progressive consolidation of the primeval "fire-mist"—nebular matter.

But whence nebular matter? And whence the force which draws its particles together, and which manifests itself as light and heat during their consolidation? Here we come to a wall, to the other side of which we seem at present to have no access.

But *is* there no other side? Does not the whole course of the preceding inquiry show the unsatisfaction (if I may revive an obsolete word) of resting in any inherent "potency" of matter as the *ultima ratio* of the existing kosmos? If we think the man foolish who supposes the main shaft of a cotton mill to turn *of itself*, merely because he sees it apparently end in a wall which conceals from him the source of its motive power, are we not really chargeable with the like folly if we attribute self-motion to the ultimate molecules of matter, merely because the power that moves them is hid from our sight? The mere physicist may see no possible way further. But there is a philosophy which has fully as true and as broad a basis in man's psychical experience, as can be claimed for the fabric of physical science; and in the admirable words of the great master I have already quoted (Sir John Herschell, in his *Familiar Lectures on Scientific Subjects*, p. 460), I shall sum up an argument which this paper is intended rather to illustrate and enforce by an appeal to the familiar facts of consciousness, than to present in strict logical form:—

"In the *mental sense of effort*, clear to the apprehension of "every one who has ever performed a voluntary act, which is pre-"sent at the instant when the determination to do a thing is "carried out into the act of doing it, we have a consciousness of "immediate and personal causation which cannot be disputed or "ignored. And when we see the same kind of act performed by "another, we never hesitate in assuming for him that conscious-"ness which we recognize in ourselves; and in this case we can "verify our conclusion by oral communication." "In the only "case in which we are admitted into any personal knowledge of "the origin of force, we find it connected (possibly by intermediate "links untraceable by our faculties, yet indisputably *connected*) "with volition, and by inevitable consequence, with *motive*, with "*intellect*, and with all those attributes of mind in which personality "consists."

As a physiologist, I most fully recognize the fact that the physical force exerted by the body of man is not generated *de novo* by his will, but is derived from the oxidation of the constituents of his food. But holding it as equally certain, because the fact is capable of verification by every one as often as he chooses to make the experiment, that, in the performance of every volitional movement, that physical force is put in action, directed, and controlled, by the individual personality or *Ego*, I deem it just as absurd and illogical to affirm that there is no place for a God in Nature, originating, directing, and controlling its forces by his will, as it would be to assert that there is no place in Man's body for his conscious Mind.

XIII.

NATURE AND LAW.

[*The Modern Review*, October, 1880.]

"THE laws of light and gravitation," wrote Mr. Atkinson to Harriet Martineau thirty years ago, "extend over the universe, "and explain whole classes of phenomena;" and this "explanation," according to the same writer, is all-sufficient, "philosophy "finding no God in Nature, nor seeing the want of any." The "advanced" philosophy of the present time goes still further; asserting that as the progress of science now places it beyond doubt that all the phenomena of Nature—physical, biological, and mental—are but manifestations of certain fundamental "properties "of matter," acting in accordance with fixed laws, "there is no "room for a God in Nature." And scientific thinkers who do not accept this as the conclusion obviously deducible from their recognition of the universality of the "reign of law," are branded as either illogical thinkers, or as cowardly adherents of a bygone superstition—men who are either deficient in the power to reason out the conclusions to which their own premises necessarily lead or have not the courage to face them.

There can be no question of the influence that is being exerted by the reiteration of these assertions on the intelligent thought of the younger generation. Over and over again has it been pointed out with truth, that whenever science and theology have come into conflict, theology has had in the end to go to the wall. The Copernican system of astronomy has established itself in spite of the thunders of the Vatican. The geological interpretation of the history of the earth has taken the place of the Mosaic Cosmogony in the current belief of educated men, notwithstanding all the denunciations of theological orthodoxy. Any one who should now maintain the universality of the Noachian Deluge, to doubt which was once to peril one's salvation, would be laughed at as an ignoramus. The antiquity of man, which no more than twenty years ago was repudiated as a dangerous heresy, has already passed beyond the region of discussion. And so, it is affirmed, as the doctrine of evolution has now established itself in the minds of all competent judges as an indisputable verity, science—which formerly attacked and mastered only the outworks of theology—will be assuredly no less successful in its assault on the citadel itself. The "creation" of the Old Revelation will fall before the "evolution" of the New; the notion of power will be superseded by that of law; the evidences of "design" will be disposed of by the fact of "natural selection;" and the "potencies" of matter will henceforth be the only subjects about which sensible men will concern themselves.

Now I fully accept it as the highest work of the man of science, whatever his department of study, to seek out those "laws" which express the order of Nature. But I affirm that even supposing him to have so completely succeeded in his search, as to be able to formulate a general statement in which they could be all embodied, and from which all the phenomena of the universe could be traced out deductively, the question of the cause of those phenomena would be left just where it was; the "law" simply expressing *the order and physical conditions of their concurrence*, and giving no real "explanation" of them.

Much of what seems to me a prevalent confusion of thought on this subject—nothing being more common than to speak of laws as "governing" or "regulating" phenomena, and to affirm that phenomena are sufficiently "accounted for" when they can be shown to be "consequences" of a law—seems to me to be traceable to the double sense in which the word "law" is habitually used. And the purpose of my present paper will be to help my readers to "think themselves clear" upon this matter; by showing the fundamental difference between the *legal* and the strictly *scientific* conception of law, and by examining into the theological bearing of each. And if, in so doing, I go over ground which has been trodden until it seems perfectly familiar, and use illustrations that may be thought to have been worn to triteness, it is because I believe that the best lessons are often to be drawn from the most familiar things, *if they be looked at from the right point of view.*

I. When we speak of the "laws" of a State, we mean the rules laid down by the Governing Power of that State for the conduct of its members; which rules, its Executive is charged with enforcing by the power it wields. But there may be laws which a Government regards as obsolete, and thinks it inexpedient to enforce (as is the case with many of those still inscribed on our Statute-book); or others of recent enactment, which a Government may be deterred from carrying into execution by the antagonistic force of public opinion (as happened many times in regard to the "fugitive slave law" of the United States). Or, again, the Executive may itself be paralyzed by a panic, which allows mob-force for the time to reign supreme (as in the riots of London in 1780, and the riots of Bristol in 1831); or may be overthrown by a Revolution which subverts its authority, leaving anarchy to prevail until a new Government shall have been constituted. Thus it is clear that state-made laws have no coercive action *in themselves;* that action being entirely dependent upon the enforcement of them by the governing power, of whose will they are to be regarded as the expressions. The very term "government," indeed, carries with it the idea of a governing power on the one hand, and of a people controlled by it on the other. And when we speak of a State as "governed *by* law," we mean no more than that its controlling Power "governs *according to* law;" or, in other words, that it acts—not on the arbitrary dictation of its own will—but in accordance with certain fixed and determinate rules, in which that will is expressed, and within which it limits its exercise.

It is thus that when we pass from the sphere of human government to that of the Divine, and speak of the universe as "governed" by the "laws" of a supreme Ruler, we mean that his power is exerted, not like that of an arbitrary potentate who changes his course of action as his own caprice or passion may direct, but like that of a benevolent sovereign whose rule is in uniform and orderly conformity with certain fixed principles, originally determined as conducive to the welfare and happiness of his people.

Such, in the earlier stages of scientific inquiry, when the uniformities of Nature first attracted the attention of thoughtful men, seems to have been the aspect under which the "laws" that express them were generally regarded. While the Hebrew mind, nursed in the idea of an anthropomorphic theocracy, regarded all the phenomena of the universe as the immediate expressions of the personal will of its national deity, and, so far from feeling any incredulity as to "supernatural" or apparently disorderly occurrences, expected them as the appropriate attestations of his authority, the philosophers of Greece and Rome, who gave themselves rather to the study of the *order* of Nature, and were strongly impressed by its uniformities, for the most part saw in them (as expressed by the application of the word *kosmos*, originally meaning "orderly arrangement," to designate the universe) the manifestations of supreme designing and controlling minds.* And among those who, nearer our own time, most advanced our knowledge of that order, the same conception of the nature of the "laws" expressive of it continued to prevail. Thus it is recorded of Kepler, that when, after a life devoted to the search, he had discovered the three laws of planetary motion which have made his name immortal, he spoke with devout gratitude of the ample reward he had received for his labours, in having been thus permitted "to think the thoughts of God." And no one who has followed the course of Newton's discoveries and his own mode of viewing them, can doubt that this idea was alike dominant in his mind. For when charged by some of the theologians of his time with (as they affirmed) superseding the Divine agency in the production of the movements of the planetary system, by attributing them to hypothetical forces of his own creation, he defended himself by showing that his "Principia" simply aimed to express the mode in which that agency exerts itself.

* Every reader of Cicero's treatise "De Naturâ Deorum" will recollect this to be its "argument."

II. But as the *scientific* conception of "law," based on the discoveries of Kepler and Newton, extended itself into every department of nature, and one class of her phenomena after another was brought within its range, the idea of Divine government, originally embodied in the phrase "laws of nature," dropped away; the study of "final causes" was found to hamper, instead of guiding, scientific research; and the more thoroughly the pursuit of the truth as it is in nature has been freed from theological trammels, the more successful that pursuit has been. While, however, the idea of "government" by a God is now excluded, by general consent, from the domain of science, the notion of "government" by law has taken its place, not only in popular thought, but in the minds of many who claim the right to lead it; and it is the validity of this notion which I have now to call in question.

We may, I think, best begin our inquiry into what a "law of nature" really means, by tracing historically the progress of our knowledge of that one, whose simplicity of form allows it to be stated with the greatest clearness and precision, and whose universality seems to have been demonstrated beyond all question. I mean, of course, the law of gravitation, as enunciated by Newton; which affirms that "all masses of matter attract one another with "forces directly proportional to their masses, and inversely proportional to the squares of their distances." As I pointed out in my former paper, what is meant by "force," in this and similar expressions, is the "pull" of which we ourselves become sensible in any attempt we make to resist its action—as when we try to hold back a piece of iron that is being drawn towards a powerful magnet.

That all solid or liquid bodies fall to the ground if unsupported, must have been among the very earliest of the generalized experiences of the human race; and the downward "pull" felt by every one who held such bodies in his hand, justified his attributing their fall, when let go, to the "attraction" exerted upon them by the earth. The difference upon the "pulls" exerted by stones of different sizes, would give the notion of differences of *weight;* and certain standards being adopted, the balance applied the means of more exactly determining the downward "pull" of a mass, than any personal estimate of it could afford. Differences of weight being thus determined between masses of the same size, but of different kinds of matter—as, for instance, between a cube of lead and a cube of stone, or between a cubic vessel of water and a block of wood of the same dimensions—gave the notion of differences of *relative weight* (or "specific gravity") and the weight of water being taken as the standard of comparison, a distinction was drawn between "heavy" and "light" bodies. The floating of a piece of wood on the surface of water, and its rising up from the bottom when no longer held down, were rightly interpreted as a consequence of their respective downward tendencies or relative weights; for since it could be shown by experiment that if equal measures of wood and of water were put in the two scales of a balance, the water would go down, it was seen that the earth must have a greater attraction for it, and that the ascent of the wood is brought about by the descent of the water to take its place.

Now here we have a very simple case of what is commonly called the "explanation" of a natural phenomenon. To those who first reflected on the matter, the ascent of the solid wood through the liquid water might seem an *exception* to the general uniformity, for which the philosopher of the time would be desired to account. And he would do so by showing that it is really *in accordance* with such uniformity. Further than this he could not go; and *further than this no scientific explanation can go.* As J. S. Mill has truly said, "In science, those who speak of explaining "any phenomenon mean (or should mean) pointing out not some "more familiar, but merely some more general, phenomenon, of "which it is a partial exemplification."—But our ancient philosopher could *not* have so explained the ascent of the *smoke;* for he knew not that both the atmosphere and the smoke have weight; but that the smoke, being the lighter of the two, ascends like a piece of wood through a column of water; and he could only account for it by attributing to the smoke an exceptional "levity," which made *it* ascend, whilst *all other* bodies descended. But he could not really get any nearer to the "cause" of the *general,* than to that of this *exceptional* phenomenon. As it is a "property," he would say, of the earth to attract, and of bodies in general to be attracted by it, *downwards*, so it is a "property" of smoke to mount *upwards.* But this is nothing more than another form of stating the facts familiar to everybody. Such philosophers as talk of laws "explaining" phenomena, or of the "potencies" of matter as giving a sufficient account of its activities, seem to me not to have got beyond that "wisdom of the Ancients," which, in such a case as that just cited, they would themselves repudiate as mere "folly."

The notion of the attractive force of the earth, unchecked by any right conception of the action of force in producing motion, led the Ancients into a very strange error. As the "weight" of a body is the expression of the downward "pull" which the earth exerts upon it, it seemed natural to suppose that the *rate* of the fall of any heavy body to the ground would increase in proportion to that weight, so that a body weighing ten pounds would fall ten times as fast as a body weighing one pound. And this was formulated as a "law" by Aristotle, and accepted by "educated" mankind as such for nearly two thousand years: for although it might have been at once disproved by the very simple experiment of letting fall the two weights at the same moment from the top of a high tower, and observing when they respectively struck the ground at the bottom, the authority of Aristotle on the one hand (to doubt which was rank heresy), and what seemed the "common sense of the matter" on the other, prevented it from being called in question.

Here again (as it seems to me) we may find a lesson of great value. Aristotle was undoubtedly—as regards science—the "master mind" of the ancient philosophy; but in this matter he proceeded upon *his own conceptions*, instead of upon *ascertained facts;* and he consequently presumed to make laws *for* Nature, instead of setting himself to determine what are the laws *of* Nature—framing general expressions of what he thought *must* be her orderly uniformities, instead of inquiring what these uniformities really are, and basing his generalizations upon them.

It was by Galileo that this matter was first experimentally investigated. While yet a student in medicine at the University of Pisa (his native town), his attention was attracted by the swinging of one of the chandeliers from the lofty roof of the Cathedral, which suggested to him a series of experiments upon the vibrations of pendulums of different lengths—without, however, causing him to pursue the subject further than the devising an instrument for measuring the rate of the pulse. But the interest he took in the study of mathematics and mechanics proved so strong as to lead him to devote himself entirely to them, with a success that caused him to be appointed lecturer on those subjects at the University. Although no religious reformation could then make head in Italy, a revolt against the domination of Aristotle was beginning to break out among its scientific men; and undeterred by the fate of Giordano Bruno (who was burnt by the Inquisition at Rome in 1600), Galileo early joined the movement party. One of the first of the Aristotelian doctrines which he called in question, was that which I have just cited. He saw that it *must* be erroneous, as taking no account of the very obvious consideration that while the "pull" of the earth on the weight of 10 lbs. is ten times as great as it is upon the weight of 1 lb., it has to give motion to ten times the mass; so that the *rates* of fall of the two bodies would be the same. His teaching on this subject being opposed by his colleagues, Galileo, in the presence of the whole University, ascended the "leaning tower," and dropping from its summit bodies of different weights, he showed that (with an inconsiderable difference, due to the resistance of the air) they reached the bottom in the same times.

As the monument of an experiment which gave the death-blow to the *unscientific* legislation of Aristotle, and prepared the way for the *scientific* legislation of Newton, the "leaning tower" of Pisa, beautiful in itself as an architectural work, has a far grander interest for all who can appreciate this great step in the emancipation of thought, which should cause it to be preserved with the most jealous care so long as its stones will hold together.

But this demolition of an old error was only the first result of Galileo's experimental researches. For he found, by letting fall similar weights from different heights, that the rate of motion of the falling body continually increases as it descends; a body that falls 16 feet in *one* second, falling 64 feet in *two* seconds, 144 feet in *three* seconds, and 256 feet in *four* seconds, this last being probably the greatest height at which he could experiment. These results were found capable of being expressed by a very simple formula—that the *total fall* in any number of seconds is the product of the square of that number multiplied into the fall in the first second. But there was no adequate ground for asserting, or even for expecting, that this formula would hold good in regard to a body let fall from a height of *ten* or a *hundred* times 256 feet. The "law" was, in that stage, the simple generalized expression of facts within the range of actual knowledge. No one had a right to say *how far* above the general surface of the earth its attractive force extends; nor could it be affirmed with any certainty, that the fall of bodies from great mountain heights would follow the same "law" as their fall from the top of a tower.

But a great advance was made, when Galileo applied to this case the general doctrine of the action of "accelerating forces," to which his study of mechanics had led him. For he saw that when the falling body is let go, it starts from a state of rest, its velocity being 0; and that since it is receiving afresh, at every instant of its fall, the same "pull" from the earth as that which first puts it in motion, its rate of movement must undergo a continual regular acceleration. On the basis of this conception, a very simple computation showed that during the first second it will have thus acquired a velocity, which, if there were *no* fresh "pull," would carry it through 32 feet in the next second, but which, *with* the fresh "pull," would cause it to descend 48 feet, making 64 feet in the two seconds—and so on. The simply *empirical* law, then, which at first had no higher value than it derived from its accordance with a very limited experience, and which might, or might not, be found to hold good beyond the range of that experience, acquired a *rational* value, as the expression of what may be fairly anticipated to be the continually accelerating rate of motion of falling bodies, due to the constantly acting attraction of the earth upon all bodies within its range. And thus it was *reasonable* to expect, that within the range of the earth's attraction—whatever that range might be—the rate of descent of bodies falling towards its surface would still be found to conform to it. But no one could then form any definite idea as to the extent of that range. It was, as we shall presently see, the bold "scientific imagination" of Newton, which first framed the conception—and his vast mathematical ability, which enabled him to give it definite shape—that the moon is constantly "falling" towards the earth at a rate exactly conformable to that "law" of terrestrial gravitation, with which the name and fame of Galileo will ever be associated.

My own first ideas of the Newtonian Philosophy, if I rightly remember, were drawn from the answer given in that best child's book of my generation—"Evenings at Home"—to the question "Why does an apple fall?" Whether the apple of Newton is to be relegated, like that of Tell, to the limbo of "myths," is a question I shall not stop to discuss. It is enough that the story serves to illustrate the "idea." Probably if the question were put to a hundred "educated" people, ninty-nine of them would give one of these two answers, "Because of the earth's attraction," or, "Because of the law of gravitation." But, as I have shown, to speak of the attraction of the earth, is merely to express, in different words, the fact that it "draws" the apple downwards; and if we go further and say that the earth draws downwards not only apples, but stones, water, and air—in fact, all material bodies whatever—we only express a general uniformity, of which we know nothing more than that it *is*. Clearly it is no real "explanation" of the fall of any *one* apple, to say that *all* apples or *all* material bodies fall when unsupported. So the "law" of gravitation is merely an expression of that general uniformity, framed with a scientific exactness which enables us to say "with certainty" (in common parlance) what will be the time occupied in the fall of a heavy body through any given number of feet. But that "certainty" depends not upon any "governing" action of the "law" itself,—for into the purely scientific conception of law the idea of a governing power does not enter;—but solely upon our rational expectation that what has been found conformable to a vast experience in the past, under every variety of conditions, will in like manner prove conformable to it in the future.

Before, however, we follow the development of Galileo's doctrine of terrestrial gravitation into the Newtonian doctrine of universal gravitation, we must deal with another of the "laws" imposed on Nature by the ancient philosophy. It was held that as a *circle* is the most "perfect" figure, and as the motions of the celestial bodies *must* be "perfect," they must revolve in circles;—whether round the sun, as Pythagoras maintained, or round the earth, as Aristotle and the later Schoolmen taught. Every tyro knows how the Ptolemaic system of astronomy, based on the latter conception, developed itself into a mechanism of most ingeniously devised complexity, by the necessity of continually adding new cycles and epicycles to "account for" the new discordances which improved methods of observation were continually bringing to light between the actual and the predicted places of the heavenly bodies. This method of "accounting for" them was a pure assumption; and yet it answered its purpose so well, as to form the basis of the methods of astronomical computation in use at the present time.* But when Copernicus revived the scheme of Pythagoras, and the comparative simplicity of his system (doing away with a large part of the cumbrous machinery of the Ptolemaic) recommended it to the acceptance of minds not trammelled by their own scholastic prejudices, or dominated by ecclesiastical tyranny, the whole question had to be studied afresh; and it was by the marvellous perseverance and ingenuity of Kepler, the contemporary and friend of Galileo, that the solution of it was found. Starting with the conviction that there *must* be an "order" (if he could only find it out), he passed his life in a series of *guesses* as to what that order might be; and his ingenuity in guessing was only surpassed by his eagerness in subjecting every guess to the test of its strict conformity with observed facts, and by his candid readiness to abandon it so soon as its discordance became clear to him. Limiting his studies to the orbit of Mars, he brought to the explanation of the observed places of that planet all the resources of *eccentric* but uniform *circular* motion, which he could devise both for Mars and

* It is not a little singular that, notwithstanding the great advance which mathematical science has made since Newton's time, no formula has yet been devised for *directly* computing the place of a planet or comet in an *elliptic* orbit; all such computations being still made on the assumption of *uniform circular motion*, with cycles and epicycles "interpolated" (after the method of Ptolemy) so as to attain any required approximation to absolute correctness. And thus, both as generalizing the facts of observation, and as furnishing the only basis for accurate prediction, this complex conception (as now perfected) would have had even a higher claim to be received as true to Nature than Kepler's "laws" of *elliptic* motion, until these were shown to be deducible from Newton's grand and simple assumptions.

the earth; but found, time after time, that Mars "burst all the "chains of the equations, and broke forth from the prisons of the "tables." At last it occurred to him to try an *ellipse;* and on projecting this as the path of the planet, he found, to his great joy, that the observed places of Mars in the heavens corresponded so exactly with what they should be on that assumption, as to afford the strongest assurance of its truth. But this hypothesis of the elliptical orbit of Mars did not "explain" anything; it did no more than state in general terms the course of that one planet's motion. *Why* Mars should take that course, was a question on which he threw no light. And, however probable he might think it that the other planets also move in elliptic orbits, he neither proved it as a fact by the like experiential investigation, nor could adduce any other ground for such probability than that general idea of uniformity and harmony which was the basis of his whole work. It is clear, then, that Kepler's *first* "law of planetary motion" has in itself no "governing" power whatever.

While working out his conception of elliptical motion, Kepler was baffled for a time by the discordance between the observed places of Mars, and the places which would be predicted for him on the assumption of "uniform" motion in an elliptic—instead of in a circular—orbit. Finding that motion to be much more rapid in the part of the orbit nearer the sun, than in the part more remote from it, he again applied himself to his old work of *guessing;* and it is singular that he was led to hit upon what is known as his *second* law—the passage of the "radius vector" over equal areas in equal times—by an erroneous physical conception of a driving force emanating from the sun, and acting more powerfully on near bodies than those at a distance. Now this second "law," like the first, was simply nothing else than a theoretical generalization of a class of facts; its value lay entirely in the correctness with which it expressed them; and so far was Kepler from having attained to any higher conception of its import, that what he regarded as a triumphant confirmation of his doctrine came out of a merely accidental relation between the ellipse and the circle.*

* I do not know any more instructive or interesting scientific biography than the "Life of Kepler," by Drinkwater, published by the long-since-defunct "Society for the Diffusion of Useful Knowledge," which did much good work of this kind half a century ago.

It was not until twelve years after the publication of his first two "laws," that Kepler was able to announce the discovery of the *third;* which expresses the numerical relation between the respective *distances* of the planets from the sun, and the *times* of their revolution around him. This, again, was the outcome of a long series of guesses. And what was remarkable as to the error of the idea which suggested the second law to his mind, was still more remarkable as to the third; for not only, in his search for the "harmony" of which he felt assured, did he proceed on the erroneous notion of a whirling force emanating from the sun, which decreases with increase of distance, but he took as his guide another assumption no less erroneous, viz., that the *masses* of the planets increase with their distances from the sun. In order to make this last fit with the facts, he was driven to assume a relation of their respective *densities*, which we now know to be utterly untrue; for, as he himself says, "unless we assume this proportion "of the densities, the law of the periodic times will not answer." Thus, says his biographer, "three out of the four suppositions "made by Kepler to explain the beautiful law he had detected, are "now indisputably known to be false;" what he considered to be the *proof* of it, being only a mode of false reasoning by which "any "required result might be deduced from any given principles." And yet I cannot doubt that if Kepler had found his "law" to be inconsistent with the *facts* of which it was the generalized expression, he would have at once surrendered this pet child of his old age, with the same honest zeal for truth that led him to abandon the earlier offspring of his creative brain.

Neither of the "laws" formulated by Kepler, then, can be regarded as having any higher than an absolutely *empirical* value; being good as expressions of certain classes of uniformities observable in nature; but, as he left them, quite untrustworthy—except as a guide to further inquiry—beyond the limits of the experience on which they were based. They had (as it seems to me) just the value of what is commonly known as "Bode's formula" (called by Professor Newcome the "law of Titius"), in regard to the distances of the planets from the sun: for this gave a numerical expression of the several distances of Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Uranus, which not only agreed sufficiently well with the observed facts to suggest the existence of a real "law;" but actually led to the prediction of a "lost planet" between Mars and Jupiter, which has been verified by the discovery of somewhere near two hundred "asteroids," to say nothing of streams of meteorites. The discovery of Neptune, however, effectually demolished the credit of this "law;" the distance of that planet from the sun proving to be nearly one-fourth less than the formula would make it.*

The first of the great achievements of Newton in relation to our present subject, was a piece of purely geometrical reasoning. Assuming two forces to act on a body, of which one should be capable of imparting to it uniform motion in a straight line, whilst the other should attract it towards a fixed point in accordance with Galileo's law of terrestrial gravity, he demonstrated that the path of the body would be deflected into a curve, which *must* be one of the conic sections; and that, if the two forces are in near equivalence the one to the other, the curve will be an ellipse. (Galileo had already shown that the path of the projectile in which gravity preponderates over the onward force, is a parabola). He proved, moreover, that the motion of any body thus traversing an elliptical orbit round a centre of attraction, *must* conform in its varying rates to Kepler's *second* law. And further, he showed that if a number of bodies be moving round the same centre of attraction at different distances, the rates of their revolution *must* conform to Kepler's *third* law. By assuming the existence of these two balanced forces, therefore, he not only showed that all the observed uniformities could be deduced from that one simple conception, but furnished a rational basis for the assured expectation that the like uniformities would prevail in every other case. And the verification of this expectation by the discovery that even comets

* It may not be uninstructive to note that in their mathematical search for this stranger, which manifested its presence by disturbing the motions of Uranus, both Adams and Leverrier took Bode's formula as the basis of their computations, assuming its distance from the sun to be somewhat more than twice that of Uranus. And it was by nothing more or less than a fortunate coincidence, that the new planet was found in the place which they agreed in assigning to it; for if the search had been made a year earlier or a year later, its actual place would have been so far from its computed place, that it would probably not have been found until new computations had been made on the basis of some more lucky guess.

move in elliptical orbits, and that, if these orbits can be exactly determined by observation, and the influence of perturbing forces rightly estimated, their return can be predicted, may be considered as fully justifying such an expectation, so far at least as the solar system is concerned.

But the "law" at which we thus arrive, is only a higher and more comprehensive generalization of the facts of celestial observation, and rests on assumptions which are not only *unproved* but *unprovable.* For the idea of continuous onward motion in a straight line, as the result of an original impulsive force not antagonized or affected by any other—formularized by Newton as his first "law of motion"—is not borne out by any acquired experience, and does not seem likely to be ever thus verified. For in no experiment we have it in our power to make, can we entirely eliminate the antagonizing effect of friction and atmospheric resistance; and thus all movement that is subject to this retardation, and is not sustained by any fresh action of the impelling force, must come to an end. Hence the conviction commonly entertained that Newton's first "law" of motion *must* be true, cannot be philosophically admitted to be anything more than *a high probability*, based on the fact that the more completely we can eliminate all antagonizing influences, the nearer we get to the perpetuity of movement once initiated. To say that this "law" is so self-evident that we cannot help accepting it as an "axiom" or necessary form of thought, is to run counter to the historical fact, that the great thinkers of antiquity—whom none have ever surpassed in pure thinking power—accepted as the dictate of universal experience, that all *terrestrial* motions come to an end; and were thus led to range the *celestial* motions in a different category, as going on for ever.

So, again, we have no *proof*, and in the nature of things can never get one, of the assumption of the attractive force exerted either by the earth, or by any of the bodies of the solar system, upon other bodies *at a distance.** All that we can be said to

* Newton himself strongly felt that the impossibility of rationally accounting for *action at a distance* through an intervening *vacuum*, was the weak point of his system. The science of the present day is seeking for the solution of this difficulty, in the hypothesis of the universal pervasion of space by moving molecules of some form of highly attenuated matter.

know (as I have already pointed out) is that which we learn from our own experience as to the attraction of the earth for bodies near its surface. And although Newton is commonly credited with having "demonstrated" the identity between terrestrial gravity and the force which deflects the moon out of its straight course, and with thus having "proved" the universality of the mutual attraction of masses of matter, I speak with the authority to which I consider myself entitled, not by my own study of this subject, but by the answers of the greatest masters of it to questions I have put to them,—that what Newton really did was to show that such an exact *numerical conformity* exists between the rate of fall of the moon towards the earth (that is to say, her deflection from her onward rectilineal path) in any given time, and the rate of a body actually falling to the earth's surface (according to Galileo's law), as *justifies the assumption* of the identity of the force which causes the former, with that of which we have experience in the production of the latter.

Now, in regard to the sun's attraction for the earth and planets, we have no certain experience at all. Unless we could be transported to his surface, we should have no means of experimentally comparing solar gravity with terrestrial gravity; and if we *could* ascertain this, we should be no nearer the determination of his attraction for bodies at a distance. The doctrine of universal gravitation, then, is a pure assumption; and, as a highly competent writer,* who obviously takes my own view of the matter, has lately said with reference to Descartes' theory of "vortices" (which, essentially the same with Kepler's, for some time disputed the field with Newton's theory):—"Had Descartes been able to "show that the parts of his vortex must move in ellipses having "the sun in one focus, that they must describe equal areas in equal "times, and that their velocity must diminish as we recede from "the sun, according to Kepler's third law, his theory would have "so far been satisfactory." But while "all three of Kepler's laws "were expressed in the single law of gravitation towards the sun, "with a force acting inversely as the square of the distance," Descartes' theory entirely failed to grasp them, and therefore fell

* Professor Simon Newcomb, of the United States Naval Observatory, in his admirable "Popular Astronomy."

before the comprehensive power of the Newtonian doctrine; which soon afterwards obtained its verification in the discovery that the regular movements of the planets in their orbital revolution round the sun, show "perturbations" whose actual amounts are found to be exactly conformable to the results of computations based on the assumption that *they*, too, attract one another in proportion to their respective masses. A like verification was found in the application of the doctrine of gravitation to the familiar phenomena of the tides; the *rationale* of which had remained a mystery until Newton traced not only their diurnal rise and fall, but their monthly and annual variations, to the attractive force exerted by the moon (and in a less degree by the sun) upon the waters of the ocean.

It will not, I believe, be questioned by any one who has carefully studied Newton's writings, that he himself regarded the doctrine of universal gravitation as an *hypothesis*, the value of which entirely depends upon the conformity of every deduction that can be drawn from it by the most rigorous mathematical reasoning, with the facts determined or determinable by observation.* But as all experience since his time has but afforded fresh illustrations of that conformity,—as no perturbation, great or small, has been observed in any of the bodies of the solar system, which has not been "accounted for" (to use the familiar phrase) by its conformity with the general doctrine,—and as the orbital movements of double stars round their common centre of gravity are now found to be in equally exact conformity with it, we feel an assurance of its truth, which nothing, save a complete revolution either in the world of matter or in the world of mind, can ever shake.

But this brings us no nearer to the idea of "government" by that law. That Newton's law is higher and more general than Kepler's—being, to use the language of J. S. Mill, one of those *fewest and simplest assumptions from which, being granted, the whole order of Nature would result*—does not give it any "power" to produce or maintain that order. It is simply (again to quote J. S. Mill) one of those *fewest general propositions from which all the uniformities which exist in the universe might be deductively*

* See note, p. 379.

inferred * Newton, then, was the unquestionably greatest revealer the world has yet seen of the *order* of the universe. As was grandly said by a contemporary poet—

> "Nature and Nature's laws lay hid in night,
> God said, 'Let Newton be,' and all was light."

But so far was he from claiming to have revealed anything of the *cause* of that order, that he most distinctly repudiated the notion. I altogether deny, then, the right of the so-called philosophers of our time to attribute to Newton's or any other hypothesis the solution of the problem of the Kosmos. No law of pure science *can* be anything but an expression of the *fact* of its orderly uniformity. And that fact gives us in itself no clue to its *cause.* But it clearly does not exclude the notion of an Intelligent First Cause, or *Causa causarum.* And to that notion we seem to be led (as I pointed out in my former paper) by our own experience of *volitional* or *purposive* agency. To me the uniformities of Nature, so far from suggesting blind force, have ever seemed to present, in their wonderful combination of unity and variety, of harmony and diversity, of grandeur and minuteness, the evidences of such a Designing Mind as we recognize in any great human organization which approaches our notion of ideal perfection, such as a well-conducted orchestra, a thoroughly disciplined army, or an admirably arranged manufactory. To see a great result brought about by the consentaneous but diversified action of a multitude of individuals, each of whom does his own particular work in a manner that combines harmoniously with the different work of every other, suggests to me nothing but admiration for the Master-mind by which that order was devised, and by the influence of which it is constantly sustained. And so, as I wrote more than forty years ago, "every step we take in the progress of "generalization, increases our admiration of the beauty of the adap-"tation, and the harmony of the action, of the laws we discover; "and it is in this beauty and harmony that the contemplative mind "delights to recognize the wisdom and beneficence of the Divine "Author of the universe." And I persuade myself that to those who have followed me through this discussion, it may not be

* "System of Logic" (eighth edition), vol. i. p. 366.

uninteresting to see in the closing paragraph of my first attempt to work out the "Principles of General and Comparative Physiology" (1839), the conception I had then formed, and to which I still adhere, of the highest aim of scientific research :—

"If, then, we can conceive that the same Almighty *fiat* which "created matter out of nothing—impressed upon it one simple "law which should regulate the association of its masses into "systems of almost illimitable extent, controlling its movements, "fixing the times of the commencement and cessation of each "world, and balancing against each other the perturbing influences "to which its own actions give rise—should be the cause, not only "of the general uniformity, but of the particular variety of their "conditions, governing the changes in the form and structure of "each individual globe protracted through an existence of count-"less centuries, and adjusting the alternation of 'seasons and times "'and months and years;' should people all these worlds with "living beings of endless diversity of nature, providing for their "support, their happiness, their mutual reliance, ordaining their "constant decay and succession, not merely as individuals, but as "races, and adapting them in every minute particular to the con-"ditions of their dwellings; and should harmonize and blend "together all the innumerable multitude of these actions, making "their very perturbations sources of new power: when our know-"ledge is sufficiently advanced to comprehend these things, then "shall we be led to a far higher and nobler conception of the "Divine mind than we have at present the means of forming. "But, even then, how infinitely short of the reality will be any "view that our limited comprehension can attain, seeing, as we "ever must in this life, 'as through a glass, darkly!' How much "will remain to be revealed to us in that glorious future, when the "light of truth shall burst upon us in unclouded lustre, but when "our mortal vision shall be purified and strengthened so as to "sustain its dazzling brilliancy!"

I purpose, at some future time, to apply the above method of inquiry to the Law of "Evolution," which is very commonly supposed to "account for" the existing fabric of the universe—animate, as well as inanimate; and to show that it really does nothing more than express an *orderly sequence* of phenomena, leaving the *cause* of that order entirely unexplained.

XIV.

THE DOCTRINE OF EVOLUTION IN ITS RELATIONS TO THEISM.*

[The following Address had been in preparation, by request, as a reply to one previously delivered by the then President of Sion College, before Mr. Darwin's death. I purposely dwelt chiefly on the *Cosmical* Evolution, as a matter on which scientific men are now generally agreed; and did not attempt to do more, in regard to *Biological* Evolution, than show that the same general doctrine applied also to it.]

THE subject on which I am to address you can only be profitably discussed, when the ground has been previously cleared of all misconception as to the relative claims and limitations of science and theology, and the boundaries of the two have been distinctly marked out. Dr. Martineau has told us that the object of science is to determine the *order* of Nature, whilst it is the function of theology to determine its *cause;* but this definition would not be accepted by those who find in the interaction of the *physical forces* a sufficient account of the phenomena of Nature; and I should rather define the province of *science* as the interpretation of the phenomena of Nature from the stand-point of physical causation, whilst theology interprets them from the stand-point of moral causation. Now, although the two conceptions we thus frame differ essentially in their aspect and character, yet, as I shall endeavour to show, they are perfectly consistent with each other.

The scientific conception of causation has recently undergone a remarkable change, which has scarcely yet received its formal recognition. Most of you, I presume, are familiar with the discussions by which the minds of the logicians of the last century

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and the first half of the present were exercised, as to its real nature. While Hume and his followers admitted nothing but invariable and unconditional *antecedence*, as the "cause" of a phenomenon, excluding altogether that notion of *force* or *power* which was expressed by the term "efficient cause," there has always been a school of scientific men, who have maintained that this notion is not only accordant with the fundamental instincts of the human mind and the uniform teachings of human experience, but is justified by the highest scientific reasoning. And I hold it to be not the least of the vast services rendered to science by Sir John Herschel, that by constantly keeping this great principle in clear view, he prepared the way for that general recognition of it, which has latterly come about almost insensibly, as a result of those researches into the mutual relations of the physical forces, which have culminated in the general doctrine of the Conservation of Energy. For even John Stuart Mill, who was the most powerful upholder of the Hume doctrine, had come, in his later years, to perceive (what I had frequently urged upon him at an earlier period) that when the assemblage of antecedents is analyzed, they are always found resolvable into two categories—the force or power which *produces* the change, and the material collocations which constitute the *conditions* of its exercise. Thus —to use one of Mill's own illustrations—although we speak of a man's fall from a ladder as "caused" by the slipping of his foot or the breaking of a rung (as the case may be), the efficient cause is the attractive force of the earth, which the loss of support to the man's foot brings into operation. And now that heat, light, electricity, magnetism, chemical affinity, and vital agency, are universally admitted to be only varied expressions of different kinds of movement among the *particles* of matter, sustained by the same agency as that which, when it acts on *masses* of matter, produces or resists mechanical motion, the "efficient cause" of every phenomenon in nature is sought in the action of one or other of these forces, and the determination of the conditions of that action becomes the primal object of scientific inquiry.

The first result of thisstudy is the recognition of *uniformity* in the action of these forces; like results happening under like conditions; and diversities in the conditions being attended with corresponding differences in the results. And it is from observation and comparison of the conditions of the phenomena of nature, that the materials are obtained for those general expressions of them which are termed *laws*. Thus, by letting fall weights from different stories of the leaning tower of Pisa, and accurately noting the times of their respective descents, Galileo was able to frame that very simple expression of the uniform relation between the space fallen through, and the square of the time occupied in the fall, which constitutes the law of Terrestrial Gravitation. This enables us to predict, with what we call scientific certainty, how many feet a heavy body will fall through in a given period of time; but this certainty has no other basis than our own confident expectation, that what has always (so far as our knowledge extends) proved true in the past, will prove equally true in the future. For the "law" has no power *in itself;* only by a false analogy with the law of a State, can it be said to "govern" or "regulate" the phenomena which it enables us to predict. In short, though perhaps ninety-nine persons out of a hundred would reply to the question why a stone falls to the ground, "because of the law of gravitation," this answer would be only tantamount to saying, "Because *all other stones*, if un-"supported, similarly fall to the ground," which is obviously no explanation at all. But when we express this general fact "in terms of force," taking as a fundamental fact of human experience the downward pull which we feel the earth to exert upon every body which we raise above it by our own effort, we bring it home to our own consciousness of personal agency, which, as I shall presently show, constitutes the connecting link between the scientific and the theological conceptions of Nature.

The attributing to "properties of matter" the phenomena which we witness in the universe around us, is only another mode of expressing the fact of those uniformities, which science finds it convenient to employ, and does not give any other "explanation" of any one of them, than that which consists in showing it to be a particular case of a general fact. Thus, when the genius of Newton recognized in the deflection of the moon's motion from the straight path into an elliptic orbit round the earth, a phenomenon of the same order as that which brings to the ground in a parabolic curve a cannon-shot fired obliquely into the air, and extended the same conception to the orbital revolution of the earth and other planets round the sun, he perceived that even these were only cases of the still more general fact, that *all* material bodies attract one another with forces proportional to their respective masses, and inversely as the squares of their distances, which expression is known as the law of Universal Gravitation. Now the attributing this general fact to a universal property of mutual attraction inherent in every particle of matter, is really but another mode of expressing the same thing, a mere figure of speech, which no more *accounts for* the phenomenon, than does its similarity to any number of other phenomena.

Let me illustrate this by reference to a "property" which is not universal. I might place before you two bars of iron, exactly resembling one another in every particular of which our senses can directly inform us, such as size, weight, external aspect, and internal texture, as shown by fracture; and yet one of them, under certain conditions, exerts powers of which the other shows itself to be altogether destitute. When brought near to a piece of iron, it draws it to itself with a force of which we become conscious in endeavouring to resist it; and even from a considerable distance it deflects a compass-needle from its true position, in a manner altogether dissimilar to that which happens when the other bar is brought near it. From observation of these facts, I can predict that if both these bars be buoyed up so as to float on water, one of them will soon settle itself in a north and south direction, and will return to that direction whenever deflected from it; while the other will remain in any position in which it may be placed. And I distinguish the former as having "magnetic properties" of which the latter is destitute. Further, my knowledge of the laws of magnetic science enables me to predict that by moving the magnetic bar in a particular manner over the non-magnetic bar, I can render the latter also magnetic, or, as may be said, can impart magnetic properties to it; but as this cannot be done to a bar of gold or silver, copper or lead, we say that iron is distinguished from metals generally by its capacity for being magnetized. Now, this is clearly no *explanation* of the phenomena which we trace to the action of magnetic force; it is simply a general expression of one of the conditions under which that force is exerted; and the embodiment of our knowledge of those conditions into such general expressions, enables me to predict other phenomena at first sight having no relation to them. Thus we have the scientific certainty that the magnetic bar, when moved within a coil of copper wire, will generate in that wire an electric current, which, when conducted to any distance, and made to pass in a coil of wire around a soft iron bar, shall render *it* capable of attracting iron, deflecting the compass-needle, and so on. Thus, to say that a piece of iron has magnetic properties, is only another way of saying that it is a magnet; but whilst the ancients only knew of a magnet as having the power of attracting iron, *we* know that it is capable of doing many other things; and of this capacity, the phrase "magnetic properties" is nothing more than a convenient expression, embodying the general fact that the piece of iron which is shown to be possessed of any one of them, possesses all the rest.

I might follow the same train of reasoning into every department of scientific inquiry, and show that what has been called the "promise and potency" of matter is nothing else than a phrase embodying a general conception of the various uniformities observable in its actions, and not helping us in the least degree to an explanation of those uniformities. But as the real significance—or, rather, *un*significance—of the term "property" becomes most apparent when it is used to designate the respective potentialities of different species of organic germs, I shall defer until the latter part of my address what I would further say upon this point.

One of the most remarkable among the many doctrines which have been recently propounded to account for particular groups of physical phenomena, is that known as the kinetic theory of gases; to which the eminent ability of the late Professor Clark Maxwell gave such a remarkable development, that, according to the statement of one of its ablest expositors (Professor Tait), it is "capable of explaining almost everything that we know with "reference to the behaviour of gases, and, perhaps, even of "vapours." The application of high mathematical reasoning to the facts of observation seems not only to justify, but to necessitate, the conclusion, that the ultimate particles of all kinds of gaseous matter are constantly darting about in all directions, with enormous rapidity, and impinging not only against each other, but against the walls of any space in which any portion of gas may be enclosed; the rates of movement of the particles of different gases, and the number of their impacts against each other, being very diverse, though constant for the particles of each gas so long as its conditions remain the same. Thus the particles of hydrogen are moving at the rate of something like seventy miles in a minute, and every particle has an average number of 17,700 millions of collisions with other particles, by each of which its course is changed; whilst in atmospheric air (in which the mixture of oxygen and nitrogen has become so complete that it behaves itself in this respect like a single gas), the particles have an average velocity of only one-fourth of that of hydrogen, and the number of collisions for each particle is only half as great. But though the hypothetical assumption of these molecular movements in the gaseous particles, is said to "explain" all their sensible actions—such as their escape from the vessels in which they are imprisoned, and the uniform diffusion of one gas through another—it really does nothing more than carry us a step higher in generalization. For supposing we accept this hypothesis as a fundamental fact in physics, the question remains as to the *source* of the movements, and the nature of the *force* by which they are sustained. And it does not help us in the least to attribute them to an inherent activity of matter; seeing that our only conception of that activity is based on observation either of the movements or of the phenomena from which those movements are inferred; just as the old notion that "nature abhors a vacuum," merely expresses the general fact that air or water will rush in to fill a void space, without giving us any understanding of why it does so.

It is not a little instructive to find that two such masters in the philosophy of science as Clerk Maxwell and Sir John Herschel, agreed in the view they took as to the *ultima ratio* of any attempt to explain the constitution of the universe by the "properties" of its component atoms. For any such attempt—as Sir John Herschel long since pointed out—lands us in the conception of a very limited number of *groups* or classes of atoms, distinguished by their several attributes; each group, however, consisting of an almost infinite number of *individuals* precisely resembling one another in their properties. "Now, when we see a great number "of things precisely alike, we do not believe this similarity to "have originated except from a common principle independent "of them; and this conclusion, which would be strong even were "there only two individuals precisely alike in *all* respects and *for* "*ever*, acquires irresistible force when their number is multiplied "beyond the power of imagination to conceive. If we mistake "not, the discoveries alluded to effectually destroy the idea of an "*eternal self-existent matter*, by giving to each of its atoms the "essential characters at once of a *manufactured article* and a "*subordinate agent*." *

Thus, then, whenever we witness any change in the material world for which we desire to account, we are led by scientific reasoning to seek for the *force* which produced it; and only when we have succeeded in finding this, do we consider that we have rationally explained the phenomenon. But whence the force? Science now teaches us to look for the source of it in the transformation of some other kind of energy; as when the production of heat by the burning of coal is turned, in the steam engine, to the maintenance of mechanical motion, which, communicated to a dynamo-machine, generates an electric current, which, in its turn, may be made to produce heat, light, mechanical motion, or chemical action. But, as Sir John Herschel pointed out, "In our "own performance of a voluntary movement, we have a conscious-"ness of *immediate and personal causation* which cannot be dis-"puted or ignored; and when we see the same kind of act "performed by another, we never hesitate in assuming for him "that consciousness which we recognize in ourselves."

The Physiologist, above all others, is forced, as it seems to me, by the experience of every day, of every hour, and even of every minute, to recognize the mutual convertibility of physical and moral agency;—the pricking of our skin with a pin producing a change in our state of feeling; and a mental determination calling a muscle (or set of muscles) into a contraction which

* Discourse on the Study of Natural Philosophy," p. 38.

generates mechanical power. And thus a bridge of connection is established between physical and moral causation, which enables us to pass without any sense of interruption or inconsistency from the scientific to the theological interpretation of Nature, as here formulated:

PHENOMENA OF NATURE.

SCIENTIFIC INTERPRETATION. *Physical Causation.*	THEOLOGICAL INTERPRETATION. *Moral Causation.*
FORCES OF NATURE.—Designations of varied modes of operation of *one force* acting under diversified physical conditions.	POWERS OF NATURE.—The designations of varied modes of manifestation of one and the same Personal Agency throughout the material Universe.
LAWS OF NATURE.—Generalized expressions of past uniformities observed in the action of the forces of Nature, leading to the expectation of similar uniformities in the future.	ORDER OF NATURE.—The expression of the continuous and uniform action of a Supreme Intelligence, as apprehended by the intelligence of Man.

With these views of the relations between science and theology, I have never myself been able to see why anything else than a complete harmony should exist between them. True it is that there have been, from time to time, men of science, who, from what I believe to be an equally limited and illogical conception of the subject, have drawn the conclusion that there is "no room" for a God in Nature; the "properties of matter" being, in their view, all-sufficient to account for the phenomena of the universe and for the powers and actions of the human mind. But this seems to me only a natural reaction against what all history teaches, as to the constancy with which, ever since science emancipated itself from theology and set up for itself, it has been hampered and impeded in its search for the truth as it is in Nature, by the restraints which theologians have attempted to impose upon its inquiries. The Romish Church, adopting the philosophy of Aristotle into its own theological system, opposed as heretical every attempt to call in question the authority of Aristotle, even as to matters of fact; and while it could not repudiate the proof afforded by the experiments of Galileo, that a weight of 10lb. does *not* (as affirmed by Aristotle) fall ten times faster than a weight of 1 lb., it judicially condemned him as an impious heretic, for daring to teach that the earth moves round the sun. And Protestant divines in this country, equally taking their stand upon infallible authority, but shifting its basis from the Church to the Bible, have no less vehemently opposed any scientific inquiry which might throw a doubt upon the literal accuracy of the Book of Genesis. Thus it is within the remembrance of many of us, how the conclusions of Geologists as to the long succession of changes which had taken place in the crust of the earth, and in the races of plants and animals which had peopled its surface, before the advent of Man, were denounced as destructive of all religious faith; how, when obliged by the logic of facts to admit that the beginning of the world must be antedated indefinitely, theologians took a fresh stand upon the modern origin of Man, and did their utmost to discredit the evidence crowding in from all quarters as to his remote antiquity and the low condition of our primeval ancestors; and how, when this evidence could no longer be gainsaid, they tried to uphold the universality of the Noachian Deluge,—with the miserable result of an ignominious surrender.

But I rejoice in the conviction that the true genius of Protestantism is now coming to be generally recognized as consisting, not in its opposition to the claims of the Church of Rome to infallible authority, but in its protest against any infallible authority whatever; in its readiness to submit the basis of its religious system to the most searching criticism; in its cordial welcome to every truth of science or criticism which has been accepted by the general voice of those most competent to decide upon its claims; and in the freedom with which it surrenders such parts of its dogmatic systems, as prove to be inconsistent with those great fundamental verities of moral and physical science, whose domination over the educated thought of mankind constitutes the basis on which alone the religion of the future can securely rest. It is not, in my view, by their reassertion, with any amount of positiveness, of doctrines from which the educated thought of the age is drifting away, that the teachers of religion will best combat what they designate as the "prevalent unbelief;" but by showing themselves ready to profit by the lessons of the past, in regard to the futility of all attempts either to check the progress of inquiry or to stifle its results, and by placing themselves in hearty sympathy with the spirit of the present. Of that spirit, the noblest manifestation is to be found in the life of that great man whose departure from among us has drawn forth an expression of reverential sorrow, the universality of which speaks more eloquently than any words of the world-wide influence exerted by his thought. For in Darwin—as has been well said by one who knew him best—the *love of truth* was more than his animating motive, it was the *passion* of his intellectual nature. And its ultimate prevalence—whether including the acceptance or involving the rejection of his own system—was the firmest and most deeply rooted of his convictions.

It is in this spirit that I ask you to follow me through the inquiry which constitutes the purpose of our present meeting.

I need scarcely tell those whom I am addressing that the general idea of Evolution is by no means new. A notion that the universe has not endured for ever in the form and aspect it now presents, has been entertained in all ages, and by all peoples of whose thoughts on the subject we have any record. In the Chaos of the old Greeks we have the type of confusion and disorder; in the void and formless waste of the Hebrews, the attempt to represent a primeval condition which could only be characterized by negations,

> —a dark
> Illimitable ocean, without bound,
> Without dimension, where length, breadth, and height,
> And time and place, are lost.

Out of this Chaos, divine power evoked order and harmony; the void and formless waste was made first to take definite shape in the separation of the firmament from the earth; the great lights were set in the one; the other was first clothed with vegetation, and then peopled with animated forms, beasts of the field, fowls of the air, fish of the sea; and last of all Man was called into existence, and dominion given him over all other creatures. And even those who at the present time regard the Mosaic cosmogony as having an authoritative claim on their acceptance, are bound by it to regard Creation, not as an *immediate* but as a *progressive* act,—a gradual development, not the sudden springing of a complete universe out of nothingness. And this is equally the case whether the "six days," each with its evening and its morning, are received in their literal sense, or are lengthened into indefinite periods of time.

Lucretius and other "atomic" philosophers attempted to give a definite shape to this conception; but it first found really scientific expression in the "Nebular Hypothesis" of modern astronomy, the combined doctrine of Laplace and the elder Herschel. According to this, the original condition of the universe was a diffused "fire-mist" of unequal tenuity; the mutual attractions of whose particles would cause its denser portions to gather round them the rarer matters of the intervening spaces, would draw together the smaller collections thus formed into larger clusters, and would thus "evolve" out of the universally but unequally diffused nebular matter a limited number of separate substantial masses. At the same time, the inequality in the movements of the different parts of the condensing fire-mist would impart rotary motions to the clustering masses, just as whirlpools are formed in water, or whirlwinds in air, by the action of opposing currents; and such rotation would lead to the detachment of the outer parts of the clusters, which would then draw together into planetary masses. These would retain their rotary motion round their original centres, whilst acquiring, in the act of concentration, a rotary motion around centres of their own, and in their turn giving off their outer portions to form satellites.

As regards the stellar universe, this hypothesis mainly rests on the observations of the elder Herschel, which led him to the conviction that beside the nebulæ which the power of his telescope enabled him to resolve into clusters of stars, there are some which are still in the condition of patches of diffused faintly luminous matter, in which the process of condensation has scarcely begun; others smaller but brighter, whose central parts look as if they would soon form into stars; others, again, in which stars had actually begun to form; and finally star-clusters, in which the condensation is complete. Among the nearer stars, again, which he considered to form part of our own particular cluster, he distinguished many which are not clear points of brilliant light, but are surrounded by a more or less extended bright haze, such as would be given out by an atmosphere of nebular matter in a state of progressive condensation. And he pointed to what are known as "variable" stars, as affording evidence that the heavenly bodies are not permanently what they seem to us at any one moment, or within the limited period of our observation of them, but are undergoing progressive changes, the several stages of which are presented to us in the various bodies now visible in the firmament,—just as the several stages of any one human life from infancy to old age are presented by the members of a single community.

Now Laplace did not begin, like Herschel, with the stellar universe; but aimed to give a scientific account of the evolution of the planetary system from the atmosphere of nebular matter, which he, in accordance with Herschel's ideas, supposed to have originally surrounded the sun; and the train of reasoning by which he worked this out on the lines I have already indicated, was one of mechanical deduction from the Newtonian laws of mutual attraction and motion. That these deductions were not only in accordance with the ordinary conditions of the planetary system, but were also applicable to the exceptional cases of the ring of Saturn, and to the intervention of a multitude of asteroids, in the place of a single planet, between Mars and Jupiter, seemed to afford the same kind of confirmation to Laplace's theory, that Herschel's had derived from the different degrees of condensation observable among the celestial bodies. And the wide basis of observation on which the nebular hypothesis of Herschel was erected, commended it to the minds of many who viewed with distrust the reasoning process by which Laplace deduced the solar system from the supposed nebular atmosphere of the sun.

I have never been able to understand why this doctrine should have been the subject of so much theological opposition. It was said to have been framed by Laplace with the express purpose of "doing away with the necessity for a Creator;" but though others may have used it (as many are now using the Darwinian doctrine) as an instrument of attack on Theistic belief, there is no trace, in his own exposition of it, of any but that purely scientific conception of orderly sequence, under the constant and uniform action of physical forces, in which there is assuredly nothing anti-theistic. Let it not be forgotten that Newton, the devoutest man of science that ever lived, was reproached by the theologians of his time for setting up forces of his own invention as a substitute for the power of God; a charge of which every one now sees the absurdity. And yet Laplace merely extended the Newtonian doctrines of force and motion into the past, by showing how, under their continuous operation, a diffused nebulosity would evolve itself into a solar system. Whence came the mutual attraction of its particles, which aggregated them into masses, and gave these masses their movements of rotation, it was not for him—any more than for Newton—to explain. To Laplace it must have been apparent as it is to us, that the whole of this process of evolution implies *a commencement*,—that however far back we go in time, we come to a point at which the mutual attractions must have *begun* to exert themselves,—and that as a universal but *perfectly homogeneous* "fire-mist" (the only condition under which it could have existed from eternity) could not *of itself* have broken up into separate parts, some account has to be given of its *heterogeneousness*, the existence of which has to be assumed as the starting-point of the process. Hence it is obvious that, however remote that point to which we trace in thought the history of our universe, we are still confronted with the impossibility of accounting by physical causation for its commencement; and further, that if we find our only explanation of this commencement in moral causality, we do not exclude the subsequent perpetual agency of Creative Will, because in scientific reasoning we speak of it in the language of physical force. To the clear-seeing theologian, the evolution of an orderly Kosmos, not by a fortuitous concourse of atoms, but by the continuous operation of mutual attractions according to a law of sublime simplicity, should furnish (as it seems to me) the sublimest exemplification of an Infinite Intelligence, working out its vast designs "without variableness or the shadow of turning."

But, it may be objected, the nebular hypothesis of Herschel and Laplace has been disproved by subsequent research. One after another of the nebulæ, which Herschel regarded as consisting of unconsolidated "fire-mist," has been resolved by the superior power of modern telescopes into clusters of stars; and the mathematical reasoning of Laplace has been found not to stand the test of a rigorous scrutiny. This may be freely granted; and yet the general doctrine that the material universe has come into its present condition by a *process* of immense duration, and not by a single creative *act*, has received such a vast amount of support from new and unexpected sources, that I have no hesitation in affirming it to be accepted by all who are most qualified to judge, as having been now placed beyond the reach of discussion. Instead of starting from a hypothetical postulate, modern science reasons *backwards*,—in astronomy as in geology,—from phenomena presenting themselves to our own observation; and I shall briefly notice the *orders of facts* which seem to me of the greatest evidentiary value.

First in importance among these, is the certain distinction which the Spectroscope now enables the astronomer to draw, between the nebulæ which are clusters of stars, and those which consist of glowing gas. To the latter class belongs that great nebula of Orion, which was long considered a sort of "crucial instance" whereon the fate of the nebular hypothesis was to turn. The prolonged and minute study which the late Lord Rosse had made of this nebula, with the unequalled power (for that particular object) of his six-foot reflector, had previously led him to this conclusion; but spectrum-analysis has placed it beyond doubt; and the fact acquires a new importance when the doctrine of the Conservation of Energy is brought to bear upon it. For "a nebulous body, in order to shine by its own light, must be "hot, and must be losing heat through the very radiation by "which we see it. As it cools, it must contract; and this con-"traction cannot cease, until it becomes either a solid body, or a "system of such bodies, revolving round each other" (Newcomb).

Another fact of supreme importance, resting not only on the indications given by the spectroscope, but on chemical analysis of the Meteorites, which have now been ascertained to be planetary bodies revolving in regular orbits round the Sun, but to be deflected from these by the Earth's attraction when we cross their path,—is the *identity in elementary composition*, not only among the bodies included in our solar system, but throughout the innumerable solid and vaporous masses of which the stellar universe is composed. And it is not a little curious that a link between these two orders should be supplied by those wandering bodies—the Comets—of which many seem to belong to both; not properly belonging to our system, but presenting themselves within it as occasional visitors from the celestial spaces. Not only does this identity add immensely to the strength of the presumption as to the identity in physical origin of the entire universe, but it also gives an entirely new meaning to the facts previously determined by astronomy in regard to the relative specific gravities of the Sun and Planets. For whilst the Earth weighs more than five and a half times as much as a globe of water of the same bulk, Mercury rather more in proportion, and Venus and Mars nearly as much, the specific gravity of the Sun is only one-fourth that of the Earth, that of Jupiter a little less, that of Uranus and Neptune only a little above that of water, and that of Saturn so much *below* it, that if his globe were thrown into water it would float like a cork. Now, so long as nothing whatever was known about the chemical composition of the heavenly bodies, it might be not unreasonably surmised that the several planets might be composed of different materials. But now that we have evidence of their identical composition, their differences in density suggest differences in degree of condensation. And this suggestion derives a most remarkable confirmation from the fact, that the *greatest* density shows itself in those *smaller* planetary bodies which would have cooled the most quickly, and which have therefore more or less nearly reached their final stage; whilst the *least* presents itself in the *larger* masses, whose slower loss of heat would retard their condensation. The smallest planetary body of whose constitution we have any knowledge, —the Moon—is the one whose consolidation is most complete; even the gases and vapours which form atmospheres round the Earth, Mars, and Venus, being fixed in its solid substance. And of the relative rapidity of its cooling, we have further evidence of the most convincing nature, in the intensity of the former volcanic activity, which shows itself in the multitude of gigantic extinct craters by which its surface is now made rugged,—that activity having been due (there can be no reasonable doubt) to the rapid contraction of a solidified crust upon a still molten interior. In the ring of Saturn, on the other hand, we have a no less striking exemplification, not only of the mode in which the detachment of the peripheral parts of the planetary masses may be presumed to have given origin to their attendant satellites, but of that earlier stage of condensation which consists in the aggregation of nebular matter into such assemblages of small solid separate masses as form the Meteor-streams with which we are now familiar, and also (there is reason to believe) the trains of Comets. For mathematical investigation has demonstrated that the ring of Saturn, or rather the system of concentric rings, cannot possibly be *solid*,—that it is in the highest degree improbable that it can be *fluid*,—whilst all the conditions of its continuous equilibrium are satisfied by the hypothesis of its consisting of streams of separate small solid masses, revolving as satellites round their primary, which may itself be presumed, from the specific lightness of its mass, to be still in a somewhat similar stage of incipient condensation.

Again, an entirely new series of mathematical investigations is now being followed out, as to the effects at present produced by *tidal* action in retarding the Earth's rotation, and the conclusions that may be justifiably drawn from the backward projection (so to speak) of that retardation, so as to apply it to an earlier stage of the history of our globe and its satellite. And one of its results affords so striking a confirmation of the doctrine that the existing state of things is the resultant of a long sequence of previous continuous change, that I shall ask your special attention to it. Assuming that the Moon was once in a fluid state, the Earth's attraction must have exerted a most powerful tidal influence upon it; and the retarding effect of these lunar tides would gradually diminish the rate of that rotation of the Moon upon her own axis, which theory would lead us to suppose that she must have originally performed. At present, as every one knows, she always turns the same face towards the Earth, in virtue of a rotation on her axis which occupies exactly the same time as her orbital revolution. Now, this phenomenon has been a standing puzzle to astronomers. Of course, it may be said that the Creator, when he set the Moon in the firmamant, ordained that she should for ever turn the same face to the Earth. But no man of scientific habits of thought could rest satisfied with such a notion. The probabilities were many millions to one in favour of some *physical* cause for so singular an effect; and such a cause has recently been discovered by Helmholtz, who has shown that the continuous retardation produced by ancient tides would at last bring the moon into the only attitude it could permanently retain without being subjected to further incessant disturbance.

One more important evidentiary fact I have still to adduce, which forms the connecting link between astronomical and geological evolution, and brings what may be now designated as the scientific certainties of the past history of our own globe, to bear on the history of every other body in the universe. I refer to the determination of the *high internal temperature* of the Earth, which now rests upon so wide a basis of concurrent observations, that no one capable of scientifically appreciating their value any longer entertains the smallest doubt as to the fact. And this fact can only be rationally accounted for, as the result of gradual cooling of the entire mass from a temperature higher than that now possessed by its hottest interior, by the radiation of heat from its surface. For, as Sir William Thomson has tersely remarked, "If "we were to find a hot stone in a field, we could say with entire "certainty that this stone had been in the fire, or some other hot "place, within a limited period of time."

Astronomical Evolution, then, lands us in the idea of a globe of molten matter, over whose surface a crust is beginning to form; and it is at this point that geology takes up the inquiry, and aims to give a consistent history of the long succession of changes which that crust has since undergone—in other words, to trace the "Evolution" of its existing from its primitive condition. Here, again, two distinct lines of inquiry may be pursued. One of these, leading us *onward* in time from the assumed beginning, furnishes us with those great dynamical conceptions, that help us to account alike for the vast movements whose evidence we trace in the elevation of continents and of mountain-chains, and for the local developments of heat which have shown themselves in volcanic action and in the metamorphism of sedimentary rocks; showing these to be the mechanical results of such inequalities of the rate of cooling of different parts of the surface, as may well be conceived to arise from the conditions of the previous condensation. The other, leading us *backward* from the present to the past, brings the various agencies which we know to be at present modifying the earth's surface to bear upon its previous history; enabling us "in the fall of rain and the flow of rivers, in the "bubble of springs and the silence of frost, in the quiet creep of "glaciers and the tumultuous rush of ocean-waves, in the tremor of "the earthquake and the outburst of the volcano, to recognize the "same play of terrestrial forces by which the framework of our "continents has been step by step evolved." (Geikie.)

I cannot suppose any one I am now addressing, to be ignorant of the doctrine as to which modern geologists are now, I believe, in universal accord—that of *continuity* of change (not necessarily of uniformity in its rate) throughout the entire period of the earth's history. The old notion of universal interruptions has given place to that of local changes analogous to those of which we have present experience; that of vast sudden convulsions, to slow progressive elevations or subsidences. The regular succession of stratified deposits, while interrupted in one portion of the earth's surface, is found to be completed in another. And the same proves to be the case in regard to the succession of those organic forms, whose remains are preserved to us in those deposits. For palæontologists have long since been forced, by the "logic of facts," to abandon the idea that in each of the successive "periods" marked out by the earlier stratigraphical geologists, the earth was peopled by a set of plants and animals peculiar to that period—many of these forms being traceable with certainty, in the same spot, from one "formation" to another; whilst, when they disappear in one locality, they may often be found to have migrated to another. And thus, before the introduction of the Darwinian doctrine, the old notion of a succession of entirely new creations of Plants and Animals, to replace the Floras and Faunas which had, one after another, been swept away from the entire surface of the globe, was giving place to the notion of *continuous succession*—certain species dying out from time to time, as they have done even within our own limited experience, and these being replaced by others, of whose origin, however, science could give no account.

Now, putting aside for the moment the question of the origin of new forms of organic life, I would ask you to consider what is the real theological bearing of this general doctrine of continuous evolution, whether astronomical or geological. As I have endeavoured to make clear to you, the very fact of its *beginning* implies a moral cause for that beginning; and the experience we derive from our own sense of effort in producing physical change, justifies us in regarding the action of what we scientifically designate the "physical forces," as the expressions of a continuously acting will. Now, I fearlessly ask, which is the higher theological conception,—that of the progressive unfolding of a plan conceived in the first instance by the Infinite Wisdom whose counsels have not changed because the end has been seen even from the beginning, and of the continuous exertion, with persistent uniformity, of an Almighty Power, which "fainteth not neither is weary," during these countless ages through which we are carried back by our cultured scientific imagination; or the anthropomorphic figment, conceived in the lowest stage of religious development, of an artificer beginning the work of creation (according to Archbishop Usher's chronology) on the 23rd of October, 4004 B.C., proceeding with its successive stages for six days, and then, fatigued with his labours, taking a Sabbath day's rest, during which the newly-created world had to go on as it best could?

Passing, now, from the evolution of the inorganic universe to that of the Organic forms with which our globe is at present peopled, I must content myself with the general statement, that no one who possesses a competent knowledge of the facts brought to light by the ever-widening extension of palæontological research, can do otherwise than admit that they tend strongly and unmistakably in the direction of the doctrine of *continuity*—maintained by "descent with modification"—in opposition to the doctrine of successive creations *de novo*. And this doctrine is found to be in such singular accordance with the converging indications furnished by every department of biological research, that, to almost every unprejudiced mind, its truth seems almost irresistible. Thus the Zoologist and the Botanist, who have been accustomed to classify their multitudinous and diversified types of vegetable and animal life according to their "natural affinities," find a real meaning in their classification, a new significance in their terms of relationship, when these are used to represent what may be regarded with probability as actual community of descent. The Morphologist, who has been accustomed to trace a "unity of type" in each great group, and especially to recognize this in the presence of rudimentary parts which must be entirely useless to the animals that possess them, delights in the new idea that gives a perfect *rationale* of what had previously seemed an inexplicable superfluity. And the Embryologist, who carries back his studies to the earliest phases of development, and follows out the grand law of Von Baer, "from the general to the special," in the evolution of every separate type, finds the extension of that law from the individual to the whole succession of organic life, impart to his soul a feeling of grandeur, like that which the physical philosopher of two hundred years ago must have experienced when he came to recognize the full significance of Newton's law of universal gravitation.

I find myself quite unable to understand why the doctrine of organic evolution should have been stigmatized as atheistic. We have before us the every-day *fact* of the "evolution" of plants and animals of every type from germ-particles of a common simplicity; and, scientifically speaking, we must assign to each of these germs a determinate capacity for a particular mode of development, in virtue of which one evolves itself under certain conditions into a zoophyte, and another (not originally distinguishable from it) into a man. But if we do not, in so describing the process, set aside the Creator—any more than in scientifically describing the self-formation of a crystal—why should we be charged with doing so, if we attribute to the *primordial* germ that capacity for a particular *course of development*, in virtue of which it has evolved the whole succession of forms that has ultimately proceeded from it,—these forms constantly becoming more complex in organization and more elevated in the scale of being? Attach what weight we may to the *physical* causes which have brought about this evolution, I cannot see how it is possible to conceive of any but a moral cause for the endowments that made the primordial germ susceptible of their action. And of a *beginning*, we have even clearer evidence in the organic than in the inorganic world; since it may be accounted as certain that there could have been no *life* upon our globe, until its surface had so far cooled down that water could remain as a liquid in its depressions. And in the so-called *laws* of organic evolution, I see nothing but the orderly and continuous working-out of the original intelligent design.

There are some, however, who feel no difficulty in accepting the doctrine of evolution as regards the animal and vegetable creation generally, but nevertheless cannot bring themselves to believe that it is equally applicable to Man; whose place in Nature, it is contended, is *psychically* so far above that of the creatures which most nearly approach him *physically*, as to justify his being placed on a different platform. Now, I recognize to its fullest extent the weight of this objection; for whilst freely admitting (as the result of my own life-long study of comparative psychology) the possession, by many among the higher animals, of reasoning powers and moral attributes which are of the same *kind* as those of Man, however much below his in *degree*, I hold firmly to the conviction that Man, in his condition of fullest development, is essentially distinguished from them all, *first*, by his possession of a *self-directing power*, and *second*, by his *capacity for unlimited progress*. "The soul," says Francis Newman, "is that part of "our nature which is in relation with the Infinite;" and I do not know what better definition could be given of it. And I should regard the possession of this "soul" as fully justifying the exemption claimed for Man, if it could be shown to be something distinctly added on, at any given moment of his existence, to his previous capacities. The very contrary, however is the fact, as I hope now to satisfy you.

Every human infant born into the world, began its existence nine months previously in the condition of a "jelly-speck," not to be distinguished by any recognizable characters from what we may suppose to have been the primordial germ of the animal world in general. This first evolves itself into an aggregate of cells, corresponding with that which represents a higher stage of Protozoic life; and long before it shows any trace of the Vertebrate type of organization, this aggregate shapes itself into a *gastrula* or primitive stomach—the common possession, at this stage, of all animals that rise above the protozoic condition, which is permanently represented in the Zoophyte. It is in a certain spot of the wall of this gastrula, that the foundation is laid, in all vertebrate embryos, of that which is to become the brain and spinal cord, with its bony investment; and this "primitive trace" of what is to constitute the essential part of the human organism, does not differ in any essential particular from that of a fish, a frog, a bird, or any ordinary Mammal. So, the early development of the circulating and respiratory apparatuses proceeds upon a plan common to all Vertebrates; even the early Human embryo possessing the gill-arches which are to sprout into gills in fishes and amphibia, though they afterwards disappear in Man (as in reptiles, birds, and mammals) with the development of the lungs and the diversion of the blood-circulation into them. When, in the progress of development, the distinctively Mammalian type comes to present itself, there is still nothing distinctive of Man; in fact, the general configuration of the body is shaped out, and most of the principal organs have shown their characteristic structure, before the embryo presents any feature by which it could be certainly distinguished as *human*. And I may specially notice the fact that the *cerebrum*, whose great size and complexity of structure constitute man's most important differential character, is evolved as a sort of offset from the chain of sense-ganglia, which is the real basis of the brain in all vertebrates, and continues to represent it in insects; that it at first presents the small relative size and simple organization which we find permanently retained in the kangaroo or rabbit; that, as embryonic life advances, it comes more to resemble the brain of a dog or cat, and then that of a monkey—the distinctly Human type manifesting itself last. This is marked, not only in the backward as well as forward extension of the cerebral hemispheres, but in the number and depth of the convolutions which extend the surface of their outer ganglionic layer, and bring it into closer relation with the capillary blood-vessels, on whose supply of oxygenated blood its whole subsequent activity is dependent.

Now, I cannot suppose any one of you to be ignorant of the fact, that the Human infant at its entrance into the world is *de facto* a mere automaton—its life-movements for some time being of a purely "reflex" character, such as may be carried on without even any exercise of consciousness. And for long after the child has begun to receive and register sensory impressions, has learned to understand articulate speech, and is acquiring knowledge of *ideas* as well as of objects of sense, any parent who attentively compares its psychical manifestations with those of an intelligent dog will recognize the close correspondence between them. The uncontrolled dominance of impulses to action shows itself in both alike; and in the training of one, as of the other, we have to make our appeal to the strongest motive. But the time comes when we can fix the attention of the Human child on the motive which he knows *ought* to prevail; and in proportion as he acquires, by habitual effort, the power of regulating the exercise of his intellectual powers, and of controlling the action of his moral and emotional forces, in that proportion does he become responsible for his conduct, and capable of further self-elevation.

Thus, then, it is *a simple matter of fact*, revealed by continuous observation of the history of the Human individual, that the very highest grade of humanity is only attained by a process of *continuous evolution* from the very lowest and simplest. For while his *bodily* evolution takes place in accordance with the plan common to the whole animal creation, the same is equally true of his *psychical.* The infantile condition is the same in all races of mankind, and child-nature presents itself everywhere under an aspect essentially the same; but whilst in some races an arrest of development causes that nature to be retained through the whole of life, others present an ascending series of stages, that culminate in what we regard as the highest products of mental and moral culture. But even among the races which as a whole are most advanced, we find not individuals only, but grievously large numbers, in whom a bad heredity and depraved surroundings have tended to foster the lower animal nature at the expense of that which is distinctively human; and thus to rear a set of creatures which are morally far nearer akin to the brute, than they are to more elevated types of humanity. In these degraded outcasts we have the true types of *fallen* man; but it is now coming to be generally recognized by scientific men, that the early history of the race generally, as now revealed by the study of its primeval conditions, has been one of *upward* progress; and that the time required to bring it up to the capacity for recording its doings, even by picture-writing, must be measured by thousands—not of years—but of centuries.

If, then, we have to trace back *our own* ancestry to a primeval type now represented by races whose limited capacity makes them incapable of receiving any culture much higher than their own (save through an education prolonged through many generations), why should we shrink from attributing to these last the ancestry to which *their* bodily and mental organization distinctly points? And why should we assume, in the case of Man, a special *creative* exertion of Divine power, when everything points to a *continuity of the same original plan of action*, that has previously manifested itself in the progressive evolution of the highest mammal from the primordial jelly-speck?

To myself the conception of a continuity of action which required no departure to meet special contingencies, because the plan was all-perfect in the beginning, is a far higher and nobler one than that of a succession of interruptions, such as would be involved in the creation *de novo* of the vast series of new types which Palæontological study is daily bringing to our knowledge. And in describing the process of evolution in the ordinary language of science, as due to "secondary causes," we no more dispense with a First Cause, than we do when we speak of those physical forces, which, from the Theistic point of view, are so many diverse modes of manifestation of one and the same power. Nor do we in the least set aside the idea of an original design, when we regard these adaptations which are commonly attributed to special exertions of contriving power and wisdom, as the outcome of an all-comprehensive Intelligence which foresaw that the product would be "good," before calling into existence the germ from which it would be evolved. We simply, to use the language of Whewell, "transfer the notion of design and end from the region of facts to that of laws," that is, from the particular cases to the general plan: and find ourselves aided in our conception of the infinity of Creative Wisdom and Power, when we regard it as exerted in a manner which shows that not only the peopling of the globe with the plants and animals suited to every phase of its physical conditions, but the final production of Man himself—the heir of all preceding ages, with capacities that enable him to become but "a little lower than the angels"—was comprehended in the original scheme.

And, lastly, I would point out that the doctrine of evolution presents its greatest attractiveness, when viewed, not merely in its scientific aspect, as the highest form of the intellectual interpretation of nature, but in its moral bearings—as one which leads Man ever onwards and upwards, and encourages his brightest anticipations of the ultimate triumph of truth over error, of knowledge over ignorance, of right over wrong, of good over evil,—thus claiming the earnest advocacy of every one who accepts it as scientifically true. And it is under this conviction that I have now brought the subject before you; in the hope of, at any rate, weakening what I cannot but regard as the prejudices of some, and strengthening in others that disposition to regard it favourably, which its cordial acceptance by many of the ablest leaders of religious thought may have already engendered.

XV.

THE ARGUMENT FROM DESIGN IN THE ORGANIC WORLD,

Reconsidered in its Relation to the Doctrines of Evolution and Natural Selection.*

[*The Modern Review*, October, 1884.]

The request which has been courteously presented to me on your behalf, that I should address you on a subject on which scientific thought is at present much exercised, and which has a direct and important bearing on theological inquiry, gives me an opportunity of which I am very glad to avail myself, of setting forth the results of the careful and, I hope, candid reconsideration of the old Theistic "Argument from Design in the Organic World," which has been continually before my mind from the time when the publication of Mr. Darwin's "Origin of Species by Natural Selection" brought its validity seriously into question.

You are all familiar with the frequently repeated remark, that whenever science and theology have come into conflict, theology has had to "go to the wall." And there are probably several among you whose faith in the old "argument from design" has been more or less seriously shaken by the confident assertions of men of high scientific distinction, that the last victory which science has gained over theology has been its greatest,—consisting in nothing less than the complete subversion of the whole doctrine of final causes. For, as they affirm, the adaptation of means to end which is recognizable in the structure of plants and

* An address delivered to the London Ministers' Conference at Dr. Williams's Library, June 6th, 1884.

animals, can now be so fully accounted for by natural agencies, as to afford no evidence whatever of an originating intention, a creative purpose.

Now if I regarded this claim as scientifically valid, I should unhesitatingly counsel you to abandon your former position without any attempt to defend it. For if we look back at the results of former conflicts, we see that nothing has been more injurious to theology than the persistence of theologians in antiquated error. We of the present time can only wonder at the obstinacy with which the self-styled "orthodox" have clung to the idea that the world with its living inhabitants was created in six successive days of the year 4004 B.C., the Creator resting from his labours on the seventh; that our own terrestrial globe is the fixed centre of the universe—sun and moon, stars and planets, revolving around it every twenty-four hours; that not more than 6000 years have elapsed since man was first called into being; and that the Noachian Deluge extended over the whole globe and destroyed all the animals then living on its surface, except the few pairs that found a refuge in the ark. As each of these positions has been successively impugned by scientific research, theologians have raised the cry that the foundations of Christianity were being undermined; and yet they have now, tacitly if not openly, agreed to abandon them all, as ancient traditions altogether destitute of historical value. That theology has gained and not lost by this abandonment, I do not suppose that any one now doubts; the lamp of truth must always shine brighter, when no longer darkened by the mists of error. But theologians have not come out unharmed from the conflict; for they have given their opponents a right to charge them with either a wilful blindness to scientific truth, or an intellectual incapacity to recognize it; and this lesson should not be lost upon us of the present time.

I cannot doubt that all whom I am now addressing agree with me in the conviction that Theology can only maintain its ground in the future, by placing itself in accord with the highest scientific thought of the time,—by readily accepting all that science reveals to us in regard to the Order of Nature,—and by rigorously abstaining from all attempts to fetter or discourage its advance. Such has ever been the teaching of one to whom we all look as the best exponent of liberal theology, and the influence of whose writings is more and more advancing its progress. Whilst strenuously defending the Theistic position against its scientific as well as its non-scientific assailants, Dr. Martineau has ever cordially welcomed every real advance in science, not merely as extending our knowledge of the material universe, but as leading us to a more thorough recognition of its unity, its order, and its harmony. And he has shown us how, by availing itself of the highest and best results of scientific investigation, Theology is expanding and elevating itself above the narrow limits of Mosaic anthropomorphism, so as to reveal to us the Divine Thought as pervading all space, and exerting itself in action through all time.

It was in this spirit that, two years ago, I reviewed, before a different but kindred audience,* the bearing upon Theistic belief of that doctrine of the progressive evolution of the inorganic universe, which modern astronomical research, by the help of methods of observation altogether new, has now established beyond reasonable question. For, I maintained, if ever the entire succession of changes by which the consolidation of the original nebular matter into the multitude of suns and systems that have sprung out of it, shall be scientifically shown to be the work of physical forces acting in accordance with determinate laws, we shall have only arrived at a knowledge of the Order of Creation, and shall have advanced no nearer to that of its primal Cause. The physicist who deduces from the activities of different forms of matter certain "properties" which he attributes to them, and then uses these very "properties" to account for those activities, is obviously reasoning in a circle. What he calls "properties" and "laws" are really but *forms* or *categories* under which he finds it desirable to correlate those "uniformities of coexistence and sequence" which his observation of nature brings under his cognizance. "Why does an apple fall to the ground?" is a question which has as great a significance to us now, as it had before Newton was led by pondering upon it to the discovery of the law of gravitation. For that law only expresses the *conditions of action* of a universal force tending to draw together all masses of

* "The Doctrine of Evolution in its Relations to Theism,"—an address delivered at Sion College, see p. 384.

matter ; while of the *force* itself it gives no account whatever. We recognize it by our own consciousness of effort in lifting a weight from the ground ; and this recognition carries us from the sphere of physical into that of moral causation. For, as Sir John Herschel long ago pointed out, our consciousness of direct personal causation in the performance of a voluntary act, leads us to regard what we call the "Forces of Nature" as the emanations of an all-pervading will, and those uniformities in their action which we term her "laws" as the manifestations of its unchanging continuity. As Dr. Martineau has admirably expressed it, "In whatever sense, and on whatever grounds, we affirm the "tenancy of our own frame by the soul that governs it, must we "fill the universe with the ever-living Spirit of whose thought it is "the development." The very conception of evolution involves a beginning ; and for that beginning, which *de facto* excludes all antecedent physical agency (otherwise it would not be a real *beginning*), none but a moral cause can be assigned. And thus the continuous uniformity in the evolutionary process, which some have regarded as *explained* by the laws that merely *express* it, really testifies to the perfection of the original design, the progressive unfolding of which has never needed a departure from it.

I have never met with a valid reason for regarding the relation of the evolution-doctrine to the organic world, as in any respect different from that in which it stands to the physical universe. All the elders among us were brought up in that anthropomorphic conception of "special creations," which seemed natural to the childhood of our race, just as it does to the child-mind of the present day. And to the older geologists, who regarded the successive geological "periods" as marked off, one from another, by cataclysmic interruptions that involved the destruction of all the existing races of plants and animals, a similar introduction of fresh forms, to re-people the newly modelled globe after each cataclysm, seemed quite as conceivable as the original creation. But all geological and palæontological inquiry has of late so decidedly tended towards the substitution of the idea of slow continuous change for that of violent convulsionary disturbances, that when Mr. Darwin showed that a doctrine of continuous "descent with modification" might be built upon a really scientific basis, it gained a much more ready reception among unprejudiced thinkers than he had himself ventured to expect. Many of us had been already prepared to entertain it favourably by the plausible and in some respects forcible manner in which a similar doctrine had been previously presented in the "Vestiges of Creation;" in reviewing which book, nearly forty years ago, I expressed myself as fully concurring with its author in regarding the idea of a *continuous ascending succession*, along which the various races of plants and animals of the past and present epochs, each of them adapted to its external conditions of existence, have come into existence according to "laws" of genetic descent, as a far higher expression of Creative Wisdom and Power than that of special creations devised to meet each exigency as it arose.

Considered from this point of view, the Darwinian doctrine of "evolution," even when based on "natural selection," seems to me to have no other bearing. For it is simply a concise expression of what is maintained to have been an orderly and continuous succession of phenomena, referable to natural causes; and no more *excludes* the idea of moral agency, than does the substitution of the idea of the continuous evolution of the inorganic universe for that of the creation of that universe in its present form. In the pursuit of biological as of physical science, I most fully recognize the essential importance of keeping clear of what are termed "final causes," or assumptions of purpose, and of rigorously limiting our study to "physical causation." But the question now before us,—whether the evidences of intelligent design, which theology has hitherto recognized in the structure of organized beings, are or are not any longer tenable, when viewed under the new light thrown upon them by the Darwinian lamp, is one which—though science has much to say upon it—it is beyond the province of science to decide. Newton and Laplace were both accused of atheism by their contemporaries for setting up their own conceptions in the place of the action of the Creator; and you well know that the same charge has been brought against Darwin. I shall endeavour to show you that in his case, as in that of his great predecessors, the real result of his scientific work has been to effect for biology what they are well said by Dr. Whewell to have effected for astronomy—the "transfer "of the notion of design and end from the region of facts to that "of laws."

For the thorough consideration of this question, I think it very important that we should start with a clear conception of what the "Argument from Design" really means, and with a right appreciation of the probative value of the evidence on which it rests; and these will therefore be the subjects to which I shall first direct your attention.

It is a mere truism to assert that design implies a designer; because the definition of design is "the intentional adaptation "of means to a preconceived end." We do not perform any voluntary motion without a preconception of the action we "will" to perform. It is this preconception of result that constitutes the foundation of the effort made to carry it out. I may determine the action itself; as when I 'will' to bend my fore-arm on my arm. Or I may 'will' to do something—as to lift a book from the table, or to carry a spoon to my mouth—which requires this flexion to carry my purpose into effect. But no action, in which there is not such a preconception, is "intentional" or "voluntary." We are constantly using the word "design" in this sense. An architect "designs" a building; a ship-builder "designs" a ship; an artist "designs" a picture, and so on. In all such works, we unhesitatingly recognize an intentional adaptation of means to a preconceived end (though the designer and his purpose may be alike unknown to us), from our personal experience of other cases more or less familiar.

But we have now to deal with cases in which we have had no such experience; and to consider the grounds on which, in any individual instance, we should feel justified in concluding that an obvious *adaptiveness* has been "intentional," or, in other words, that the object has been "designed" for the use which we find it to answer. I do not affirm that we can in any case obtain logical or demonstrative *proof* of such "designed" adaptation; but I think I can make it clear that this is one of the numerous instances in which a *convergence of separate probabilities* acquires the probative value of a *moral certainty*.

What we call "demonstration" rests entirely upon our mental inability to accept as true anything that contravenes the thing affirmed; and if, in a chain of demonstrative reasoning, every link has the strength of a necessary truth, we accept its conclusion as having the same validity as the *datum* from which it started. Now, I hold that exactly the same state of "conviction" may be produced by a concurrence of probabilities, if these point separately and independently to the same conclusion,—like radial lines that converge from different parts of the circumference of a circle, though none actually reach its centre. For the result of that concurrence may be as irresistibly probative as any demonstration; the conclusion to which they all point being one which we are compelled to accept by our inability to conceive of any other explanation of the *whole aggregate* of evidentiary facts, though any one of them may be otherwise accounted for. I am not aware that this principle has been discussed in any treatise on logic; but it is familiar to every lawyer who practises in courts of justice; and its validity cannot, I think, be questioned by any one who has studied the theory of what is commonly called "circumstantial" evidence. Indeed, it would be difficult to adduce a more remarkable example of the stability of an argument erected on a broad basis of independent probabilities, than is presented in the wonderful fabric built up by the genius of Darwin; the general acceptance of the evolution-doctrine resting on exactly the same kind of evidence as that on which I base the argument from design. The most pronounced evolutionist may be challenged to produce anything like a "demonstration" of any one of his propositions. But (as I showed in my Sion College address) the concurrence of probabilities supplied by morphology and embryology, by physiology and palæontology, is so complete as, in the minds of those most competent to appreciate their probative value, to exclude any other hypothesis. Those, therefore, who find in this concurrence a sufficient reason for their assent to the doctrine of evolution, should be the last to impugn the validity of the same mode of reasoning, when brought to bear on the evidences of design which are afforded by the very orderliness of that evolution.

In applying this principle to the question we are now considering, I am quite willing to admit, *in limine*, that the mere adaptiveness of a thing to a particular purpose, is often a very unsafe ground for concluding that it was devised for that purpose. For cases are constantly occurring, in which we find ourselves able to turn some instrument to a use altogether different from that for which it was intended by its maker; and every one who has had much experience of changes of residence (as happened to myself in early life), has found pieces of his furniture fitting into appropriate recesses just as exactly "as if they had been made for them." But I rest my argument on cases in which the idea of such *casual* adaptiveness is altogether excluded by the *accumulation* of separate and independent evidentiary facts, all indicative of the same purpose; and I shall further show you that it is not invalidated (as Professor Huxley has maintained it to be) by a possible misapprehension of that purpose; the evidence of a "design" being the same, even though we may be mistaken as to what that design was.

Necessarily limiting myself to two typical illustrations, I shall select one of a very simple nature, in which conviction is produced by the accumulation of *similar* evidentiary probabilities, each of which—taken individually—is of the slightest character and the lowest value, their probative force depending entirely on their collocation; whilst in the other I shall show that our conviction rests on the elaborate character of the constructive arrangements by which a small number of separate but *dissimilar* adaptations are so combined as to work out a single product.

About thirty years ago we began to hear a good deal about "flint implements." They had not been altogether unknown previously, as specimens of them were to be found in museums of antiquities; but they had never been brought to light in such numbers, and under such very peculiar circumstances, as in the working of the gravel beds of the valley of the Somme, near Abbeville and Amiens. The matter was brought into notice by M. Boucher de Perthes, a distinguished antiquarian and collector at Abbeville. English men of science went over to study the conditions under which these flint implements were found; and very soon satisfied themselves of the genuineness and importance of this discovery. There were many who at first denied that they afforded any evidence of the existence of man at the time when these gravel-beds were deposited; maintaining that their peculiar shapes had been given by accidental collisions. I do not know that any sane man now questions their human production; and I ask you to follow me in the examination of the evidence which has wrought that universal conviction. We are all familiar with the opening passage of Paley's "Natural Theology:"—"In crossing "a heath, suppose I pitched my foot against a *stone*, and were "asked how the stone came to be there, I might possibly answer "that, for anything I knew to the contrary, it had lain there for "ever: nor would it perhaps be very easy to show the absurdity "of this answer. But suppose I had found a *watch* upon the "ground, and it should be inquired how the watch happened to "be in that place, I should hardly think of the answer which I "had before given—that, for anything I knew, the watch might "have always been there" Now, if you were to "pitch your foot" against one of these *flint implements*, you would find it very difficult to account for its condition by any hypothesis of accidental configuration. Flints are found, in considerable numbers, wherever there has been a great denudation of the chalk; those originally embedded in it having been left on the surface of the ground. You will generally find them whole, but not unfrequently they have undergone fracture. If, in walking through a chalk country, you look at a heap of flints collected by the roadside for mending the road, you will find the greater part of them entire, having shapes that suggest to the naturalist the forms of the sponges, by the silicification of which they were originally produced. You will doubtless find some broken; but you will never meet with one that even remotely resembles the characteristic "flint implement" of the Amiens and Abbeville gravels. They may have one or two, or perhaps half a dozen, fractured surfaces; but these are quite irregular, having no relation one to another. Now, a "flint implement" exhibits, perhaps, fifty fractures; and they are all so related in size and position as to bring out a very definite shape. Yet this consideration alone did not by any means satisfy those who were unwilling to admit the conclusion that this shape had been worked out by human hands. I well remember that when these objects were first brought into public notice, there were many persons who said, "The shaping of these flints is merely accidental; the flint fell "into a river in which there were many stones knocking about, "and the fractures have been produced by the flint having got, "so to speak, under a number of hammers; so that, a bit having "been broken away here and a bit there, it has come to be shaped "as it is now found." I will not say that this is an absolutely impossible supposition with respect to any single example; but when we find numbers of these flints, all showing the same form, in one gravel bed,—when we meet with forms exactly similar in other gravel beds—and when we learn that exactly similar flints are used at the present time by peoples (some of the hill tribes of India, for instance) among whom iron implements have not yet found their way, the implements being held in a cleft stick, and bound round by a leather thong,—then, I think, we have an accumulation of evidence which makes it inconceivable that these gravel flints, of which I have spoken, owed their shape to anything else than human handiwork. But besides these large and powerful implements, there are also a number of other kinds. Some of these, though smaller, are of the same general shape, each showing a similar series of regularly disposed fractures. But there are also found, in the same beds and in the same numbers, smaller "flakes" of flint, whose shapes might more easily be supposed to have been accidentally acquired, for many of them exhibit only two fractured surfaces, indicative of two knocks; so that it would be by no means inconceivable that any single flake had been casually struck off by a second blow from a flint which had already sustained a fracture nearly in the same direction. But when we look at a number of these found together, and when we know that similar flakes are used as cutting instruments at the present time by some of the survivors of the old "flint folk" (being often retained for sacrificial purposes, long after the use of metallic cutting instruments has become general), then we come to feel sure that even these small flakes must have been struck off *with a purpose.*

Such is the *cumulative* argument that I would draw from a consideration of this case. Even if we admit it as conceivable that any single flint implement, or a small number of implements, might have derived their regular shape from a number of accidental blows, and that the people who now use such instruments might have adopted and turned to account such as thus came to their hands ready made, I hold it impossible for any one who brings an unprejudiced mind to the examination of a sufficiently large collection of them, brought from localities widely remote from each other, to come to any other conclusion than that they have been shaped by human handiwork.

I might carry this argument from the "palæolithic" to the "neolithic" forms; in the latter of which smooth surfaces and sharp continuous edges have been given by friction on other stones. It is true that every pebble of a shingle beach exhibits the result of similar attrition against other pebbles, in the shaping and smoothing of its surface; but any one who should maintain that a characteristic flint implement of the neolithic kind could have got its shape and polish from any such casual milling, would be accounted destitute of common sense.

Now, although we can assign a use for each kind of implement, it does not at all follow that such was the use for which it was designed by its maker; but the argument that it *had* a maker, and that he designed it for *some* purpose, is not in the least weakened by this uncertainty. And I shall hereafter show that we are justified by exactly the same kind of evidence, in distinguishing the variations in organized structures, which persistently take place in definite directions, and culminate in the evolution of a more elevated type, from those "aimless" variations which correspond to the accidental fractures of flints.

From one of the earliest products of human ingenuity I now pass to one of the latest—the Walter printing-press, which I first saw in operation in the Great Exhibition of 1862, and which embodies one of the most marvellous combinations of different actions, all related to one and the same end, that I have ever seen in any single machine. In fact, it more impressed me with its resemblance to an *organized structure*, than any other piece of mechanism that I am acquainted with. If you were to join on to the Walter printing-press the paper-making machine, which is worked separately for convenience merely, you might put in paper-pulp in one end, and this would come out at the other end as printed *Times* newspapers, at the rate of 15,000 per hour, without any human intervention. For the paper-making machine is now so perfected, that a continuous sheet can be produced of any length desired. Rolls three miles long are brought to the *Times* printing-office, and put into the machine: the paper, as it is unrolled, is damped through by passing over a hollow roller pierced with multitudes of small holes, through which water is ejected from the inside; and the superfluous moisture is then squeezed out by passing the paper between another pair of rollers, so that it is prepared to receive the impression. Then there are a number of most elaborate and beautiful contrivances, by which for the flat "form" of the ordinary printing-press is substituted a stereotype plate, wrapping completely round a cylinder, the continuous revolution of which at a very rapid rate impresses the paper that is made to pass over it. When the compositor has finished setting up his type, and the proof has been taken, read, and corrected, so that the "form" can be "made up," an impression of it is taken off on a sheet of damp *papier maché;* and this, having been bent round the interior of a hollow cylinder and rapidly dried, serves as the mould from which a cast is made in type-metal, exactly representing on a cylindrical surface the flat type-surface of the "form." This cast, after being examined for defects, which are rapidly repaired, is fitted on the printing-cylinder; which is thus made ready, in a wonderfully short space of time, for impressing the paper which is to pass over it, with the "matter" of which the original "form" was composed. As the paper has to be printed on both sides, two such cylinders are needed; and the sheet, having been printed on one side by passing over the first, is printed on the other by being conducted over the second. Another set of beautiful and yet simple contrivances is provided for distributing the ink with the most perfect uniformity, and for preventing any accidental deficiency, such as might be produced by an air-bubble, from leaving a blank on the type. After having passed over both cylinders, the continuous roll passes through a cutting-machine, which cuts off the sheets one after another at the proper length; and these fall from above to one and the other alternately of two boys who receive the sheets and lay them in two piles.

Now, could any one who should see such a machine in operation, doubt that every part of it had been constructed with a view to a preconceived purpose, whatever he might suppose that purpose to be? An illiterate savage who knows nothing about the meaning of *Times* newspapers, would none the less (if he had a capacity for reasoning upon the matter at all) recognize an intelligent purpose in the construction of the machine. But it is by him who knows something of the difficulties which baffled all previous attempts at printing from a continuously revolving cylinder, and can thus appreciate the beautiful simplicity of the method by which these have been overcome, and by which the machine has been brought to its present perfection, that the greatest admiration will be felt for the ability with which so many separate and dissimilar arrangements have been brought into consentaneous and mutually related action, so as to concur towards a common result, which the machine would altogether fail to work out, if any one of its processes were to suffer derangement.

Now, in the first of these cases we have a very close parallel to those forms of Vegetable and Animal life, which are characterized by the Biologist as of "low organization;" by which is meant that there is comparatively little differentiation in the structure of their several parts, which are often repeated almost without limit, performing actions identically the same. And yet in these, as in the collocation of the individual fractures which have shaped out a flint implement, we see evidence of a *plan*, in the orderly arrangement of these parts, and in the adaptiveness of their combined action to the well-being of the organism as a whole. Look, for example, at a sea-anemone in the act of feeding; and see how its multiple tentacles attach themselves to a piece of fish, or to the shell of a mussel or periwinkle, and draw it by their united contraction into the creature's stomach. The adaptation is not less perfect, because the action is so simple; nothing could be conceived more suitable to the conditions under which the sea-anemone lives; and the multiplication of *similar* parts, so disposed as to enable them to work together to a common end, seems to me as clear an evidence of "designed" adaptation in the sea-anemone, as it is admitted to be in the "flint implement." But, as we ascend the scale of animal life, we find this repetition of similar parts giving place to differentiation, alike in structure and in action; and in proportion as each kind of functional activity becomes limited to a particular organ, does the mutual dependence of the several parts of the organism necessarily become more intimate. With this functional limitation we commonly find an increasing complexity of structure, which enables the function to be more effectively performed; and thus the body of any "highly organized" animal consists of a number of *dissimilar* organs, each —like the several parts of the Walter press—doing its own proper work, but thereby contributing, at the same time, to maintain the activity of the rest.

It has been on this marked adaptiveness of particular organs to the kinds of action they respectively perform, that the "argument from design" has been commonly based; and no case of this adaptation has been more frequently dwelt upon, as showing in its perfection the most obvious and convincing evidence of "design" than the human eye. The perfection of this adaptation, however, has been partially denied by several modern writers, who have based their denial on a statement contained in a most interesting and instructive lecture on "The Eye and Vision," given some years ago by my very distinguished friend, Professor Helmholtz.* The first part of this lecture is devoted to an exposition of the structure and actions of the eye, considered merely as an optical instrument, and of those more recent researches, which have shown that, in addition to retinal defects previously known, the eye is not perfectly corrected for either spherical or chromatic aberration, that the crystalline lens has by no means the perfect clearness it has been supposed to possess, and that its fibrous structure produces an irregular radiation in the image of any single bright point. "Now, it is not too much to say," continues the lecturer, "that if an optician wanted to sell me an "instrument which had all these defects, I should think myself "quite justified in blaming his carelessness in the strongest terms, "and giving him back his instrument." †

Every one who has any knowledge of theological controversy, will recollect how frequently the charge has been justly raised of

* "Popular Lectures on Scientific Subjects." Translated by Dr. Atkinson, London, 1873.

† Ibid., p. 219.

unfairness of quotation ; a single passage, detached from its context, often conveying a meaning altogether different from that which it bears when taken with its context, so that even "the "devil can cite Scripture for his purpose." Those who take the anti-theological side are specially bound, as it seems to me, to abstain from doing the very thing for which they would severely blame their opponents ; and yet I have seldom met with a case so unfair, as the citation of this statement without any of the qualifications which it subsequently receives. Thus, after showing that these defects scarcely reveal themselves in our ordinary vision—some of them requiring most refined methods of observation for their detection—Professor Helmholtz continues : "If I "am asked why I have spent so much time in explaining the imper-"fection of the eye, I answer, as I said at first, that I have not done "so in order to depreciate the performances of this wonderful "organ, or to diminish our admiration of its construction. It was "my object to make my readers understand, at the outset of our "inquiry, that it is not any mechanical perfection of the organs "of our senses which secures for us such wonderfully true and "exact impressions of the outer world. The extraordinary value "of the eye depends on the way in which we use it : its perfection "is practical, not absolute, consisting not in the avoidance of every "error, but in the fact that all its defects do not prevent its render-"ing us the most important and varied services." This "practical "perfection" he afterwards defines as "adaptation to the wants of "the organism ;" the defects of the eye as an optical instrument being "all so counteracted, that the inexactness of the image which "results from their presence very little exceeds, under ordinary "conditions of illumination, the limits which are set to the delicacy "of sensation by the dimensions of the retinal cones." *

An optical defect which has long been known to ophthalmologists, — the inferiority in the sensitiveness of the retinal surface generally, to that of the central spot known as the *macula lutea*,— is shown by Professor Helmholtz to be fully compensated by the facility and rapidity with which we move the eye, in such a manner as to bring the image of the object, or of any part of the object, which we wish to examine minutely, upon this sensitive spot ;

* "Popular Lectures," p. 226.

whilst the field over which our vision ranges with sufficient distinctness to see our special object in combination with its surroundings, is far larger than is attainable in any optical instrument of human contrivance.

I venture to think, moreover, that my special experience as a microscopist has given me the means of adding something to Professor Helmholtz's demonstration of the practical efficiency of the eye.

Until recently, it has not been found possible by the most skilful constructors of the microscope to produce object-glasses of high power and wide angular aperture, which should be perfectly free from both *spherical* and *chromatic* aberration. This, however, has recently been accomplished by what is called the "oil-immersion" system; but the correction can only be perfectly made for a certain relative position of the conjugate foci;—that is, when the object is at the precise distance in front of the lens, and its image is formed at the precise distance behind it, for which it is adjusted by the maker. Hence, the principal continental constructor of these lenses, Zeiss, of Jena, makes two forms of each power: one for the short 8-inch body of the microscopes generally used on the Continent, and one for the long 10-inch English body. Neither of such object-glasses will work perfectly with a microscope of the other length. For, in order that its image may be projected at ten inches' distance, the object must be brought nearer to the objective than when its image is formed at eight inches' distance; and this diminution will sensibly disturb the performance, on the English microscope, of the combination which was perfectly corrected for the Continental microscope; whilst a disturbance in the opposite direction will be produced by the increase of distance between the object and the objective, which becomes necessary when an objective corrected for the long English body is used with a short Continental microscope. These disturbances will alike affect the chromatic and the spherical aberration; and there is no known method by which they can be prevented. In fact, I believe I may say that it is demonstrable that no combination *could* be constructed, which should give perfectly aplanatic and achromatic images at different focal distances.

Mark, now, the superiority of the eye. In its normal condition, this wonderful organ possesses a power to which no optical instrument of human construction can show the remotest parallelism,—that of *adjusting itself* to differences of focal distance. Thus, if I close one eye, and hold up my finger between my other eye and the clock at the far end of the room, I cannot see both of them distinctly at the same time, because, as they are at different distances from my eye, their pictures on my retina cannot both be distinct. But, without moving either my head or my eye, I can so "focus" my eye on either as to see *it* distinctly, the *other* becoming hazy. This we all constantly do without the least knowledge of the mechanism by which it is effected : and all that the most careful and refined investigation has revealed to the Physiologist, is that the focal adjustment is made by a change in the curvature of the crystalline lens ; its curvature being increased when the rays that fall upon it are *more* divergent, because proceeding from a nearer object ; and being diminished when the rays, proceeding from a more distant object, are *less* divergent ;—so as in each case to bring them to a focus on the retina. This change of curvature is produced, it is believed, by the action of the ciliary muscle which surrounds the lens ; but *how* that action is called forth we do not know. Indeed, we are quite unconscious that we are putting it into contraction. I simply determine, "I "will look at the clock," or, "I will look at my finger," and my eye adjusts itself accordingly. If, on the other hand, I were to look with a telescope, first at a watch-face a few feet off, and then at a church-clock at a distance, I should have to diminish the distance between the object-glass and the eye-piece ; and I cannot conceive of any optical mechanism by which the telescope could be enabled to make this adjustment *for itself*. That the eye should be provided with such a mechanism, has always seemed to me a most wonderful evidence of intelligent design ; and the importance of this provision in our daily life is so great (as every one knows in whom it is even partially deficient*), as to outweigh beyond all

* While a person with good ordinary vision has a range of focal adjustment from six or eight inches (ten inches being the ordinary "reading distance") to as many miles, that of a "short-sighted" person is limited to near objects, and that of an elderly "long-sighted" person to distant objects. A *complete* want of power to adjust the focus of the eyes is seldom met with ; but sometimes occurs as one of the odd local paralyses often left for a time by an attack of diphtheria.

comparison the slight want of optical perfection which—as I have already shown you—is inseparable from it.

Let us now turn our attention to the fact that it is only in the sensitive spot of the retina, the *macula lutea*, that we have the most perfect provision, in the elaborateness of its structure, for the reception and transmission of the visual picture. The "rods," and "cones," as they are called, of that spot are much smaller than they are in any other part of the retinal surface; and our vision of objects whose picture falls upon it is proportionately distinct and minute. Now to me it seems that the inferior visual perfection of the rest of the retina, far from being disadvantageous, is a positive advantage. How completely the disadvantage is compensated by the facility with which we move our eyes, I have already shown in Professor Helmholtz's own words. The direction of their axes which is required to bring upon the *macula lutea* the image of any object at which we wish to look, is given without any conscious exertion of our own; we have only to "will" to look at the object, and the muscles of our eyes automatically bring their axes into convergence upon it. If you look at the eyes of a person who is reading or writing, you will see them move from left to right as he follows each line across the page, and then turn suddenly to the left again as he begins the next line; and yet he is not conscious of giving them any such direction. So, again, if we fix our gaze on any object, and move our head upwards or downwards, or from side to side, another person looking at our eyes will see them move in the opposite direction, so that their axes continue to point to the object at which we are looking.* Now while the disadvantage of the limitation of distinct vision to the *macula lutea* is thus fully compensated, I hold that this limitation is postively advantageous in this way,—that we see the object, or the part of the object, at which we will to look, with *much greater distinctness* than we should do if the whole of the visual picture which we receive at one time were as complete and vivid as that portion of it which is formed on the central spot of the retina. For our *mental* receptivity of this picture depends upon the *attention* we give it; so that the more completely our attention is con-

* Any one may make this experiment for himself, by looking at his own eyes in a looking-glass, and moving his head either horizontally or vertically.

centrated upon the thing at which we specially wish to look, the more distinctly we see it. The Microscopist well knows the great advantage of limiting his field of view when he is examining objects of the greatest difficulty. And every one who has been accustomed to visit picture-galleries is aware how much more fully he is able to appreciate a picture, when he looks at it in such a manner that its surroundings are kept out of his view.

To be able to bring our fullest measure of visual power to bear upon any object we desire to examine, and at the same time to see surrounding objects with sufficient distinctness for the recognition of their local relation to it, is, thus, far more advantageous to us, than would be the extension of that highest degree of visual power over the whole range at once. Here again, therefore, the asserted imperfection of the eye as an optical instrument proves to be the very contrary, when its structure and action are regarded in their relations to the use we make of the organ; added force being thus given to the final conclusion drawn by Professor Helmholtz, that "the adaptation of the eye to its function is most complete, and is seen in the very limits which are set in its defects" (p. 228).—Those who quote his previous statement for the purpose of depreciating the perfection of the organ, are bound in honesty to cite this also.

In the human eye, then, as in the Walter printing-machine, we find a combination of a number of separate contrivances, each individually of the most elaborate kind, yet having most complete consentaneousness of action, all tending towards one common end, which is attained with a perfection not theoretically surpassable by our highest science. And the cumulative probability that the eye, like the machine, is the product of "intelligent design," though not logically demonstrative, has a cogency not inferior to the "moral certainties" on which we are accustomed to rely in the ordinary conduct of our lives.—This argument seems to me not to be in the least invalidated, but rather to be strengthened, by the fact that in the ascending series of animals we meet with eyes which, compared with ours, are very imperfect. Beginning at the bottom, we find a little coloured spot, generally on some part of the surface of the animal, with a nerve-fibre proceeding from the central ganglion to that spot; and we judge this to be a rudimental organ of vision, by what we encounter as we proceed upwards. The next stage consists in the addition of something like a crystalline lens—a little, bright, pellucid particle on the end of the nerve-fibre, that seems by the concentration of luminous rays to intensify the sensation of light. We have strong reason to believe that animals very low in the scale are guided by this sensation; not in the manner of plants, whose *growth* towards light is accounted for by its physiological action on the formation of their tissues; but in *movements* directed by a conscious perception of light, resembling that of a nearly blind person who can just distinguish light from darkness. We find this direction towards light, and the avoidance of intervening obstacles, more and more obviously manifested in the movements of animals, as we pass upwards to higher forms of the visual organ. In front of the crystalline lens, we meet with a transparent film representing a cornea, separated from it by an anterior chamber; and behind it we come to distinguish a vitreous humour, covering an expansion of the nerve-fibre which is backed by a pigment layer. When we have arrived at this stage, seen in the "simple eyes" of insects, it is most beautiful to trace how the further ascent takes place along two distinct lines; one culminating in the "compound eye" of the insect, and the other in the single eye of the vertebrate animal, of which that of the predaceous birds is, perhaps, the highest type.

The "compound eye" of the insect, as you all know, is, in its typical form, an almost hemispherical mass projecting from the side of the head, which is made up of a number of separate "eyelets" of nearly cylindrical form, whose several axes are directed radially towards the spheroidal surface. Each "eyelet" consists of a number of different components which appear to correspond with those of our single eye; probably giving an achromatic character to the minute picture formed by its refractive action. But each can receive only those rays of light, whose direction corresponds with that of its own axis; and as the eye of the insect is immovable, no eyelet can be made to turn towards any particular object. By the multiplication of these eyelets, however, and the radial direction in which they are fixed, the aggregate "compound eye" will have a range fully equal, and probably superior, to that of any single eye constructed on the vertebrate plan. In some Butterflies and Dragon flies, each "compound eye" is made up of many thousands of these "eyelets," the individual "corneules" of which give the "facetted" appearance presented by the exterior of the aggregate mass; whilst the inner extremities of the cylinders abut upon a bulbous expansion of the optic nerve, from which a filament proceeds to each of them. Now we seem fully justified by observation of the movements of Insects, in concluding that these are guided by visual perceptions of external objects not less distinct than our own. And it seems probable, therefore, that the action of the compound eye is to impress the sensorium of the Insect with a single picture, corresponding to that which is formed upon our own retina, though received through a very differently constructed instrument. Modern investigations, moreover, have shown that the difference is rather apparent than real. For it is now known that the retinal layer of the human eye is not a mere spreading-out of the fibres of the optic nerve; but that in front of these terminal fibres is a layer of "rods" and "cones" on which the retinal picture is formed. Thus, the visual picture which our mind receives from either retina, is made up (so to speak) of the aggregate of the visual impressions made separately and individually upon each of its "rods" and "cones," and—through these—upon the individual fibres of the optic nerve on which they severally impinge. And thus what may be called the "mechanism" of our own vision, is really analogous to that of the vision of the Insect. In fact, it would now seem probable that the "rods" and "cones" of our own retina are really homologous with similar structures contained in the cylindrical "eyelets" of the Insect; so that the difference between its "compound eye" and our own "single eye" lies only in the arrangement of the parts of the recipient nerve-structure. Whilst *we* have a single refractive apparatus for the whole retinal area, by which a continuous picture is thrown upon its entire expanse, the Insect has a separate refractive apparatus for each of its retinal elements; but as the retinal elements themselves are essentially the same in both cases, we may fairly presume that the resulting visual sensation, which the Insect receives by the combination of their separate actions, corresponds closely with our own. That in the Insect the same effect is produced by *multiplication of parts*, as is produced in ourselves by their *concentration in a single apparatus*, is altogether conformable to their general type of organization. And it seems to me greatly to strengthen the argument of "intention," that a similar perfection of adaptiveness should be attained by the working-up of the same elementary materials on two different methods of construction, in accordance with the general plan of Articulates and Vertebrates respectively. With regard to those more simple forms of visual apparatus which *we* regard as inferior or rudimentary, it is to be borne in mind that they prove no less suitable than our own to the requirements of the animals which possess them, and are therefore *equally perfect in their kind.* All the wants of the Leech, for example, are provided for by its very simply-constructed eyes; and it would have no use whatever for the elaborately-constructed eyes of the actively-flying Insect,—the evolution of the visual organs in the animal series showing a close relation to that of the locomotive apparatus.

Further evidence of "intelligent design" is supplied by the history of the development of any one of the highest forms of the eye, such as that of the Chick *in ovo.* For it has been ascertained by the careful study of this process, that the complete organ is the joint product of two distinct developmental actions, taking place in opposite directions,—a growing-inwards from the skin—and a growing-outwards from the brain: the former supplying the optical instrument for the formation of the visual picture, and the latter furnishing the nervous apparatus on which this is received, and by which its impression is conveyed to the sensorium. A hollow, pear-shaped projection is sent out from the division of the brain called the mesencephalon; the narrowed neck or stalk of which afterwards becomes the optic nerve, whilst its expanded portion, pressed back into a concavity, becomes the retina. At the same time, an inward growth takes place from the skin, at first strongly resembling that which gives origin to a hair-follicle; a sinking-in of the surface of the dermis or true skin, being accompanied by an increased development of its epidermic cells. This depression deepens into a round pit, the lower part of which expands whilst its orifice contracts, so as to form a closed globular cavity, which is at last completely shut off from the exterior. This cavity is lined by epidermic cells, out of which the crystalline lens is ultimately formed; the derm on which they rest becomes its capsule; and the loose tissue which underlies the derm becomes the vitreous humour. The back of the globe thus formed, meeting the pear-shaped projection of the brain, pushes it, as it were, inwards; and thus derives from it the retinal investment which is necessary to bring the optical apparatus into relation with the nervous centres. Neither of these developmental processes would be of any use without the other. It is only by the conjunction of the two, that this most perfect and elaborate instrument is brought into existence.

I have now put before you the original Argument from Design, as set forth by Paley, expanded by the more advanced knowledge of the present time. That this argument, based on the combination of adaptations presented in the structure of each organic type —considered as a "special creation"—to the external conditions of its existence, needs now to be reconstructed under the new light of the Evolution-doctrine, must be freely admitted by those who (like myself) maintain it to be still tenable. And I have now to inquire how it is affected, first by the acceptance of the doctrine of Evolution taken *per se;* and secondly by the explanation supposed to be given of that Evolution by attributing it to "Natural Selection."

I can best bring you to my own mode of viewing this question, by first leading you to consider how it has been affected by the substitution of our present knowledge of the evolution of any one of the higher types from its protoplasmic germ-particle, for the old notion that this germ-particle is a miniature representation of the mature embryo, into which it has only to expand by growth. The primordial "jelly-speck" in the Fowl's egg during the progress of its development into the fully-formed chick, passes through a succession of phases, of which the first represents that lowest or most homogeneous type of organization which is common to the simplest Plants and the simplest Animals,—the second, one which is distinctively Animal,—the third, one which is distinctively Vertebrate,—the fourth, one which is distinctively Oviparous,—and the fifth, one which is distinctively Ornithic,—

while the peculiarities of the special Bird family to which it belongs are the last to make their appearance. Thus, in the language of the great Embryologist, Von Baer, to whom we owe this splendid generalization, its evolution consists in a gradual progress *from the general to the special*, or, as Herbert Spencer would say, from the *homogeneous* to the *heterogeneous*.

Now if, in examining the structure of a typical Bird, we find evidences of "design" in the wonderful adaptation of its clothing of feathers alike to keep in the warmth of the body, and to sustain it in its flight through the air,—in that organization of its heart and lungs which enables them to keep up the energetic circulation and respiration required for the maintenance of a high standard of muscular activity,—in those arrangements of the skeleton and muscular apparatus which give support and motion to the expanded wings,—in the adaptation of the eye to that acute and far-ranging vision which is needed for the guidance of its actions, —and in many other provisions I might enumerate,—I affirm, without any doubt of your assent, that this evidence is not in the least degree invalidated by the discovery that the germ-particle is not a miniature bird, but a protoplasmic "jelly-speck." In its capacity for "evolution" into the complete type, the germ-particle is just as much "potentially" the Bird, as if it could become one by merely swelling out.

So, if we go back in thought to the origin of the race, as we can by actual observation to that of the individual, the old conception of "design" which was based on the idea of an original Bird-creation does not lose any of its applicability, if we find reason to believe that the *original* progenitor was a protoplasmic "jelly-speck," certain of whose descendants have passed through a series of forms progressively improving in structure and capacity, and culminating in the perfected Bird. We merely substitute for the idea of continuous uniform descent, that of the "progressive development" of the race, as representing the mode in which our present Bird has come to be; deeming the latter the more probable, because we find it correspond with the embryonic history of every Bird now existing. The original progenitor was just as "potentially" the Race, whether called into existence as a protoplasmic "jelly-speck," or as a fully developed Bird. And the evidences of "design," which on the doctrine of "special creations" we find in the construction of the original Bird, and in the provision for the continuous propagation of its own type, we equally find in the production of the original "jelly-speck," and in the evolutionary process by which the very lowest type of organization has been progressively elevated to one of the highest. The marvellous succession of changes by which a chick is evolved from the germ-spot of the fowl's egg in the short period of two-and-twenty days, assuredly does not become less worthy of our admiration, if looked at as the abbreviated repetition of one which has extended continuously over millions of years.

Let us now consider this question, not in regard to any particular species of Bird, but in regard to the class as a whole,—consisting, as it does at the present time, of many thousands of reputed "species," each of them possessing some particular adaptation to its own conditions of existence, and hence regarded (according to our former ideas) as a separate product of Creative Design.

Every Zoologist is aware that the structure of all Birds conforms so closely to a common type, as to make it difficult to divide the class into subordinate groups characterized by well-marked distinctions. For these distinctions almost entirely rest on the comparative development, or peculiar shaping, of organs which all alike possess. I remember that on remarking to my friend, Professor Milne Edwards (the successor of Cuvier as the official head of French naturalists), soon after the publication of the "Origin of Species," that I could very well believe that all Birds had descended from a common ancestry, he replied, "I regard "Birds zoologically as constituting but a single family;"—meaning that their diversities of structure are not greater than those which we find among the members of many single families of Mammals or Reptiles. Now, if we find adequate grounds for the belief that all the Birds which now exist, or ever have existed, are the descendants of a common progenitor, and that the special peculiarities of each type have arisen in the course of their "descent with modification," the adaptiveness of each resultant organism is not less an evidence of design, because the aggregate result has been wrought out through a continuous passage from the general type to the special, instead of having been elaborated in all its completeness in the first instance. If the original Bird was so constructed as to be capable not only of engendering its own type, but of giving origin by genetic succession to all the diversified forms under which the ornithic type has presented itself, we must regard that progenitor as "potentially" the entire class, and as endowed with a capacity for producing the whole aggregate of "adaptations" presented by its individual members. At each stage in the progress of differentiation, we have thus precisely the same evidence of "design," as if the entire set of specific types had been turned out complete (as it were) by their Maker's hand in the first instance; and the substitution of the idea of progressive divarication from a common Bird-type, for that of the original multiplicity and continuous transmission of separate types, thus involves no other modification in the mode of presenting the argument, than the replacement of paroxysmal exertion by continuous orderly operation,—a change which brings it into conformity with the accredited evolutionary history of the physical universe.

It is freely admitted by Mr. Darwin that it is by analogy only that we are led to regard the progenitors of the great divisions of the Animal and Vegetable kingdoms as having themselves had a common origin; but if we go along with him as far as we have now done, we can scarcely stop short of that conclusion. For as we know that the primitive germ-particles from which Birds or Mammals now spring are not distinguishable by any recognizable differences from those in which Rhizopods or Zoophytes originate, —the special "potentiality" of each only manifesting itself in the progress of its development,—so it seems more in accordance with Nature's order, that the distinctions between the fundamental types of animal organization should have arisen, like those of their subordinate divisions, by "descent with modification," than by "special creations" of their several progenitors. Accepting provisionally, then, the doctrine of evolution in this widest sense, as implying the common origin of the whole organized creation—past and present—from a single stock, we shall find that no further modification will be required in the form in which I have put the Argument from Design, than such as gives it yet further range and greater comprehensiveness. For we must then regard our one ancestral germ-particle as endowed with a "potentiality" of progressive development, that has been equal to the peopling of our globe with all that vast variety of living creatures, by some or other of which it has been inhabited through all save the remotest periods of its ever-changing history to the present time. That this progressive development has taken place according to an orderly succession, the study of which will ultimately enable us to frame "laws" that shall express the conditions of the "perturbations" as well of the "uniformities" of genetic descent, is the belief of every philosophic Biologist. But when biological science shall have reached this elevated point, it will have revealed to us only the Order of the evolutionary process, leaving us still to seek for its Cause. But how much grander a conception of that order do we obtain, when we are thus led to regard it as embodied in one original design continuously working itself out through the ages, in constant harmony with the changes contemporaneously taking place in the condition of the terrestrial surface, than when we suppose it to have needed successive interpositions for re-adaptation to those changes as they successively occurred!

But, it is affirmed, there is nothing in this adaptation that cannot be accounted for by "Natural Selection." As changes took place in their "environment," variations occurred in the living inhabitants; some of these were favourable to their new conditions, some were the reverse; the fittest survived, the unfit became extinct; and thus those "adaptations" came about in the natural course of things, for which theologians have needlessly invoked the "design" of a *Deus ex machinâ.* In one of those most able expositions of the doctrine of the "Origin of Species by Natural Selection," by which Professor Huxley very early impressed the educated public with the scientific value of the new views which Mr. Darwin had opened out, he remarked that nothing had more strongly impressed him than the fact that they had completely disposed of the old teleological argument; the adaptations in organized structures which had been regarded as evidences of "design" being sufficiently accounted for as results of the "survival of the fittest." And this view of the case has been so zealously adopted by some of the younger advocates of the doctrine, that they have gone the length of representing the plants and animals which exhibit them, as having *made themselves* for the purposes which their organization is found to answer,—as if *they* had the intelligent design which is denied to an universal Creator. When challenged to justify that language, they represent it as merely "figurative;" their intention being only to show that, as Natural Selection gives a sufficient account of the adaptiveness, there is no need to seek for any other explanation of it.

But to me it seems that Professor Huxley and his followers in this line of argument have entirely overlooked the consideration, that before Natural Selection among varietal forms could come into operation, there must have been varieties to select from,—that for the "fittest" to have survived, they must have *come to possess* the structure that made them the fittest. It was very early pointed out that Natural Selection only expresses a *general fact*, and can in no sense be accounted a *vera causa;* and this, in his later years, Mr. Darwin showed himself quite willing to admit. In what I believe to be his last public utterance on the subject, he spoke of the causes of variation as at present the greatest problem of biological science; and the greater our success in the investigation of it, the more surely—I feel convinced—shall we recognize the evidences of an originating Design. While the argument is carried back—exactly as by the determination of the "laws" of the celestial motions—a stage nearer to the primal source, its basis is extended, and its upward reach elevated. In the admirable language of Dr. Martineau, "The law of 'natural "selection,' instead of dispensing with anterior causation, and "enabling the animal races to be their own Providence and do all "their own work, distinctly testifies to the constitution of a world "pre-arranged for progress, externally spread with large choice of "conditions, and with internal provisions for seizing and realizing "the best."

The life of every organized structure, from the lowest to the highest, consists in a series of physical interactions between itself and its environment; these interactions being maintained by certain physical forces, and requiring certain material supplies. The simplest Algal protophytes, under the influence of light and a moderate degree of heat, can manufacture their own food out of the inorganic components of air and water; and can thus flourish at all ordinary temperatures, wherever they can get an adequate supply of these elements. Most of the higher Plants, on the other hand, whilst still capable of generating out of air and water the organic materials which they require for their own sustenance, need also to be supplied with certain special mineral substances; and will only flourish within certain limits of temperature. Moreover, as Mr. Darwin has shown us, many of them require the agency of Insects for the fertilization of their ovules; and cannot reproduce themselves by seeds where that agency is not supplied. But the aggregate of these physical conditions constitutes only a part of the *cause* of the Plant's growth: there must be an aptitude on the part of the organism itself to turn them to account; and of the source of that aptitude, we at present know nothing whatever. Some Plants can adapt themselves in a much greater degree than others, to differences in external conditions; that adaptation involving some modification of their own structure. "What," said Professor Lindley, fifty years ago, "is a 'common' plant, but "one which can grow and propagate itself in almost any kind of "soil, and under almost every range of temperature; and what is "a 'rare' plant, but one which cannot flourish and produce seed, "except under certain special conditions?" Every botanist knows that among our own wild plants, *Rosa*, *Rubus*, and *Salix* are alike the most "variable," and the most "common" types; "common," because they have the capacity for adapting themselves to different conditions of growth; "variable," because of the influence of those varying conditions upon their organization. Out of the forms of Rose, Bramble, and Willow, ranked as "varietal" by Mr. Bentham, our ablest student of them, previous systematists had created more than three hundred "species."

Take, again, the influence of cultivation. There is no more remarkable example of the alteration produced by more abundant supply of food and more regulated temperature, than that exhibited in the development of the wild *Brassica oleracea*, a rambling sea-shore plant, into the various kinds of cabbage, broccoli, and cauliflower. Why will not culture produce the like effect upon other plants? It is quite illogical to say that this transformation has been the effect of "physical causes," when the most essential factor in that entire "aggregate of antecedents," which (according to J. S. Mill) constitutes the "cause," is the "unknown quantity" which we designate as the "constitution" of the organism itself. As I have already pointed out, we do not get any nearer to the explanation of this constitution by tracing it backwards ancestrally; for supposing *Rosa*, *Rubus*, *Salix*, and *Brassica* to have derived their respective peculiarities by "natural selection" from among previous varieties, the question recurs,—Whence those varietal modifications? No physical agencies can be assigned, at any stage whatever of the descent, as an adequate account of them; since, for those agencies to take effect, there must have been a concurrent capacity for variation, either in the organism itself, or in its germ, in virtue of which its varietal forms were engendered. The necessity for this factor is evinced by the negative results of its deficiency, shown in the "rareness" of many wild plants, and the unconquerable resistance made by others to all improvement by cultivation.

Precisely the same thing obtains in the Animal kingdom. The lowest *Protozoa*, of which *Amœba* is the type, find in every pond the organic materials which they require for their sustenance; and live and multiply under all ordinary ranges of temperature. But most Animals of high organization require particular kinds of food: some being purely carnivorous, others purely herbivorous; whilst others, like Man, are omnivorous, and are thereby enabled to sustain themselves on a greater variety of alimentary substances. So, again, all the higher types of Animals need an elevated temperature for the maintenance of their activity; but while the "cold-blooded," as Insects and Reptiles, are entirely dependent upon the temperature of the medium they inhabit, and are therefore reduced to a state of torpidity by its depression, "warm-blooded" Birds and Mammals carry their heating-furnaces about with them, and are thus in a great degree independent of depressions in external temperature. Yet even with this advantage, we find the whole Quadrumanous order and the larger Carnivora, as well as the (existing) Elephant, Rhinoceros, and Hippopotamus, restricted to tropical or sub-tropical climates; none of them being able to resist the winter cold of the temperate zone.

In striking contrast with their limitation of range is that of our "domesticated" animals, especially Dogs and Cats, Sheep and Oxen, Asses and Horses; all of which possess more or less adaptability to a wide range of climatic and other conditions, while the original (or supposed original) type of each becomes the subject of numerous varietal modifications. Some of these are distinctly *adaptive*, rendering the animals that exhibit them more fit to sustain themselves in the new conditions in which Man's agency (directly or indirectly exerted) has placed them; whilst others are as distinctly *non*-adaptive, rendering the animals *less* fit to maintain their existence if left to take care of themselves, although perpetuated by man's "artificial selection" as either useful or pleasing to himself.

In these varying capabilities of particular races, then, we must recognize—no less than in the ordinary characters proper to each race—the constitutional factor which extends the range of some, and limits that of others, so that the physical agencies to which the former show themselves amenable, have no similar effect upon the latter. If we say that the unknown cause of the variability of the one, or of the invariability of the other, lies in the "properties" of the germ of each,—whether that of its immediate progenitor, or of the primordial ancestor of both,—we really get no nearer to an explanation of it, than we do by calling the former x and the latter y. There is no family in the whole Mammalian series, of which the members are more closely similar in the essential parts of their conformation, than the *Cat* tribe; the Lion, Tiger, Panther, Leopard, Puma, and Jaguar, differing in little else than stature and hairy covering, and the domestic Cat being but a reduced copy of the general type. What it was in its original wild state, is not certainly known; many races of "wild cats" being pretty certainly descendants of the domesticated stock. In virtue, however, of its adaptabilility to a lower range of temperature *Felis catus* has established itself where neither *Felis leo* nor any other of the larger (existing) cats can keep itself alive; but whence did it get this adaptability? Suppose it to be replied, that, being a smaller species than the rest, it was very early brought under the influence of Man; and that as the people who domesticated it extended themselves further and further north of their original home, successive generations came to adapt themselves to greater and yet greater degrees of winter cold,—the question still recurs, whence this *ancestral adaptability?*

The influence of physical conditions in modifying the constitution is well known to be most strongly exerted during the earlier period of life; for as long as the organism is in process of development, it will *grow to* its environment, as it will not do at a later epoch, when it will either resist or succumb. We are told by Sir Charles Lyell that the Cornish miners who went out some sixty years ago to work the Real del Monte mines in Mexico, took out some greyhounds to hunt the hares which abound on the elevated *plateaux* of that country; but that, in consequence of the rarefied condition of the air, the dogs could not continue the chase, but lay down panting for breath. The offspring of those dogs, however, brought up at this elevation, were able to run down the hares as well as if both had been on a lower level. The constitution of the young dogs adapted itself to the environment in which they grew up; but whence that adaptability? We do not find it in any but *living organisms*; no physical property gives the least account of it.

The most remarkable example with which I am acquainted, of the effect of physical conditions in modifying the developmental process, is that which is seen in the economy of the Hive-bee. It is well known that whenever, from any cause, a community wants a queen, a worker-grub at an early stage is selected: a "royal cell" is constructed round it, several ordinary cells being demolished for the purpose, and their contained grubs killed; the selected grub is fed with "royal jelly" instead of with "bee-bread;" and (it seems probable) a higher temperature is maintained by the incessant activity of the bees which cluster about the royal nursery. In due time a perfect "queen" comes forth, differing from the "worker" not merely in the completeness of its reproductive apparatus, but in the conformation of its jaws and antennæ, the absence of "pollen-baskets" on the thighs, and yet more remarkably in its instincts. Now it is obviously no explanation of this extraordinary transformation to say that every worker grub is a "potential" queen; because the attributing this "potentiality" to it is only another way of expressing the fact that it can be so transformed. The existence of the "potentiality," and of the wonderful instinct that leads the worker bees to act upon it, are not less evidences of "design," because physical agencies are needed to call them into exercise.

A familiar instance of adaptiveness between the conformation of animals and their environment, is the possession by Birds and Mammals inhabiting the Polar regions, of a tegumentary covering that serves to keep in the warmth of their bodies, the former being provided with an underclothing of down, the latter with a thick close fur; whilst, on the contrary, many of the larger quadrupeds inhabiting the torrid zone show a marked deficiency, or even entire absence, of hairy covering. Now this is the more remarkable, because the ordinary effect of external warmth is to increase, and of external cold to diminish, the determination of blood to the skin; of which we see the effects alike in the increase of perspiration, and in the more rapid growth of the hair and nails during summer. Yet I have myself seen in Southdown sheep, which had been transported only two years previously to the West Indies, the thick covering of wool replaced by short crisp hair, scarcely distinguishable from that of the goats which had inhabited the island for several generations; and the hottest parts of the South American Pampas are inhabited by breeds of cattle (the descendants of those introduced by the Spaniards), of which some are nearly, and others quite, destitute of hair, and which cannot live in the more temperate air of the slopes of the Andes. It seems clear, then, that this adaptation results from some direct physical action of temperature on the constitution of the animals; and yet (like the expansion of water in cooling from 39·2° to 32°) it is in direct opposition to a very general law.

The same may be said of the winter whitening of the fur and plumage of Arctic Mammals and Birds. For although this (like the preceding) has been adduced as an example of "natural selection,"—the white varieties surviving because they escape being seen upon ground whitened by snow,—yet there must have been some cause for the production of the white varieties; and it has been the experience of some of our Arctic voyagers, that the winter whitening could be retarded by keeping the animals in a warm cabin, but took place in a few hours when they were put out into air whose temperature was considerably below zero.

Supposing, then, that we could trace out all the *physical* conditions under which these adaptations come to be, we have still to account for the adaptiveness in the *constitution of the animals* which exhibit them.

We find a singularly parallel case in that beautiful piece of human workmanship,—a clock or chronometer so constructed, as, by the accurate "compensation" of its pendulum or balance-wheel, to keep accurate time under all ordinary variations of climatic temperature. Surely we do not consider it a sufficient account of its self-adjustment, to attribute it to the physical action of heat or cold; for this would disturb the performance of an ordinary clock or watch. We seek the explanation of its special "potentiality" in the compensating apparatus; and we trace back the origin of this apparatus to the mind of its contriver. So, as it seems to me, however long may be the chain of "causation," or the series of "unconditional sequences," that may be traceable backwards in the ancestral history of any organized type, we come to a *beginning* of it, as to the first term of an arithmetical or geometrical progression; and we have no less to account for the common beginning of the whole Organized Creation, with its unlimited possibilities of modification and adaptation, than if we had to account for the separate production of each type of Plant and Animal.

I shall introduce one more curious illustration of my argument, from a department of inquiry well worthy of systematic study,—the influence of *psychical* conditions on the *colour* of animals. The advocates of "natural selection" as an all-sufficient explanation of the correspondence between the gorgeous hues of tropical Birds and Insects, and the brilliant foliage and blossoms of the trees in the midst of which they live, altogether neglect to tell us how those varieties came to be engendered, the conformity of whose colours to those of their environment made them the "fittest" to survive. The story of Jacob and Laban shows the antiquity of the belief that some influence exerted by the colour of the "environment" on the visual sense of the parents, affects the colour of the progeny; and this belief seems justified by modern observation. Thus, the Dingo, or wild dog of Australia (probably the descendant of some domesticated race originally introduced thither by man), has a uniform dull brown hue; but when the parents have been brought by domestication into a more varied environment, the pups vary in colour,—as has been often seen in the Zoological Gardens. The breeders of the polled Angus—a particular race of black cattle in Scotland—who make a great point of keeping up the perfect uniformity of their blackness, getting rid of every individual that has even a single white foot—take care to have everything black about their farmsteads; all the buildings are black, the horses are black, the dogs are black, the fowls are black. No breeder will have anything coloured or white about his place. Though no account can be given of the physiological action which makes these precautions effective (as they are asserted to be) in securing the desired result, yet I am strongly inclined to think that some influence of this kind is concerned in producing many singular correspondences between the surface aspect of Fishes and Crustacea inhabiting shallow waters, and the characters of the bottoms on which they live. Every angler for trout is familiar with variations of this kind; and I have been assured of cases in which these fish, when transferred from one part of a stream to another, were found in no long time to have undergone a change in surface-markings, which gave them the same conformity to the new bottom as they previously had to the old. I once found in a pool on the sea-shore some small Fishes and shrimp-like Crustaceans, the hue of whose surface so exactly resembled that of the yellow sand speckled with black that formed the bottom and sides of the pool, that the closest watching scarcely enabled me to distinguish them; and I found, on microscopic examination of their respective integuments, that their coloration was due in both alike to the presence of large yellow pigment-cells, with small black ones interspersed. Hence, even if we attribute this singularly close adaptation to "natural selection," we have just as much to account for the development of the peculiar pigmentation in the variety—alike of the Fish and of the Crustacean—that exhibited it, as if we believed these animals to have been originally created with it.

And if we prefer to believe, as I am myself disposed to do, that in all these instances the colour of the environment is reproduced by some sort of physiological reflexion in the integument of the animal (the *psychical* impression, as in numerous other cases, re-acting in a *physical* change), we have still to account for the peculiarity of constitution which made those particular races amenable to that influence.

I trust that I have now satisfied you of the validity of the position I took up in the first instance, that "natural selection" does not—as has been affirmed—effectually dispose of the teleological argument, by reducing adaptiveness to an accidental conformity between the capacities of the "fittest" and the external conditions of their existence. That conformity cannot exist, unless the beings possessed of it have previously come into existence. There is no such thing as "accidental" variation. A departure from the rule that "like produces like," never takes place without a cause. If it should happen that a variation is—under the circumstances—injurious rather than beneficial, it would not be right to call it "aimless;" for it may be no less perfectly adapted to conditions which exist elsewhere, than is that variation which gives to the race that possesses it an advantage in the struggle for existence. If a Highland cow were to produce a hairless calf which could not stand the winter cold, or a Pampas cow were to bear a calf with a thick shaggy covering of hair which would unfit it for its tropical habitat, none the less should we recognize the *general* adaptiveness between each race and its climatic environment, and see the evidence of "design" in the provision for thus peopling almost every country in which Man can maintain his existence, with races of Oxen serving for his support.

I have now, in fine, to ask you to follow me through an entirely different line of argument. All the variations among which "natural selection" can be shown to have any effective operation, have reference to comparatively insignificant modifications of structure. Let us grant, for the sake of argument, that all past and present modifications of the original Bird type may have thus arisen. But on the mode in which that singularly specialized *type* came into existence,—in which that most wonderful feature of its organization, the feather, arose out of the scaly covering of its Reptilian ancestors,—in which its heart came to be divided into four chambers instead of three, and the arrangement of its blood-vessels altered accordingly, in the establishment of the "complete double circulation," that insures the perfect aëration of the blood needed for the maintenance of the extraordinary muscular energy by which the feathered wings can sustain the body in flight,—I cannot see that "natural selection" throws the least light. There is, as I have already pointed out, an adaptation in the several parts of the structure of the Bird, not only to one general result, but to a consentaneous action in bringing about that result, which shows itself to be more complete, the more closely it is scrutinized. And on the hypothesis of "natural selection" among "aimless" variations, I think it could be shown that the probability is infinitely small, that the progressive modifications required in the structure of each individual organ to convert a Reptile into a Bird, could have taken place without disturbing the required harmony in their combined action; nothing but intentional pre-arrangement being competent to bring about such a result. And the point on which I now wish to fix your attention, is the evidence of such pre-arrangement that is furnished by the *orderly sequence of variations allowing definite lines of advance.*

I shall illustrate this, in the first place, by a general outline of a Memoir which I last year presented to the Royal Society, in which I embodied the final results (as relating to this subject) of an inquiry on which I had been engaged for forty years into the organization of the *Foraminifera;* a group of marine animals of the simplest protoplasmic nature, which yet form for themselves shelly coverings of singular regularity and complexity of structure, the aggregation of whose remains forms many important Limestone strata (as the Nummulitic limestone of which the Pyramids are built, and the Miliolite limestone which has furnished the chief building material of Paris), whilst Chalk is a product of their disintegration. My studies of this group began with a comparatively gigantic type called the *Orbitolite;* which is a shelly disk, sometimes attaining the diameter of an inch, living at the present time on the coast of Australia, the Fiji reefs, and other Pacific shores, and found fossil in the early Tertiary limestones of the north of France, one bed of which is in great degree formed of an accumulation of disks very similar to those now piling themselves up near its Antipodes. I was supplied, moreover, with a series of smaller disks (chiefly picked out of shore-sands), down to an almost microscopic minuteness, but agreeing with the larger in this fundamental feature of their structure,—the arrangement

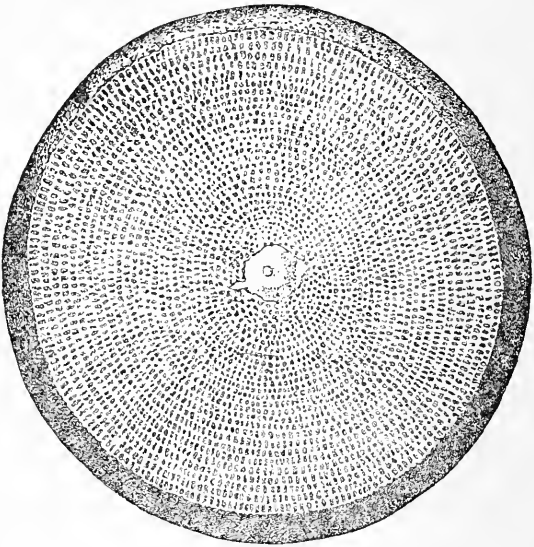


FIG. I.

Shelly Disk of *Orbitolites complanata*, showing concentric rings of chamberlets, arranged round a central nucleus.

of their mutually connected "chamberlets" in successive circles round a central "nucleus," their plan of growth being thus *cyclical.* This plan is most fully carried out in typical specimens of the large *Orbitolites complanata* (Fig. I.); in which the "sarcodic nucleus," consisting of a flask-shaped "primordial segment," *a*, Fig. II., and of a "circumambient segment," *b*, *b'*, *c*, is at once surrounded by a complete ring of sub-segments, separately budded off from it; successive rings, with constantly increasing numbers of sub-segments, being in like manner budded off around the outer border of their predecessors, sometimes to the number of 100. The shell, moulded upon this composite body, thus acquires the very regular discoidal form shown in Fig. I.; and its vertical thickness usually increases from its centre towards its circumference. A vertical section of the disk (Fig. III., 2) shows that the chamberlets visible on its two surfaces form two superficial layers, which communicate with continuous annular galleries that lie just beneath them (Fig. III., 3, *d'*, *d''*), every chamberlet, *a*, opening at each end into one of these galleries; whilst the intermediate part of the disk is occupied by columnar chamberlets (*b*, *b*), which open at either end into the annular galleries, and are connected with each other by several ranges of oblique passages (*e*, *e*, *f*, *f*). The passages proceeding outwards from the last-formed ring, open on the margin of the disk as pores arranged in more or less regular vertical series (Fig. III., 1); and these pores constitute the only means of communication between the complicated cavitary system of the disks, and the surrounding waters from which the animal that inhabits them draws its nutriment. The substance of this animal is apparently altogether protoplasmic. Notwithstanding this complexity in the structure of the disk, there is not the least trace of differentiation in the contents of the several series of chamberlets. On the contrary, there is every reason to believe that a continuous interchange must be always going on between the protoplasmic substance of the central and that of the peripheral parts of the disk; so that the nutriment taken in by the "pseudopodial" extensions which the latter puts forth through the marginal pores, may be diffused through the whole multiple series of sub-segments, of which the body of this organism consists. This I characterized as the "complex" type of *Orbitolite* structure.

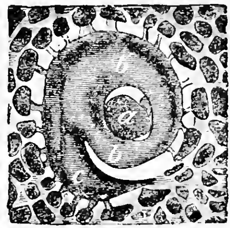


FIG. II.

Central Portion of Animal Body of *Orbitolites complanata.*

The minute disks picked out of shore-sands, however, were found to present a much simpler plan of structure ; the chamberlets being arranged in a single plane around the central nucleus,

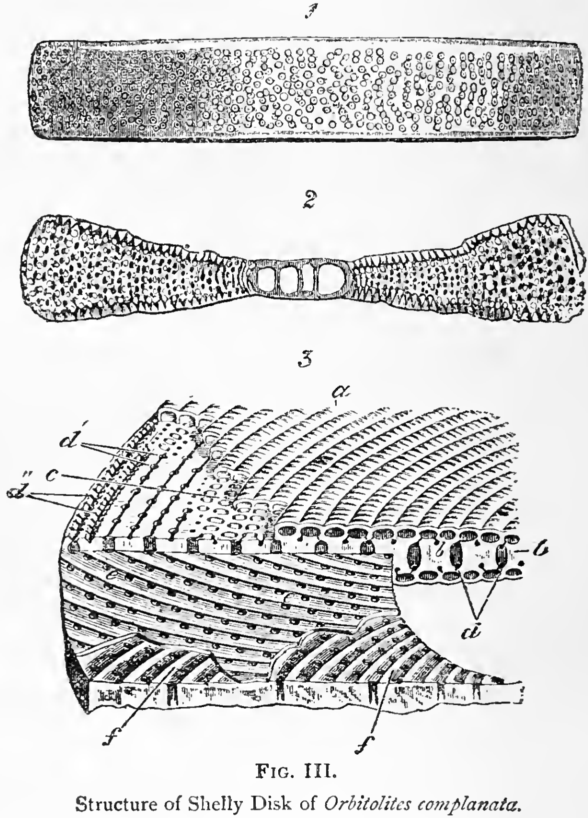


FIG. III.

Structure of Shelly Disk of *Orbitolites complanata.*

1. Edge of Disk, showing multiple series of marginal pores.

2. Vertical Section, showing two superficial planes of chamberlets, separated by intermediate columnar structure.

3. Internal Structure :—*a*, superficial chamberlets ; *b*, *b*, columnar chamberlets of intermediate layer ; *c*, floors of superficial chamberlets, showing the opening at each end into the annular gallery beneath ; *d*, annular galleries cut transversely ; *d′*, *d″*, annular galleries laid open longitudinally ; *e e*, *f f*, oblique stolon passages of the intermediate layer.

those of each ring being connected by a single annular gallery, and their openings at the margin forming but a single row of pores (Fig. IV., 1, 3, 4). The arrangement of the first-formed chamberlets, moreover, presented a single departure from the cyclical plan, showing a distinctly *spiral* disposition (Fig. IV., 2); the mouth of the spire, however, rapidly opening out by successive

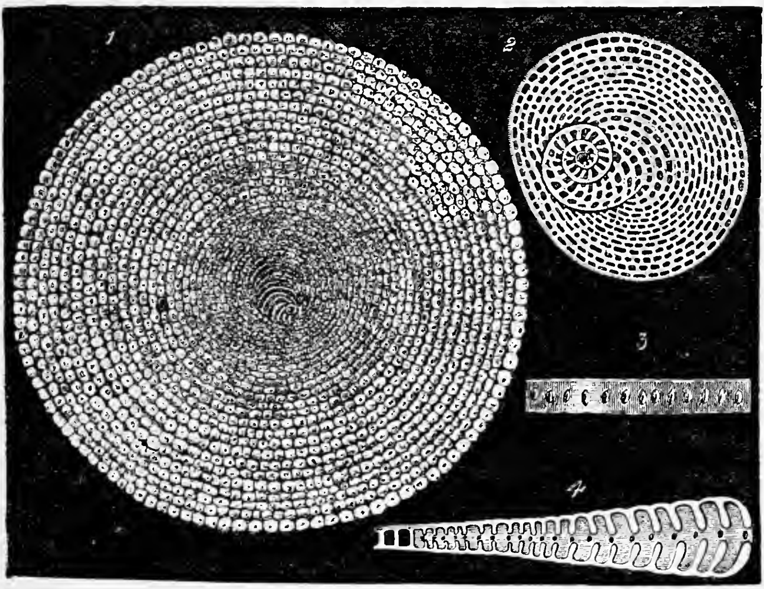


FIG. IV.

Disk of Simple Type of *Orbitolite*.

1. Surface of Disk, showing later growth of concentric rings of chamberlets around a first-formed spire.
2. Central portion enlarged.
3. Edge of Disk, showing single row of marginal pores.
4. Vertical Section, showing succession of chamberlets communicating with each other radially by passages in the annular partitions, and laterally by the annular canals, whose sections are seen as dark spots.

additions, so as to enclose the "nucleus"; after which all succeeding additions were complete rings, so that the cyclical plan came to be completely established. This I designated as the "simple" type of *Orbitolite* structure.

I was further able to show that these two typical forms were connected by a gradational series of connecting links; the formation of disks of the "complex" type often commencing on a plan resembling that of the "simple;" and the change from the latter to the former taking place, not at any fixed epoch of growth, but after a variable number of rings had been formed, sometimes abruptly, sometimes more gradually, in the manner to be presently detailed. And I also found that the inner rings of even the largest "complex" disks, if their early growth had taken place on the "simple" type, were not complete, but showed a tendency to one-sided and therefore spiral growth, like that seen in Fig. VI., 3.

Reflecting on the relations of these highly specialized Foraminiferal types to the simpler forms of the *Milioline* group, to which (in virtue of the "porcellanous" character of their shells) I referred them, I ventured to construct a hypothetical pedigree; tracing their descent (Fig. V.) from the particle of protoplasm that forms the spheroidal chamber in which every Foraminiferal shell begins, first to an open undivided spiral (1); then to a type in which the spire is constricted at intervals (2); then to a type in which it is completely divided into chambers by transverse partitions (3); then to a type in which the spirally arranged chambers are divided by longitudinal partitions into chamberlets (4); then to the "simple" type of *orbitolites*, in which the spiral plan of growth gives place to the cyclical (5); then to an "intermediate" type, in which the original spiral almost disappears (6); and finally to the "complex" type, in which the plan is cyclical from the beginning (7).

This hypothetical pedigree has found its complete confirmation in a deep-sea *Orbitolite* of extraordinary delicacy and beauty, which was brought up in the *Porcupine* Expedition of 1869. For this little disk, about the size of a fourpenny piece, while for the most part truly cyclical, has a long succession of inner chamberlets arranged upon the *spiral* plan, as in *Orbiculina*; these, again, arise from expanded but undivided chambers, like those of a *Peneroplis;* and these chambers are the continuation of a spiral tube, with occasional constrictions, resembling that of a *Spirolo-*

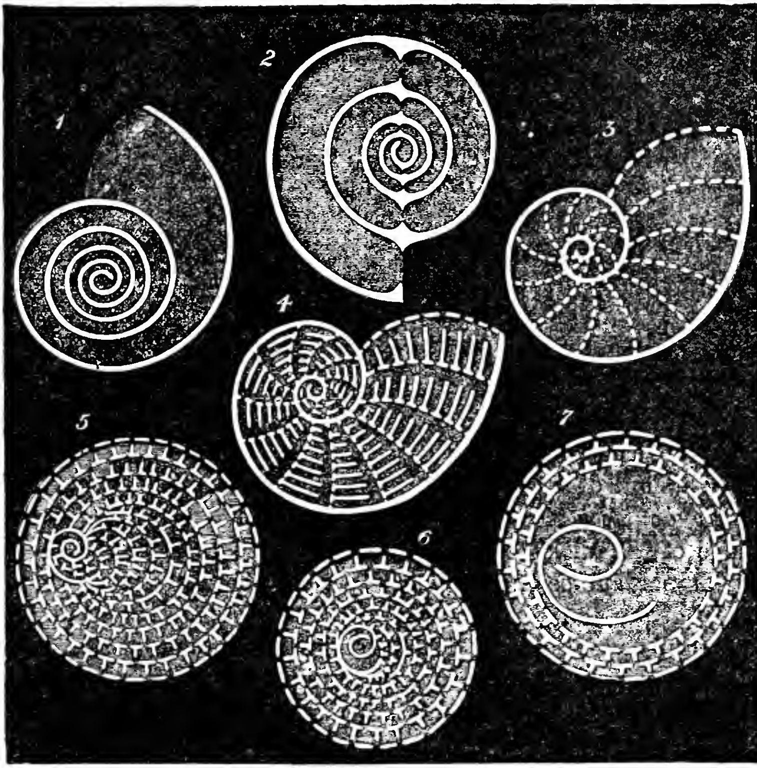


Fig. V.

Diagram illustrating the Pedigree of the Complex type of *Orbitolite.*

1. Simple undivided Spire of *Cornuspira.*
2. Partially interrupted Spire of *Spiroloculina.*
3. Spire of *Peneroplis*, divided by partitions into chambers.
4. Spire of *Orbiculina*, its chambers divided into rows of chamberlets.
5. Disk of "simple" *Orbitolite*, showing first-formed spire, surrounded by concentric rings.
6. Disk of "duplex" *Orbitolite*, showing earlier passage from spiral to cyclical plan of growth.
7. Central portion of Disk of "complex" *Orbitolite*, in which the chambered nucleus alone shows an abbreviated spire, the very first row of chamberlets forming a complete ring.

culina, coiling continuously round a primordial chamber, as in *Cornuspira*. Thus, in this interesting organism we find *permanently represented* the whole developmental history of the "simple" type of *Orbitolite* from the primordial jelly-speck. The large *Challenger* collection of *Orbitolites*, made on the Fiji reef, has furnished me with the means of still more completely working out the transition from the "simple" to the "complex" type; a distinctly intermediate type there presenting itself in great abundance. This, which I term the "duplex" type (Fig. VI., 1), resembles the "simple" in having its annular series of chamberlets disposed in a single plane, and in the connection of the chamberlets of each ring by a single annular canal; but differs in having its successive rings connected by a *double* series of radial passages, which issue on the edge of the disk (Fig. VI., 2) as marginal pores. The columnar sub-segments, *a a'*, *b b'*, of each ring are strung, as it were, on the annular cord, *c c'*; and this sends off an upper and a lower series of stolon-processes, *d d*, *d'd'*, which pass into the upper and lower halves of the sub-segments of the next ring.—The plan of growth in the first-formed portion, shown in Fig. VI., 3, is singularly intermediate between that of the "simple" and that of the "complex" type. The regular spire of the former is now reduced to the single turn made by the "circumambient segment," *b b*, round the "primordial segment" *a*; but a partial continuance of the same plan is shown in the incompleteness of the first two or three rings of sub-segments; these being budded forth from only *half* of the "circumambient segment," instead of from its *whole* periphery, as in the typical "complex" *Orbitolite* (Fig. II.). Yet even in large disks, whose later growth is characteristically "complex," the nucleus and earlier rings are often formed on the "duplex" plan, which passes into the "complex" in the manner to be now described.

Believing, with Sir James Paget, that "the highest laws of "biological science are expressed in their simplest terms in the "lives of the lowest orders of creation," I shall now ask you to follow me through a detailed examination of the transition from one type to the other; as shown in Fig. VII., which represents a vertical section, taken in a radial direction, of one of those large "complex" disks whose life was commenced on the plan of the "simple." The first-formed series of chamberlets (m, m^1, m^2, m^3, m^4) exactly correspond with those of the "simple" type (Fig. IV.,

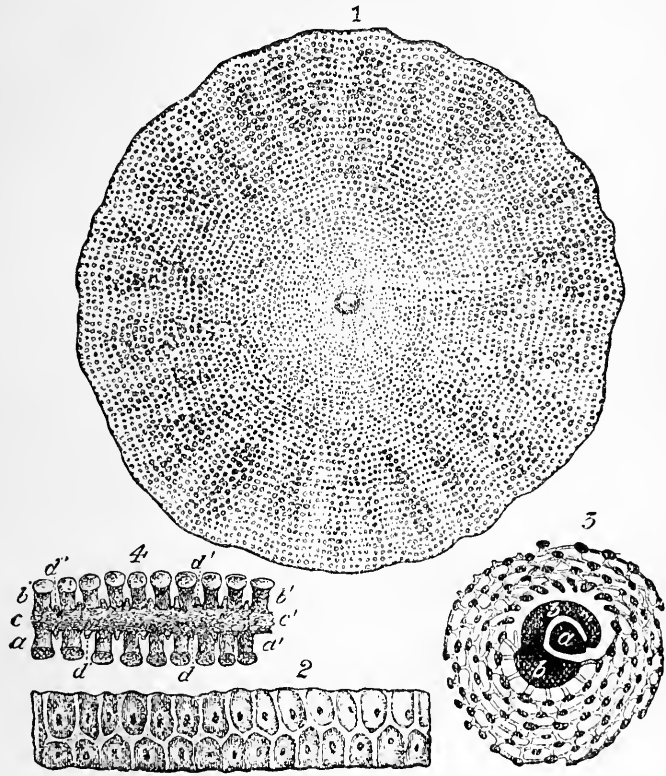


FIG. VI.

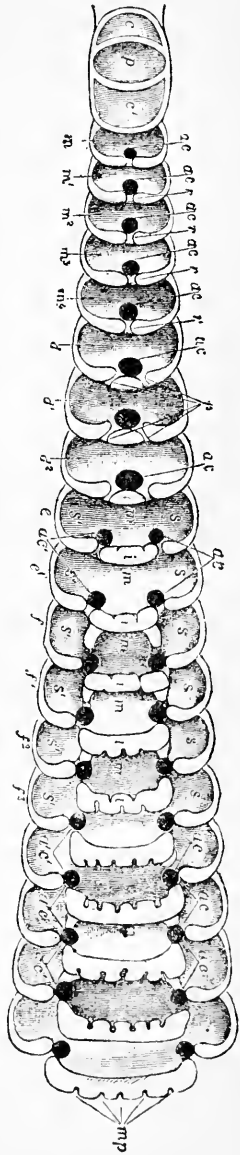
1. Disk of Duplex type of *Orbitolite.*
2. Edge of Disk, showing double row of marginal pores.
3. Central portion of Sarcode body:—*a*, primordial segment; *b*, circumambient segment, budding off a half-ring of sub-segments, from which complete rings are afterwards formed.
4. Portion of the Sarcodic body of one ring; *a a'* and *b b'*, the two halves of the columnar sub-segments in connection with *c c'*, the annular cord; from this are given off the pairs of stolon-processes *d d'*, *d d'*, which connect it with the sub-segments of the next annulus.

4), constituting but a single plane; those of each series being connected together by a single continuous annular gallery (shown in cross-section at (*ac*, *ac*), while those of each series are connected with those of the next by single radial passages (*r*, *r*, *r*), which, as each annulus was formed, would open at its outer edge as a *single* row of marginal pores. But these are surrounded by rings (d, d^1, d^2) in which, while the annular canal is still single, two radial passages (*r*) go off from it obliquely, one into the upper and the other into the lower portion of each chamberlet of the next annular series, those of the last-formed annulus showing themselves at its edge as a *double* row of marginal pores. From this "duplex" type, the first advance towards the "complex" is shown at e, e^1, in the splitting, so to speak, of each annular canal into two (ac, ac'), and the interposition of a columnar cavity (*m*, *m*) between its two halves. Now, in the inner (or earlier-formed) of the annuli which show this complication (e, e^1), the two series of chamberlets (s s, s' s') which lie between the two annular canals and the two surfaces of the disk, are continuous with the intermediate columnar chamberlets, and bear the same relation to their respective annular canals as in the "duplex" type, each being connected with one canal only; and this stage of differentiation characterizes the Orbitolites of the French Tertiaries, which seem to have attained their full growth without any advance upon it. But in the large Orbitolite disks of Australia and Fiji, I find this simpler arrangement giving place to a more complicated one (f, f^1, f^2, f^3); the chamberlets of the two superficial layers being separated from those of the intermediate layer, and being so shifted in position, that each annular series lies over the interval between two annular canals, and communicates with both of them; while the sarcodic body which occupies this cavitary system thus comes to have the more complicated arrangement shown in Fig. VIII. With the increase in the thickness of the intermediate layer, the double row of marginal pores of the "duplex" type gives place to the multiple series (Fig. VII., *mp*) of the "complex."

Now it seems to me impossible not to recognize the fact, that the evolution of this type has taken place *along a definite course;* every stage being one of *progress*, and each being (so to speak) a preparation for the next. This, perhaps, will be most clearly seen

FIG. VII.

Diagrammatic representation of the transition from the "simple" to the "complex" plan of growth, as shown in vertical section, from the primordial and circumambient chambers ($c\ p\ c'$) of the centre, to the margin, whose pores are shown at *mp*. The chambers *m*, m^1, m^2, m^3, m^4, are all formed upon the *simple* type (as in Fig. IV., 4), and show at *ac*, *ac*, the cross sections of the annular canals, which connect all the chamberlets of one ring, and at *r*, *r*, *r*, the radial passages connecting the successive annuli. The chambers *d*, d^1, d^2, are formed upon the *duplex* type; the annular canals, *ac*, *ac*, being single, but the radial passages *r* being double. The chambers *e*, e^1, show two annular canals *ac*, *ac*, between which is interposed a columnar chamberlet, continuous with the two superficial chamberlets *s s′*. In the chambers *f*, f^1, f^2, f^3, to the margin, which are all formed on the fully-developed *complex* type, the upper and under superficial chamberlets *s s*, *s′ s′*, are completely cut off from the intermediate columnar portion, and, by a shifting of their position, each is made to communicate with *two* annular canals.



by looking at the progressive complication in the structure of the sarcodic body on which the shell is modelled. First, we have a simple pear-shaped particle, extending itself into a cord that lies in a continuous spiral around it, with constrictions at intervals. This spire flattens out; and then, by the formation of transverse partitions, traversed by pores, the successive additions become segmentally separated from each other, though mutually connected by sarcodic extensions. Next, these segments undergo a further division into sub-segments: all those forming each row being strung (as it were) on a continuous sarcodic cord, which connects them laterally; while the successive rows are connected, as before, by radial "stolon processes," those of the last-formed row issuing forth through the marginal pores, as the *pseudopodia*, through which nutriment is absorbed for the entire body. Then, by the opening out of the spire, the lateral connecting cords become complete rings, from which the radial stolon-processes are given off; and the future increase of the "simple" type consists in the formation of new circular series of sub-segments, each strung, as it were, on its own annular cord. Now, the advance towards the "complex" type is prepared for, so to speak, by the sending forth of two sets of radial stolon-processes instead of one;—a change which, taken by itself, is meaningless, since every one who is familiar with the variability of the Rhizopodal type (especially as exhibited in the transitional forms between *Peneroplis* and *Dendritina*) knows that it cannot make any difference to the animal whether its pseudopodia issue from the margin of the disk, through a single or through a double row of pores; but which is full of meaning when regarded as a preparation for that splitting of each annular cord into two, in which the transition from the "simple" to the "complex" type essentially consists. Every annulus of the body of the latter consists of a series of columnar segments (Fig. VIII., *e e*, *e′ e′*), passing at each end into an annular cord (*a a′*, *b b′*), and communicating with the series internal and external to it, by oblique stolon-passages, the number of which is related to the length of the columns; this again, determining the thickness of the calcareous disk which is modelled upon them. The sub-segments of the two superficial layers (*c c*, *d d*) do not communicate with each other; but those of each circlet are connected (as already described) with the two annular cords that lie beneath. And by this elaborate arrangement, every part of the minutely subdivided protoplasmic body which occupies the minutely sub-divided cavity of these disks, is brought into continuous relation with every other part, and with the peripheral annulus whose marginal pores constitute the only access through which nutriment can reach it from without.

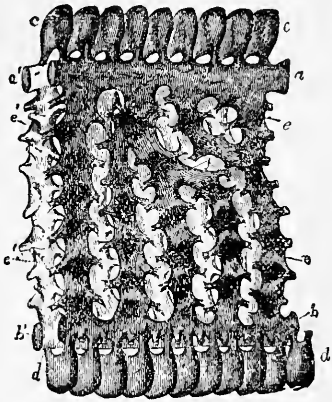


FIG. VIII.

Portion of Sarcodic body of Complex Orbitolite:—*a a'*, *b b'*, upper and lower annular cords of two concentric zones; *c c*, upper layer of superficial sub-segments; *d d*, the lower layer; *e e* and *e' e'*, intermediate columnar sub-segments of the two zones, giving off oblique stolon-processes.

I might further illustrate my argument that we have here the obvious indication of a pre-arranged plan, by the remarkable provision made, not merely for the reparation of injuries, but for the restoration of the typical form when the disk has been so much broken as to destroy that form completely. Even a broken-off marginal fragment may give origin to a new disk; its sarcodic body extending itself all round it, so as to form a continuous band; and this forming a complete annulus of chamberlets, round which new annuli are successively added.

In the Life-history of the perfected type, then, we can clearly trace a sequence which runs exactly parallel to what we have reason to regard as its Evolutionary history, and, in addition, a provision for the maintenance of the *perfected* model; the reparative process being carried on—alike in the "simple," the "duplex," and the "complex" types — upon the plan characteristic of each.

But my special reason for dwelling upon this "instance" (as Bacon would call it) is, that the influence of Natural Selection would here seem to be excluded by the fact that the whole series of ancestral forms through which the most elaborately constructed *Orbitolite* now existing may be assumed to have passed, continue to live and flourish at the present time. The very same dredging may bring up shells of *Cornuspira*, constructed upon the undivided spiral plan shown in Fig. V., 1; shells of *Spiroloculina*, in which the spiral is partially interrupted by rudimentary partitions, as at 2; shells of *Peneroplis*, in which the partitions are complete, bu traversed by pores, as at 3; shells of *Orbiculina*, in which the peneropline chambers are divided into chamberlets, the plan of growth still remaining spiral, as at 4; and shells of the three types of cyclically growing *Orbitolites* 5, 6, 7. As already stated, the condition of the sarcodic body undergoes no corresponding advance; that of the most "complex" *Orbitolite* being as homogeneous or undifferentiated as that of the simple *Cornuspira*. There is no evidence whatever of any "struggle for existence" or "survival of the fittest"; all showing themselves equally fit to survive. All "variation" seems to have taken place in such a definite direction, as to evolve calcareous fabrics of ever-increasing complexity; but this complexity can scarcely give any advantage to the organisms which have attained it, these being fully as incapable as the simpler forms of escaping from their enemies by movement, and showing no such differences of aspect as would enable them to elude observation. In fact, the Fishes and larger Crustaceans which would probably be their chief destroyers, would be likely to be most attracted by the larger disks of the "complex" type; while the younger specimens of that type, being indistinguishable except by the Microscopist from full-grown specimens of the "simple" and "duplex" types, are not likely to be passed over by any hungry destroyer that might find these latter of more suitable dimensions.

The last remark I have to make in relation to this noteworthy "instance," is that its value is not in the least degree lessened by the fact that the evolutionary process seems to be dependent upon physical agencies. The *Orbitolite* type (as at present known to us) flourishes best in tropical or sub-tropical seas; the largest "complex" forms yet discovered being found on the Fiji reefs; while the smallest "simple" forms only extend as far north as the Mediterranean,—with the singular exception of the deep-sea type found to the west of Ireland, which is probably a survival from the warmer climate of some former epoch. And among the specimens collected by the *Challenger* on the Fiji reef, I have found a marked difference; all the most highly-developed forms of the "complex" type having been found near the surface, where the temperature is the highest, and the supply of food most abundant. But it can no more be said that these physical agencies *produced* the advance, than that heat can *make* a chick out of the yolk and white of an egg, without a germ to appropriate and build up these materials. These physical agencies supply only the conditions required for the evolutionary process, —the source or spring of which is in the germ itself.

As Natural Selection gives no account of the *changes in the plan of growth* which constitute so marked a feature in the evolutionary history of the *Orbitolite*, so, as it seems to me, it gives no explanation of the appearance of *new organs:* the complete possession of which fits their possessors for a higher condition of existence, and accords with other modifications that enable them to take advantage of it; but which, in their rudimentary state, cannot be conceived to be of any service to animals altogether framed upon a less advanced type, and continuing to live in accordance with lower conditions. And I shall take, as a suitable "instance," what is known as the "swimming bladder" of the Fish, which is an earlier form of the organ that becomes a lung in air-breathing Vertebrata.

In the Vertebrate series we pass by a succession of stages from the Fish, with gills fitted only for aquatic respiration, to the Reptile which is fitted only for aërial respiration: the intermediate being the true Amphibia, which, as regards their respiratory apparatus, are fish in their early stage, and reptiles in the complete stage; some of them retaining their gills even after the development of their lungs, so as to be able to live either in air or in water. Now, the first rudiment of a "swimming bladder" that we meet with in Fishes, is a little *diverticulum* or pouch opening off from the pharynx or gullet; and this extends itself in many cases so as to become a bag or sac, lying along the spine, but entirely cut off, by the closure of its neck, from any communication with the gullet. Such fish cannot take into it any air from the outside; so that the air which is found in the sac in some instances, would seem to have been secreted from the blood. It is commonly supposed that the fish uses this bladder for so regulating its specific gravity as to rise or sink in the water; but there is no adequate basis for this hypothesis. For there is no muscular structure in the bag to cause it to increase or diminish in size; and there is no outside arrangement of muscles that can be conceived to answer this purpose. Moreover, when deep-sea Fish, having a closed swimming-bladder, are brought to the surface, their swimming-bladders burst in consequence of the removal of external pressure, and the fish are killed. The most singular thing is, that there are genera of fish, the *Scomber* (or Mackerel tribe) for instance, of which some species have a swimming-bladder, and others none; and it cannot be affirmed that the latter are less able to swim at different depths than the former. This swimming-bladder, in certain other forms of fish, retains its original communication with the pharynx; and air can then pass into it from the outside. Carp in ponds are often seen to swallow air; and you may occasionally see gold-fish, which are a kind of carp, coming to the surface of the water of the globes in which they are kept, discharging air-bubbles and taking in a fresh supply. It seems pretty certain, then, that there are fish which use this rudimentary lung really for the purpose of respiration; certainly the Ganoid fishes do, which are a most important group in the evolutionary series, connecting Fishes with Reptiles.

Now, of the first appearance of this organ, and of its development into a closed air-bladder, it seems to me that Natural Selection gives no account whatever. Let it be supposed that the pharyngeal pouch "formed itself" in some ancestral fish as an "aimless" variation; how can it be conceived to have been of such service to the animals which possessed it, that they beat others in the struggle for existence,—when we do not find this to be the case even with the fully-developed swimming-bladder? And how can we account for the progressive elongation of the pouch into a closed swimming-bladder, if, in this condition, it is of no use to its possessors? To me it seems as if the whole evolutionary history of this organ plainly points to its ulterior development into an organ for atmospheric respiration; and is unmeaning if not so viewed.

So, again, we may trace a remarkable uniformity in the line of progress from the lower to the higher forms of pulmonary apparatus. The purpose which the lung has to serve being the exposure of the blood to the air over an extended surface, that extension must be proportionate to the demand for aëration set up by the muscular activity and temperature-standard of the animal. The swimming-bladder of the Fish, even when used for atmospheric respiration, is a simple, undivided sac, or, as in the Ganoids, a pair of such sacs. The lung of the Frog has its internal surface increased by its extension into a number of little pockets in the upper part of the principal cavity. The same is the case in the Snake, and in many other Reptiles; each lung having a large undivided cavity, with diverticula in its walls, over the extended surface of which the blood-vessels are minutely distributed. In some of the higher Reptiles, as the Crocodile, the cavity of the lung exhibits an incipient subdivision. In the lung of Man, as of Mammals generally, an extraordinary increase is given to the extent of aërating surface, by the excessively minute subdivision of the cavity into air-cells; of which thousands are clustered round the end of each terminal twig of the bronchial tree. But this increase would be without effect, if there were not at the same time a most elaborate provision in the skeleton of the trunk, in the disposition of its muscles, and in the mode in which these are acted on by the nervous apparatus, for alternately filling and emptying the lungs, so as to take in fresh supplies of oxygen for the aëration of the blood, and to get rid of the carbonic acid which it gives off. The chief feature in this provision is the enclosure of the lungs in a distinct cavity (that of the chest) cut off from the abdomen by a muscular partition—the diaphragm; the contraction of which, by increasing the capacity of the chest, produces an in-rush of air down the air-passages, which penetrates to the remotest parts of the minutely-subdivided cavity of the lungs. By no other action could the air contained in that cavity be so effectually renewed. Thus the pulmonary apparatus of the Mammal is the most perfect form that could be devised for obtaining the highest amount of respiratory power within the smallest compass.

But the Bird requires a yet more active respiration than the Mammal: being far higher in point of animal activity. It must put forth far more muscular power in proportion to its size, in order to raise itself in the air; and it must be able to sustain that power for a great length of time. Its animal energy can only be kept up by the maintenance of a higher temperature. All this involves a much larger consumption of oxygen, and a greater production of carbonic acid. Hence you would suppose that if "natural selection" had in any way worked out the respiratory apparatus of a Bird, it would be a more highly organized instrument than that of a Mammal. So far, however, is this from being the case, that the lung of the Bird is really formed upon the lower plan of the lung of the Reptile. Instead of having the minutely subdivided air-cells of the Mammalian lung, the lung of the Bird is an aggregation of little lunglets, each resembling the entire lung of the Frog; and instead of the provision made in the general structure of the Mammal for the constant renewal of the air in the cavity of the lungs, we find the diaphragm absent, and the bony framework of the trunk so firmly knit together (thus affording fixed attachments for the powerful muscles of flight) as to be incapable of the movement which our ribs and sternum perform in aid of the action of the diaphragm. How, then, is the more active respiration required by the Bird provided for? Just as in the Insect, to which Birds have so many analogies,—by the extension of the respiratory surface through the body generally. The long bones, instead of being filled with marrow, are hollow; and their cavities are connected with each other and with that of the lung on either side: there are also air-sacs disposed in various parts, which probably take a share in the same action. Further, by the elasticity of the framework of the trunk, the lungs are kept full of air, the state of emptiness being forced; so that when they have been compressed by a muscular effort, they fill themselves again spontaneously as soon as the pressure is relaxed.

Thus, looking at the general plan of the respiratory apparatus, we find it undergoing a uniformly progressive *elevation of type*, as we pass from the Fish to the Reptile, from the Reptile to the Bird, and from the Bird to the Mammal. But if there was no pre-ordained plan, if this advance resulted from mere "accidental" variations, we should have expected that some Bird would have been evolved by "natural selection" with the lung of the Mammal; and that this form, by the survival of the fittest, would have established itself to the exclusion of the lower type. On the contrary, without any advance on the lower plan of Ornithic structure, an *extension* has been given to its respiratory surface, which supplies all the needs of the most actively flying Bird, and makes that apparatus as *perfect*, in its relation to the general plan, as if that apparatus had been exceptionally raised to a higher grade of development.

Here then, as in the preceding instance, we seem justified in the conclusion that, as the doctrine of Natural Selection out of an endless diversity of "aimless" variations fails to account for *that general consistency of the advance along definite lines of progress* which is manifested in the history of evolution (the two cases I have brought before you being merely samples of an immense aggregate, whose cumulative force seems to me irresistible), it leaves untouched the evidence of Design in the original scheme of the Organized Creation; while it transfers the idea of that Design from the particular to the general, making all the special cases of adaptation the foreknown results of the adoption of that general Order which we call Law.—As Dr. Martineau has pertinently asked, "If it takes *mind* to construe the world, how can it require "the negation of mind to constitute it?" Science, being the intellectual interpretation of Nature, cannot possibly *disprove* its origin in Mind; and, if rightly pursued, leads us only to a higher comprehension of the "bright designs," a more assured recognition of the working of the "sovereign will," of its Divine Author.

APPENDIX.

LIST OF DR. CARPENTER'S WRITINGS.*

1835–1836. 1, 2. On the Structure and Functions of the Organs of Respiration in the Animal and Vegetable Kingdoms (*West of England Journal*, October, 1835; January, 1836).

1836. 3. A Sketch of the Present State of our Knowledge of the Laws of Chemical Combination, with some of their more Important Applications (*Ibid.*, January).

1837. 4. Oration delivered before the Members of the Royal Medical Society of Edinburgh, at the Celebration of their Centenary, February 17, 1837.

5. On the Voluntary and Instinctive Actions of Living Beings (communicated to the Royal Medical Society, March 23; printed in the *Edinburgh Medical and Surgical Journal*, No. 132).

6. On Unity of Function in Organized Beings (communicated to the Royal Medical Society, April 14; printed in the *Edinburgh New Philosophical Journal*, July).

7. Lindley, Henslow, De Candolle, Treviranus, Raspail, on Vegetable Physiology (*British and Foreign Medical Review*, July).

1838–54. 8–11. Principles of General and Comparative Phy-

* This list does not include occasional letters to newspapers on controversial matters; and it is possible that sundry early articles in various reviews, cyclopædias, etc., have not been traced.

siology. Second edition, 1842; third edition, 1851; fourth edition, 1854.

1838. 12. Hall, Grainger, Mayo, on the Physiology of the Spinal Marrow (*British and Foreign Medical Review*, April).

13. Physiology an Inductive Science (*Ibid.*, April).

14. On the Differences of the Laws regulating Vital and Physical Phenomena (Prize Essay, *Edinburgh New Philosophical Journal*, April).

15. Macilwain's Medicine and Surgery (*British and Foreign Medical Review*, July).

1839. 16. Inaugural Dissertation on the Physiological Inferences to be deduced from the Structure of the Nervous System in the Invertebrate Classes of Animals (Prize Thesis).

17. Hunter, Macartney, Rasori, Carswell, on Inflammation (*British and Foreign Medical Review*, April; the portion relating to Hunter is marked, "Not by W. B. C.").

1839–47. 18–20. Articles on "Life," "Microscope," "Nutrition" (Todd's *Cyclopædia of Anatomy and Physiology*).

1840. 21. The Claims of Bell, Majendie, Mayo, etc., to Discoveries in the Nervous System (*British and Foreign Medical Review*, January).

22. Dubois on Medical Study: Preliminary Education (*Ibid.*, April).

23. Dubois and Jones on Medical Study: Principles of Medical Education (*Ibid.*, July).

1841. 24. Alison, Bushnan, Swainson, on Intellect (*Ibid.*, January).

25. Graham, Thomson, Daniell, Daubeny, on the recent Progress of Chemical Philosophy (*Ibid.*, January).

26. Valentin on the Functions of Nerves (*Ibid.*, April).

27. Outline of a Philosophical History of the Reproductive Function in Plants and Animals (*Edinburgh Monthly Journal of Medical Science*).

1841-44. 28–31. Popular Cyclopædia of Natural Science, 5 vols. The Treatises composing this series were afterwards reissued separately:

Mechanical Philosophy, Horology, and Astronomy, 1857.

Zoology, 2 vols. (edited by W. S. Dallas, F.L.S.), 1857.

Vegetable Physiology (edited by Edwin Lankester, M.D., F.R.S.), 1858.

Animal Physiology, 1859.

1842–55. 32–36. Principles of Human Physiology. Second edition, 1844; third edition, 1846; fourth edition, 1852; fifth edition, 1855. (The sixth edition appeared in 1864, under the editorship of Mr. Power; the ninth in 1881).

1842. 37. Liebig's Animal Chemistry (*British and Foreign Medical Review*, October).

1843. 38. On the Origin and Functions of Cells, being Part II. of a Report on the Results obtained by the Use of the Microscope in the Study of Anatomy and Physiology (*Ibid.*, January).

39. On the Minute Structure of the Skeletons or Hard Parts of Invertebrata (*Proceedings of the Royal Society*, January).

40. On the Microscopic Structure of Shells (*British Association Report*, August).

41. General Results of Microscopic Inquiries into the Minute Structure of the Skeletons of Mollusca, Crustacea, and Echinodermata (*Annals and Magazine of Natural History*, December).

1844. 42. Hall and Newport on the Reflex Function of Animals (*British and Foreign Medical Review*, January).

43. Report on the Microscopic Structure of Shells (*British Association Report*, September).

44. On the Structure of the Animal Basis of the Common Egg-Shell, and of the Membrane surrounding the Albumen (*Transactions of the Microscopical Society*, October 19).

1845. 45. Vestiges of the Natural History of Creation (*British and Foreign Medical Review*, January).

46–63. On the Harmony of Science and Religion (eighteen papers in the *Inquirer* newspaper, March 22 to August 16).

1846–65. 64–67. Manual of Physiology. Second edition, 1851; third edition, 1856; fourth edition, 1865.

1846. 68. Noble on the Brain and its Physiology (*British and Foreign Medical Review*, October).

1847. 69. Moreau's Psychological Studies on Hachish and Mental Derangement (*British and Foreign Medico-Chirurgical Review*, January).

70. Matteucci on the Physical Phenomena of Living Beings (*Ibid.*, April).

71. Professor Owen on the Comparative Anatomy and Physiology of the Vertebrate Animals (*Ibid.*, April).

72. Report on the Microscopic Structure of Shells (*British Association Report*, June).

73. On Photography applied to Microscopic Objects (*Ibid.*, Part II., June).

74. Dr Mayo on the Relations of Insanity, Crime, and Punishment (*British and Foreign Medico-Chirurgical Review*, July).

75, 76. Dr. Prichard on the Physical and Natural History of Mankind (*Ibid.*, July and October).

77. Flourens, Sharpey, Tomes, on the Formation of Bone (*Ibid.*, October).

78. An Inquiry into the Effects of Alcoholic Drinks on the Human System in Health and Disease (*Ibid.*, October).

1847–49. 79–82. Articles on "Secretion," "Shell," "Sleep," "Smell" (Todd's *Cyclopædia of Anatomy and Physiology*).

1848. 83. Dalyell, Sars, Dujardin, and Van Beneden, on the Development and Metamorphosis of Zoophytes (*British and Foreign Medico-Chirurgical Review*, January).

1848. 84. Dr. Pereira's Edition of Matteucci's Lectures (*British and Foreign Medico-Chirurgical Review*, January).

85. On the Christian Name (*Inquirer*, June 20).

86. Taylor and Copland on Poisons (*British and Foreign Medico-Chirurgical Review*, July).

87. Schleiden and Ralfs on Botany (*Ibid.*, October).

88. The Position and Prospects of the Medical Profession (*Ibid.*, October).

89. Ethnology, or the Science of Races (*Edinburgh Review*, October).

90. The Objects of Medical Study and the Spirit in which they should be pursued (Introductory Lecture delivered at the Medical School attached to the London Hospital, October 2).

1849. 91. On the Microscopic Structure of Nummulina, Orbitolites, and Orbitoides (*Journal of the Geological Society*, May 2).

92. The Physiology of Parturition (*British and Foreign Medico-Chirurgical Review*, July).

93. Owen and Paget on Reproduction and Repair (*Ibid.*, October).

94. Physiological Botany (*Ibid.*, October).

1849-52. 95–97. Articles on "Taste," "Touch," "Varieties of Mankind" (Todd's *Cyclopædia of Anatomy and Physiology*).

1850. 98. The Physiology and Diseases of the Nervous System (*British and Foreign Medico-Chirurgical Review*, January).

99. On the Mutual Relations of the Vital and Physical Forces (*Philosophical Transactions*, June 20).

100. Evidence and Proof: the Trial of Dr. Webster (*British and Foreign Medico-Chirurgical Review*, July).

1850–51. 101, 102. The Use and Abuse of Alcoholic Liquors in Health and Disease (Prize Essay). Second edition, 1851.

1852. 103. On the Influence of Suggestion in Modifying and Directing Muscular Movement, independently of

Volition (*Proceedings of the Royal Institution*, March 12).

1853. 104. On the Intimate Structure of the Shells of Brachiopoda (contributed to the General Introduction to Mr. Thomas Davidson's *British Fossil Brachiopoda*).

105. The Physiology of Temperance and Total Abstinence, being an Examination of the Effects of the Excessive, Moderate, and Occasional Use of Alcoholic Liquors, on the Healthy Human System (London: Henry G. Bohn, pp. 184).

106. The Moderate Use of Intoxicating Drinks, physiologically considered (London: W. Tweedie, pp. 15).

107. The Predisposing Causes of Epidemics (*British and Foreign Medico-Chirurgical Review*, January).

108. Electro-Biology and Mesmerism (*Quarterly Review*, October).

1854. 109. On a Peculiar Arrangement of the Sanguiferous System in Terebratula and certain other Brachiopoda (*Proceedings of the Royal Society*, April 5).

110. On the Development of the Embryo of Purpura lapillus (*British Association Report*, Part II., September).

111. On the Development of the Embryo of Purpura lapillus (*Transactions of the Microscopical Society*, December 29).

1855. 112. The Physiological Errors of Moderation (Scottish Temperance League, pp. 31).

1855–60. 113–116. Researches on the Foraminifera.

Part I. General Introduction, and Monograph of the Genus Orbitolites (*Philosophical Transactions*, 1856; six plates. Abstract in *Proceedings of the Royal Society*, June 20, 1855).

Part II. Genera Orbiculina, Alveolina, Cycloclypeus, and Heterostegina (*Ibid.*, 1856; four plates. Abstract in *Proceedings of the Royal Society*, June 19).

Part III. Genera Peneroplis, Operculina, and Amphistegina (*Philosophical Transactions*, 1859; six plates. Abstract in *Proceedings of the Royal Society*, June 17, 1858).

Part IV. Genera Polystomella, Calcarina, Tinoporus, and Carpenteria, with concluding summary (*Ibid.*, 1860; six plates. Abstract in *Proceedings of the Royal Society*, June 14).

1856. 117. Address as President at the Annual Meeting of the Microscopical Society (*Transactions of the Microscopical Society*, February 27).

118. On the Minute Structure of certain Brachiopod Shells; and on Vegetable Shell-Formation (*Annals and Magazine of Natural History*, June).

1856–81. 119–124. The Microscope. Second edition, 1857; third edition, 1862; fourth edition, 1868; fifth edition, 1874; sixth edition, 1881.

[For some time, probably about this period, Dr. Carpenter contributed to the *Westminster Review;* but no particulars can now be recovered.]

1857. 125. The Phasis of Force (*National Review*, April).

126. On the Structure of the Shell of Rhynconella Geinitziana (*Annals and Magazine of Natural History*, March).

127. Remarks on MM. Koren and Danielssen's Researches on the Development of Purpura lapillus (*Ibid.*, July).

128. On the Development of Purpura (*Ibid.*, August).

1858. 129. On the Lowest (Rhizopod) Type of Animal Life, considered in its Relations to Physiology, Zoology, and Geology (*Proceedings of the Royal Institution*, March 12).

130. Binocular Vision (*Edinburgh Review*, October).

131. Handbook of Psalmody (for the use of the Congregation worshipping in Rosslyn Hill Chapel, Hampstead).

1858. 132. On Tomopteris onisciformis, Eschscholtz (*Transactions of the Linnean Society*, January 20).

1860. 133. Darwin on the Origin of Species (*National Review*, January).

134. Further Researches on Tomopteris onisciformis, Eschscholtz (*Transactions of the Linnean Society*, January 19). This paper was written in conjunction with the late Dr. E. Claparède, of Geneva.

135. On the Relation of the Vital to the Physical Forces (*Proceedings of the Royal Institution*, February 24).

136. The Theory of Development in Nature (*British and Foreign Medico-Chirurgical Review*, April).

1861. 137. Alcohol: What becomes of it in the Living Body? (*Westminster Review*, January).

138. General Results of the Study of the Typical Forms of Foraminifera, in their Relation to the Systematic Arrangement of that Group, and to the Fundamental Principles of Natural History and Classification (*Natural History Review*, April).

139. On the Systematic Arrangement of the Rhizopoda (*Ibid.*, October).

1862. 140. Binocular Vision and the Stereoscope (a lecture at the London Institution, March 19; reprinted from the *British Journal of Photography*).

141. Introduction to the Study of the Foraminifera (folio, with twenty-two plates). (Published for the Ray Society. In this work Dr. Carpenter was assisted by Mr. W. R. Parker and Mr. T. Rupert Jones).

1863. 142. On the Fossil Human Jawbone recently discovered in the Gravel near Abbeville (in conjunction with Mr. George Busk, Dr. Falconer, and Mr. Prestwich) (*Proceedings of the Royal Society*, April 16, and *Natural History Review*, July, 1863).

1864. 143, 144. On the Application of the Principle of "Conservation of Force" to Physiology (*Quarterly Journal of Science*, January and April).

145. Additional Note on the Structure and Affinities of

Eozoön Canadense (*Quarterly Journal of the Geological Society*, November 23; with two plates).

1864. 146. On the Structure and Affinities of Eozoön Canadense (*Proceedings of the Royal Society*, December 15; compare *Annals and Magazine of Natural History*, April, 1865).

1865. 147. On the Structure, Affinities, and Geological Position of Eozoön Canadense (*Intellectual Observer*, May).

148, 149. Researches on the Structure, Physiology, and Development of Antedon (Comatula, Lamk.) rosaceus (abstract in *Proceedings of the Royal Society*, June 15; *Philosophical Transactions*, 1866, with twelve plates).

150. On the Microscopic Structure of the Shell of Rhynconella Geinitziana (*Annals and Magazine of Natural History*, November).

1866. 151. Supplemental Notes on the Structure and Affinities of Eozoön Canadense (*Quarterly Journal of the Geological Society*, January 10).

152. On Rhynconella Geinitziana (*Annals and Magazine of Natural History*, April).

1867. 153. On the Perforate Structure of the Shell of Spirifer cuspidatus (*Ibid.*, January).

154. Further Observations on the Structure and Affinities of Eozoön Canadense (*Proceedings of the Royal Society*, May 16).

155. On Nachet's Stereo-Pseudoscopic Binocular Microscope, and on Nachet's Stereoscopic Magnifier; with remarks on the Angle of Aperture best adapted to Stereoscopic Vision (*Transactions of the Royal Microscopical Society*, June 12).

156. On the Shell-Structure of Spirifer cuspidatus, and of certain allied Spiriferidæ (*Annals and Magazine of Natural History*, July).

1868. 157. On the Unconscious Activity of the Brain (*Proceedings of the Royal Institution*, March 1).

158, 159. The Zoetrope and its Antecedents (*The Student*, July and August).

1868. 160. On Spirifer cuspidatus (*Annals and Magazine of Natural History*, August).

161. The Anorthoscope (*The Student*, September).

162. On the Structure of the Shells of Brachiopoda (*Annals and Magazine of Natural History*, October).

163. Preliminary Report of Dredging Operations in Seas to the North of the British Islands, carried on by Dr. Carpenter and Dr. Wyville Thomson (*Proceedings of the Royal Society*, October 22).

1869. 164. On the Temperature and Animal Life of the Deep Sea (*Proceedings of the Royal Institution*, April 9).

165. On the Rhizopodal Fauna of the Deep Sea (*Proceedings of the Royal Society*, June 17).

166. Preliminary Report of the Scientific Exploration of the Deep Sea in H.M. Surveying Vessel *Porcupine*, during the summer of 1869, conducted by Dr. Carpenter, V.P.R.S., Mr. J. Gwyn Jeffreys, F.R.S., and Professor Wyville Thomson, LL.D., F.R.S. (*Ibid.*, November 18).

1870. 167. On the Temperature and Animal Life of the Deep Sea (*Proceedings of the Royal Institution*, February 11).

168. On the Shell Structure of Fusulina (*Monthly Microscopical Journal*, April).

169. Description of some Peculiar Fish's Ova (*Ibid.*, April).

170. On the Comparative Steadiness of the Ross and the Jackson Microscope-Stands (*Ibid.*, April).

171. The Contagious Diseases Act (*Inquirer*, April 2).

172. Descriptive Catalogue of Objects from Deep-Sea Dredgings, exhibited at the Soirée of the Royal Microscopical Society, King's College, April 20).

173. On the Reparation of the Spines of Echinida (*Monthly Microscopical Journal*, May).

174, 175. The Deep Sea: Its Physical and Biological Conditions (*The Student*, July and October).

176. The Gulf Stream (*Nature*, August 25).

1870. 177. The Geological Bearings of Recent Deep-Sea Explorations (*Nature*, October 27).

178. Report on Deep-Sea Researches carried on during the Months of July, August, and September, 1870, in H.M. Surveying Ship *Porcupine*, by W. B. Carpenter, M.D., F.R.S., and J. Gwyn Jeffreys, F.R.S. (*Proceedings of the Royal Society*, December 8).

1871. 179, 180. On Eozoön Canadense (*Nature*, January 5 and March 16).

181. On the Gibraltar Current, the Gulf Stream, and the General Oceanic Circulation (*Proceedings of the Geographical Society*, January 9).

182, 183. The Microscope and its Revelations (Two Lectures at the Pharmaceutical Society, February 1 and March 1).

184. The Temperature and Life of the Deep Sea (Manchester, *Science Lectures for the People*, February 8).

185. Ocean Currents: Researches in the *Porcupine* (*Contemporary Review*, March).

186. On the Latest Scientific Researches in the Mediterranean (*Proceedings of the Royal Institution*, March 10).

187. The Physiology of the Will (*Contemporary Review*, May).

188. On the Thermo-Dynamics of the General Oceanic Circulation (*British Association Report*, August).

189. Spiritualism and its Recent Converts (*Quarterly Review*, October).

190. Darwinism in England (*Il Barth*, Valetta, December).

191. The Unconscious Action of the Brain (Manchester, *Science Lectures*, December 1).

192. Epidemic Delusions (*Ibid.*, December 8).

1872. 193. What is Common Sense? (*Contemporary Review*, February).

194. Oceanic Circulation and the Gulf Stream (*Edinburgh Review*, April).

1872. 195. On the Temperature and Movements of the Deep Sea (*Popular Science Review*, April).

196. Report on Scientific Researches carried on during the Months of August, September, and October, 1871, in H.M. Surveying Ship *Shearwater* (*Proceedings of the Royal Society*, June 13).

197. Presidential Address at the Brighton Meeting of the British Association for the Advancement of Science (*British Association Report*, August).

198. On the General Oceanic Thermal Circulation (*Ibid.*).

199. On the Temperature and other Physical Conditions of Inland Seas, in their Relation to Geological Inquiry (*Ibid.*).

200. On a Piece of Chalk (*Good Words*, October).

201. On Mind and Will in Nature (*Contemporary Review*, October).

1873. 202–204. On the Hereditary Transmission of Acquired Psychical Habits (*Ibid.*, January, April, May).

205. Ancient and Modern Egypt; or, the Pyramids and the Suez Canal (Manchester, *Science Lectures*, February 19).

206. The Voyage of H.M.S. *Challenger* (*Journal of the Royal United Service Institution*, April 18).

207, 208. The Gulf Stream (Two Papers, *Good Words*, January and February).

209–213. Spectrum Analysis (Five Papers, *Ibid.*, May to August).

214. On the Physical Condition of Inland Seas (*Contemporary Review*, August).

215. On the Undercurrents of the Bosphorus and Dardanelles (*British Association Report*, September).

216. On the Physical Geography of the Mediterranean, considered in Relation to that of the Black Sea and the Caspian (*Ibid.*).

217. On the Physical Geography of the Caspian Sea, in its Relation to Geology (*Ibid.*).

1873. 218. Recent Investigations into the Functions of Different Parts of the Brain (being the Substance of two Lectures delivered before the Sunday Lecture Society, November 2 and 9).

219. The Psychology of Belief (The Roscoe Lecture, delivered before the Literary and Philosophical Society of Liverpool, November 24; see also *Contemporary Review*, December).

1874. 220. On the Temperature of the Atlantic (*Proceedings of the Royal Institution*, March 20).

221. Remarks on Professor H. J. Carter's Letter to Professor King on the Structure of the so-called Eozoön Canadense (*Annals and Magazine of Natural History*, April).

222. On the Physical Cause of Ocean Currents (*Philosophical Magazine*, May).

223. New Observations on Eozoön Canadense (*Annals and Magazine of Natural History*, June).

224. Further Inquiries on Oceanic Circulation (*Proceedings of the Geographical Society*, June 1).

225. The Depths of the Sea (*British Quarterly Review*, July).

226. Final Note on Eozöon Canadense (*Annals and Magazine of Natural History*, November).

227. The Conditions which Determine the Presence or Absence of Animal Life on the Deep Sea Bottom (*Proceedings of the Geologists' Association*, December 4).

228. Principles of Mental Physiology (Fourth edition, with new Preface, 1876).

1875. 229, 230. On the Doctrine of Human Automatism (*Contemporary Review*, February and May).

231. Remarks on Professor Wyville Thomson's Preliminary Notes on the Nature of the Sea-Bottom, procured by the Soundings of H.M.S. *Challenger* (*Proceedings of the Royal Society*, February 5).

232. Is Man an Automaton? (A Lecture at the City Hall, Glasgow, February 23).

1875. 233. The Voyage of H.M.S. *Challenger* (continued) (*Journal of the Royal United Service Institution*, March 12).

234. L'Automatisme Humain (*Revue Scientifique*, May).

235. Les Fonctions du Système Nerveux chez les Invertébrés (*Revue Scientifique*, June).

236. Summary of Recent Observations on Ocean Temperature made in H.M.S. *Challenger* and U.S.S. *Tuscarora*, with their Bearing on the Doctrine of a General Oceanic Circulation sustained by Difference of Temperature (*Proceedings of the Royal Geographical Society*, June).

237. On the Anatomy of Comatula, an addendum to Professor Semper's Paper (*Annals and Magazine of Natural History*, September).

238. Ocean Circulation (*Contemporary Review*, September).

239. Remarks on Mr. Croll's "Crucial Test" Argument (*Philosophical Magazine*, November).

240–242. Articles on the "Atlantic," "Baltic," "Black Sea" (*Encyclopædia Britannica*, vol. iii.).

1876. 243. The Fallacies of Testimony in Relation to the Supernatural (*Contemporary Review*, January).

244, 245. On the Structure, Physiology, and Development of Antedon (Comatula, Lamk.) rosaceus (*Proceedings of the Royal Society*, January 20).

246. On the Genus Astrorhiza of Sandahl (*Quarterly Journal of Microscopical Science*, April).

247. Supplemental Note to a Paper on the Structure, Physiology, and Development of Antedon rosaceus (*Proceedings of the Royal Society*, April 6).

248. Remarks on Mr. Carter's Paper "On the Polytremata," especially with reference to their Mythical Hybrid Nature (*Annals and Magazine of Natural History*, May).

249. On Oceanic Circulation (*Athenæum*, May 13).

250. New Laurentian Fossil (*Nature*, May 4, 25).

251. Notes on Otto Hahn's "Micro-Geological Investi-

gation of Eozoön Canadense" (*Annals and Magazine of Natural History*, June).

1876. 252. Foraminifera from the Cruise of the *Valorous* (*Proceedings of the Royal Society*, June 15).

253. Report on the Physical Investigations carried on by P. Herbert Carpenter, B.A., in H.M.S. *Valorous*, during her return Voyage from Disco Island in August, 1875 (*Ibid.*).

1877. 254. The Radiometer and its Lessons (*Nineteenth Century*, April).

255. On the Temperature of the Deep Sea Bottom and the Conditions by which it is determined (*Proceedings of the Geographical Society*, April).

256. Sketch of the Life and Work of Mary Carpenter (Expanded from an Obituary Notice in the *Times*, June).

257. Mesmerism, Spiritualism, etc., historically and scientifically considered (Two Lectures delivered at the London Institution, with Preface and Appendix).

1879. 258. The Eozoön Canadense (*Nature*, July 31).

259. Article on "Foraminifera" (*Encyclopædia Britannica*, vol. ix.).

1880. 260. The Force behind Nature (*Modern Review*, January).

261. Land and Sea considered in Relation to Geological Time (*Proceedings of the Royal Institution*, January 23).

262. The Deep Sea and its Contents (*Nineteenth Century*, April).

263. Nature and Law (*Modern Review*, October).

1881. 264. Article on "Indian Ocean" (*Encyclopædia Britannica*, vol. xii.).

265. The Truth about Vaccination (*Times*, May 11; reprinted with enlargements at the request of the Guardians of the Bedford Union).

266. The Morality of the Medical Profession (*Modern Review*, July).

1881. 267. Disease Germs (*Nineteenth Century*, October).

268, 269. The Relation of Food to Muscular Work (*Knowledge*, November 4 and 11).

1882. 270. Predisposition to Disease (*Dictionary of Medicine*).

271. The Ethics of Vivisection (*Fortnightly Review*, February).

272. On the Conservation of Solar Energy (*Knowledge*, March 17).

273. Small-Pox and Vaccination in 1871–81 (*Nineteenth Century*, April).

274. Sir Charles Bell and Physiological Experimentation (*Fortnightly Review*, April).

275. Charles Darwin: his Life and Work (*Modern Review*, July).

276. Science and Religion: the Influence of Science on the Progress of Religious Thought (An Address delivered before the National Conference of Unitarian and other Christian Churches at Saratoga, U.S., September 19).

277. The Doctrine of Evolution in its Relations to Theism (*Modern Review*, October).

278–283. Six Lectures on Human Automatism (Delivered at the Lowell Institute in October and November, and intended to form a small volume; *New York Medical Journal*, xxxvii., and *Christian Reformer*, London, vols. i., ii., iii.).

284. The Physiology of Alcoholics (Address in the Tremont Temple, Boston, December 3).

1883. 285. Article on "Microscope" (*Encyclopædia Britannica*, vol. xvi.).

286. Report on the Genus Orbitolites (*Zoology: Challenger Expedition*, vol. vii. part xxi., eight plates).

287. Researches on the Foraminifera. Supplemental Memoir. On an Abyssal Type of the Genus Orbitolites; a Study in the Theory of Descent (*Proceedings of the Royal Society*, June 14; and *Philosophical Transactions*, 1883, pt. ii.).

1883. 288. On the Germ-Theory of Disease, considered from the Natural History Point of View (*British Association Report*, September).

1884. 289. The Germ-Theory of Zymotic Diseases; considered from the Natural History Point of View (*Nineteenth Century*, February).

290. On the Nervous System of the Crinoidea (*Proceedings of the Royal Society*, May 29).

291. The Argument from Design in the Organic World, reconsidered in its Relation to the Doctrines of Evolution and Natural Selection (*Modern Review*, October).

292. On the Structure of Orbitolites (Inaugural Address as President of the Quekett Microscopical Club, October 24) (*Journal of the Quekett Microscopical Club*, vol. ii. series ii.).

1885. 293. President's Address at the Annual General Meeting of the Quekett Microscopical Club, July 24 (*Ibid.*).

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