Address of Sir Benjamin C. Brodie, ... the president, delivered at the anniversary meeting of the Royal Society, on Wednesday, November 30, 1859.

ADDRESS

OF

SIR BENJAMIN C. BRODIE,

BART., D.C.L., &c. &c. &c.,

THE PRESIDENT,

DELIVERED AT

THE ANNIVERSARY MEETING

OF

THE ROYAL SOCIETY,

ON

Wednesday, November 30, 1859.

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1859.

ROYAL SOCIETY.

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THE PRESIDENT,

DELIVERED AT

The Anniversary Meeting, Nov. 30, 1859.

GENTLEMEN,

IN an address lately delivered at a Meeting of the Society for the Promotion of Social Science, a noble Lord, a Fellow of this Society, called the attention of his hearers to the advantages which the world in general had derived from the cultivation of the physical sciences. No one indeed can be better qualified to give an opinion on this subject than the distinguished individual to whom I have alluded. His first communication to the Royal Society was in the year 1796, and was published in the 'Philosophical Transactions' for that year. From that time to the present day he has, without any intermission, laboured for the advancement of all kinds of knowledge, and so he still continues to labour with all the determination and energy and intellectual vigour of youth; and I may confidently affirm that little has been done worthy of note during this interval of sixty-four years which has escaped his acute observation. The influence, however, which the physical sciences have had in adding to the conveniences and comforts, and advancing the material pros-

perity of mankind is too obvious to escape the notice of a much less close observer than Lord Brougham. If our houses and our cities are better and more economically lighted; if our population is better and more cheaply clothed; if our fields are more productive; if we travel by steam and communicate with those who are hundreds of miles distant from us by the telegraph; if a brighter light shines in our light-houses to guide the mariner at night; these and a thousand of things besides are but the result of the application by practical men of the discoveries made in the physical sciences to practical purposes. To the same cause may be attributed much of the political greatness of the British nation. The British flag floats in every sea; our colonies are established in every region of the earth; we contemplate in them with a reasonable pride the germs of future nations, which, when our fortune may possibly be changed, will speak the same language with ourselves; inheriting our literature, our political institutions, and not only our religion but our religious freedom; inheriting also our knowledge, and adding knowledge to it; but none of this could have been, if it were not that the astronomer had instructed the sailor how, with nothing but the heavens above him and the waters on every side, he may find his exact position on the surface of the globe.

But it would be a grave mistake to suppose that such as those which I have now enumerated are the only advantages which have been derived from the cultivation of the physical sciences. To know their full extent, we must take into the account not only the direct but also the indirect results to which it has led; and I trust that I may be excused if, on the occasion of the present anniversary, I occupy some portion of your time, not by an elaborate discussion of the subject, but by offering to you some suggestions as to the other ways in which inquiries such as those in which you are yourselves engaged have already affected, and may be expected still more to affect hereafter, the habits, the modes of thought, the fortunes and moral condition of mankind.

It is not our business to depreciate that form of civilization which existed in times long since past, and especially of that remarkable people who during some centuries before and after the Christian æra were distinguished for their still unrivalled excellence in art,—their

noble literature; when Aristotle sat at the feet of his master Plato; when students in search of intellectual improvement from all parts of Greece resorted to the Lyceum of Athens; when from opposite quarters of the Mediterranean Sea the Greek colonies of Alexandria and Syracuse supplied a list of mathematicians and poets to add lustre to their parent state. Neither let us forget what we owe to another people, whose civilization is to be measured, not by their wealth and luxury, their ambition and their conquests; but by those monuments of art which still draw visitors to Rome; their historians, moral philosophers, and poets. But, great as are the obligations which we owe to these nations of antiquity, it cannot be denied that the civilization which exists among us at the present time is of a higher order than that which existed formerly: and it is not difficult to show that it is to the greater extension of a knowledge of natural phenomena, and the laws which govern them, that this improvement is mainly to be attributed.

Knowledge and wisdom are indeed not identical, and every man's experience must have taught him that there may be much knowledge with little wisdom, and much wisdom with little knowledge. But with imperfect knowledge it is difficult or impossible to arrive at right conclusions. Many of the vices, many of the miseries, many of the follies and absurdities by which human society has been infested and disgraced may be traced to a want of knowledge. It was from a want of knowledge that Roger Bacon was persecuted by the Franciscan monks, and Galileo by the Inquisition; that Servetus was burned by Calvin; while others would have burned Calvin in his turn if they had had the opportunity of doing so. So it was that juries were found to convict and judges to condemn poor ignorant women as witches; that within the last two centuries well-educated men believed that they might read their destiny in the stars; and that as lately as the year 1638, on the occasion of the birth of Louis XIV., Richelieu compelled the dungeons of the Inquisition to give up the astrologer Campanella, in order that he might cast the horoscope of the future king; and so it is that at the present day grown-up ladies and gentlemen occupy themselves with the humbler and less romantic mysteries of turning and rapping tables. Cooperating with a purer religious faith, the advancement

of knowledge has humanized our institutions. It has banished slavery; it has caused our laws to be more merciful, and the administration of them more just; it has promoted religious and political freedom, and, with one or two miserable exceptions, it has rendered even despotic governments more attentive to the claims and wishes of their subjects. If sanitary and other improvements (these being the results of greater knowledge) have added to the average length of human life, be it observed that this fact includes another fact, namely, that they have added to human happiness; for true it is that the causes which tend to the shortening of life are, with few exceptions, such as produce either physical pain or moral suffering.

The investigation of the physical sciences is especially favourable to the training of some of the more important faculties of the mind, so that we may well anticipate much ultimate advantage from the movement which is already begun, having for its object, not to supersede these studies of ancient languages and ancient literature (which at the present time, in addition to mathematics, are supposed to form the staple of a first-rate education), but to add an elementary knowledge of the principal physical sciences to the list. The including of some of these at least in the instruction of early life will operate beneficially in various ways. The first step in all physical investigations, even in those which admit of the application of mathematical reasoning and the deductive method afterwards, is the observation of natural phenomena, and the smallest error in such observation in the beginning is sufficient to vitiate the whole investigation afterwards. The necessity of strict and minute observation, then, is the first thing which the student of the physical sciences has to learn, and it is easy to see with what great advantage the habit thus acquired may be carried into everything else afterwards. Slovenly habits of observation are indeed the source of a large proportion of the evils which mankind bring upon themselves; of blunders in private life by which an individual causes the ruin of himself and his wife and children; of blunders in statesmanship which bring calamities on nations. It is to these, moreover, that impostors and fanatics of all kinds and in all ages have been indebted for their influence and success.

It would be easy to show how in various other ways the study of the physical sciences cannot fail to be a useful training for the mind. Very much indeed might be said on this subject, but to enter fully into it would not only occupy too much of your time, but would involve us in a metaphysical discussion unsuited to the present occasion. There are, nevertheless, two or three points to which I shall venture, however briefly, to allude.

Investigations of this kind, more than almost any other, impress the mind with the necessity of looking carefully at both sides of a question, and strictly comparing the evidence on one side with that on the other; and in this manner they help to correct and improve the judgment. As in every such investigation classification is an important and indeed a necessary element, another effect is that of promoting and strengthening the best kind of memory;—a memory founded on some actual relation of objects to each other, and not on mere apparent resemblance and juxtaposition. Lastly, physical investigations more than anything besides help to teach us the actual value and the right use of the imagination; of that wondrous faculty which, left to ramble uncontrolled, leads us astray into a wilderness of perplexities and errors, a land of mists and shadows; but which, properly restrained by experience and reflection, becomes the noblest attribute of man; the source of the poetic genius; the instrument of discovery in science, without the aid of which Newton would never have invented fluxions, nor Davy have decomposed the earths and alkalies, nor would Columbus have found another continent beyond the Atlantic Ocean.

In the pursuit of the physical sciences, the imagination supplies the hypothesis which bridges over the gulf that separates the known from the unknown. It may be only a phantom; it may prove to be a reality. But, as these sciences relate to matters of fact which, if not directly, may be made indirectly cognizable by the external senses, they afford us peculiar facilities, far beyond what exist in other departments of knowledge, of testing the accuracy of the views which the imagination has suggested, so that we may at once determine when it has been too excursive, and if it has been so, call it back to its right place. There may be instances of mere accidental discovery; but, setting these aside, the great advances made in the inductive

sciences are, for the most part, preceded by a more or less probable hypothesis. The imagination, having some small light to guide it, goes first. Further observation, experiment, and reason follow. Thus, for example, it had been long suspected that there is some sort of relation between electricity and magnetism. Much thinking on the subject had strengthened this suspicion in the mind of Oersted. Still it was but an hypothesis, and might even now have been regarded by many as no better than a dream, if it had not been that in the year 1820 the Danish philosopher devised the experiments which demonstrated the law of reciprocity between an electric current and the magnet, and the identity of the two forces. As an instance of an opposite kind, I may refer to the doctrine of phlogiston as propounded by Stahl. While the art of chemical experiment was imperfectly understood, that doctrine was very generally received as affording a true explanation of the phenomena of combustion. But no sooner had Lavoisier and his friends introduced a more accurate mode of experiment by weight and measure, than it was proved to have no foundation in reality, and consigned to the same place in the history of science with epicycles and vortices and animal spirits.

But the effect of some kind of instruction in the physical sciences being recognized as an essential part of a liberal education, may be contemplated under another point of view. Except in the case of particular professions or occupations, a profound knowledge of these subjects is not required; but there is no situation in life in which some knowledge of them may not be turned to a good account. Is there any country gentleman or farmer who might not derive advantage from knowing something of vegetable physiology and chemistry? —would not a knowledge of scientific botany make a man a better gardener?—is there any county magistrate, or mayor, or alderman of a borough, to whom it would not be useful to know something of the principles on which what are called sanitary measures are to be conducted?—and is there anyone in any situation in life to whom it would not be a benefit to know something of animal physiology, of the functions of his own body, and of the influence which his bodily condition exercises over those moral and intellectual faculties by which he is distinguished from the rest of the animal creation? If it did not teach him how to cure disease, it might be useful for him to know

how far disease may cure itself, and what are the limits of Nature in this respect? To man, looking at him as an individual, there is no art so important as that of understanding and managing himself, —an art so simply and well expressed by the two significant words Γνῶθι σεαυτὸν, which were inscribed over the heathen oracle of Delphi. To correct bad habits when once acquired is no very easy task. A strong sense and a strong will, such as only a limited number of persons possess, are necessary for that purpose. But it would go far towards preventing the acquirement of such habits, if young persons, during the period of their education, were made to understand the ill consequences to which they must inevitably lead, and how, eventually, the body must suffer and the mind be stupefied and degraded, not by the reasonable indulgence, but by the abuse of the animal instincts.

In the Introduction to his 'Inquiry into the Human Understanding,' David Hume, having referred to the remarkable progress which had been lately made in a knowledge of astronomy and other physical sciences, has suggested that "the same method of inquiry, which has been applied with so great advantage in these sciences, might also be applied with advantage to those other sciences which have for their object the mental power and economy." I call your attention to this remark, because it brings me to the consideration of another subject, namely, the influence which the pursuit of the physical sciences, conducted as it has been more or less since the days of Galileo and Kepler, has exercised over other studies, and in the advancement of other kinds of knowledge. It needs no argument to prove, for it must be sufficiently plain to everyone, that other sciences as well as the physical have at the present time a very different character from that which they had formerly. It was probably from the operation of various causes (a principal one, however, being the too exclusive and undue importance attached to the Aristotelian logic in the schools), that some centuries had elapsed since the revival of learning before the inductive method (which, by the way, is nothing more than the logic which we all make use of instinctively in the ordinary concerns of life) became generally applied to the investigation of the phenomena and laws of the material universe. But a still further time elapsed, even after the publication of Lord Bacon's

views on the subject, before other sciences began to partake of this movement, and when they did so, it seems not possible to doubt that it was the result of the impulse which the rapid growth of the physical sciences had communicated to them.

That such was the opinion of David Hume as to the influence thus exercised on one class of inquiries in which he was himself engaged, I have already shown. But long before Hume wrote, the same impression had existed on the mind of Locke, as will be sufficiently obvious to anyone on reading the Introductory Chapter of his 'Essay on the Human Understanding.' In fact Locke had originally directed his attention to Natural Philosophy and Medicine, and his researches in Moral and Intellectual Philosophy were engrafted on his earlier studies. So in the case of Dr. Berkeley: his treatise on 'Vision' contains the essential part of those doctrines which he afterwards published in his 'Treatise on the Principles of Human Knowledge;' and it is easy to see how, step by step, these gradually arose out of his former studies of Natural Philosophy. I make no reference to the modern German school of metaphysicians, and indeed am quite incompetent to do so. Neither do I refer to another order of metaphysicians, one of whom informs us how ideas and emotions and volitions are produced by big and little vibrations of the molecules of the nervous system; while another undertakes to explain "the action of material ideas in the mechanical machines of the brain." But with regard to the more eminent of our English writers on these subjects, and what has been called the Scotch school of metaphysicians, including Reid, Adam Smith, Dugald Stewart, and Brown, it may be truly asserted that the advantage which they have had over the dreamy metaphysicians of former times is to be attributed to their having in their mode of inquiry followed the example which had been set them in the study of the physical sciences.

I must not exhaust your patience by going on to explore so wide a field as that on which I have just entered. The subject is one to which justice cannot be done without a much more ample discussion than would be convenient on an occasion like the present. All that I shall say besides may be comprised in a very few words. In composing his 'Essays' on what is now called Political Economy, we may presume that David Hume's mind was influenced by the same

considerations as when he composed those other Essays to which I have alluded ; and it is not too much to say that these researches of Hume's may be regarded as having, more than anything besides, contributed to lay the foundation of that vast science which has been since developed through the labours of Adam Smith and Horner, and of others who are still alive among us.

At the same time, in giving this credit to Hume, we must not overlook what is due to one of our own body, and an original Fellow of the Royal Society. Sir William Petty contributed several papers to the 'Philosophical Transactions.' In an early part of his life he had been engaged in giving lectures on Anatomy and on Chemistry at Oxford, and, his mind having been thus prepared, he entered on the consideration of other subjects, such as taxation and trade, as effecting the material prosperity of nations, and social statistics. His 'Discourse on Political Arithmetic' seems to have been the last result of his labours, it having been first published after his death by his son, Lord Shelburne. In his Preface to this Discourse he thus expresses himself, and I quote the passage because it will serve to show how in these later investigations his mind was influenced by those in which he had been previously engaged :—"The method I take to do this is not very usual: for, instead of using only comparative and superlative words, and intellectual arguments, I have taken the course (as a specimen of the political arithmetic I have long aimed at) to express myself in terms of number, weight, or measure ; to use only arguments of sense, and to consider only such causes as have visible foundations in Nature."

It would be easy to adduce from other sciences analogous illustrations of the proposition which I have ventured to advance. Compare the natural theology of Derham, Paley, and the Bridgewater Treatises, all founded on the observation of natural phenomena, with the speculations of the ancient philosophers, or with the abstractions and *a priori* arguments of Dr. Samuel Clarke. Compare the unravelling of early history by Niebuhr and Arnold with anything regarding history that had been done before, or the best practical treatises on politics and government of modern times with the elaborate but fantastic scheme of Plato's republic.

If I have made too large a demand on your patience by dwelling on

matters which have no special or exclusive relation to our body, you will, I hope, accept it as a sufficient apology that I have done so under the impression that whatever relates to the advancement of knowledge generally cannot be altogether uninteresting to those who are the living representatives of the great men by whom the Royal Society was founded, and who themselves now constitute the most ancient scientific institution in the world.

Looking at what more particularly concerns ourselves, I may congratulate you on the results obtained during the last year. In the volume of the 'Philosophical Transactions' which is now in the course of publication we find that there is scarcely any department of physical knowledge which is not honourably represented; at the same time that, besides the abstracts of the principal papers, many investigations which have not been deemed to be of sufficient importance, or sufficiently original to have a place in our annual volume, but which nevertheless are of considerable interest, are recorded and published from time to time in the smaller volume bearing the title of 'The Royal Society's Proceedings.' By means of this less pretentious publication many facts, many thoughts and suggestions are preserved, which might otherwise have been neglected or lost, but which, being thus preserved, may prove to be of much value hereafter. Our weekly meetings have been well attended, and have been rendered more attractive by a practice which is not altogether new, but which has been more generally adopted than heretofore during the last Session; I allude to that of the authors of papers communicated to us giving an oral or *vivâ voce* explanation of their contents; those explanations being rendered more intelligible by a reference to diagrams, or to the apparatus used for experiments, and even by experiments actually displayed. Such illustrations are useful both to the authors and to others, by causing the subject-matter of the several communications to be better understood; and they are useful in another way, inasmuch as they lead to conversations and discussions, and to the interchange of opinion at the time, from which we may all of us derive something to think of, and reflect on afterwards.

Having occupied so much of your time already, I do not feel justified in making a further demand on it by entering into a recapitulation of what has been done in the way of scientific discovery

during the last year. There is, however, one subject to which I am led to advert because it is of more than usual interest, not only on account of its connexion with scientific investigations, but also on other grounds.

After an interval of two years, Captain M'Clintock and those who were associated with him have returned in safety from their voyage of discovery, and their investigations in the Arctic regions. The result has been that, although our most earnest wishes have not been realized, it cannot be said that our more reasonable expectations have been disappointed. There seemed to be no more than a small probability that any of those who accompanied Sir John Franklin when he quitted his native country in the year 1845 should be still alive in the dreary and inhospitable regions in which after the loss of their vessels they had been imprisoned. Captain M'Clintock's careful inquiries have fully dissipated whatever faint hopes might have been entertained of its being otherwise, leaving us only the poor consolation of knowing that the sufferings of these gallant spirits are at an end.

As scientific discoverers, Captain M'Clintock and his officers have well fulfilled their mission, as is proved by the magnetic observations which Captain M'Clintock has already communicated to the Royal Society, and of which General Sabine, with his usual perspicuity, gave us some account at one of our evening meetings.

In speaking of those engaged in the late expedition I am unwilling to pass over in silence the name of Mr. Young, who, having been the commander of a merchant-ship, took so much interest in the projected enterprise that he not only contributed £500 towards defraying the expenses of it, but volunteered his personal services on the occasion, by acting as master of the vessel. Nor ought I to omit to notice the name of Dr. Walker, who, being engaged as surgeon, acted also as naturalist to the expedition, and availed himself of such scanty opportunities as those ice-bound countries afford of extending his researches in natural history. Of the results which he has been able to obtain I am not in a condition to give you an account at present; but they will, I doubt not, in due time, be communicated to the public.

The greatest honour which the Royal Society has to bestow,

namely the Copley Medal, has been awarded to Professor Wilhelm Edward Weber of Göttingen, foreign member of the Royal Society, for his investigations contained in the 'Maasbestimmungen' and his other researches in electricity, magnetism, acoustics, &c.

The first work in which Professor Weber was engaged was 'The Theory of Undulations,' published in conjunction with his brother Ernest in 1825. This work is still one of standard authority. It contains not only a complete account of all that was previously known on the subject of waves in water, but is the repository of many original and important experiments throwing light on this subject. The volume contains also many valuable investigations in acoustics. Subsequently to this, Professor Weber communicated to Poggendorff's 'Annalen' numerous memoirs containing his further observations in acoustics, among which were his experiments on the longitudinal vibration of rods and strings; on reed organ-pipes; on grave harmonic sounds; and also his method of determining the specific heat of bodies by their sonorous vibrations. In this department of physical science he has been a worthy coadjutor of Chladni and Savart.

In association with his brother Edward, then Anatomical Prosector in Leipsic, he in 1835 published the details of an anatomical, physical, and mathematical investigation of the mechanism of the human organs of locomotion, one result of which was the promulgation of a theory of animal progression more nearly in accordance with observed facts than any that had been proposed previously.

On his association with M. Gauss in the Magnetic Observatory at Göttingen, Professor Weber devoted himself almost exclusively to the subject of magnetism and electricity. The annual volumes of the 'Results of the Observations of the Magnetic Union,' published by these eminent philosophers between 1838 and 1843, contain the description of several new instruments, some of which have been the models of those which are now used in all observatories. They include also a great variety of important original researches.

It ought not to be omitted that the researches of Gauss and Weber with reference to the transmission of electric signals did more to excite attention to the practicability of an electric telegraph than anything that had been done previously.

In 1846 Professor Weber published a memoir on "The Measures

of Electro-dynamic Forces" ("Electrodynamische Maasbestimmungen"), a work not less remarkable for the original mathematical than for the experimental researches embodied in it. A high authority has pronounced this to be "one of the most important works both with regard to mathematical theory, and the practical application of it, that has been published in this department of science since the researches of Ampère," and the same authority has added, "His transformation of Ampère's law of electric action, so as to exhibit the analyses of the *plus* and *minus* elements in each stream, and his deduction thence of the law of statical from that of dynamical action, seems to me, both as a specimen of mathematical analysis and of physical philosophy, exceedingly beautiful."

More recently Professor Weber has produced two additional memoirs on the same subject, one of which contains a mathematical and experimental investigation of the phenomena of dia-magnetism discovered by Faraday.

Professor Miller,

As I have not the opportunity of presenting it to him in his own person, I request of you, as Foreign Secretary, to cause the Copley Medal which I now place in your hands to be conveyed to Professor Weber, with a request that he will be pleased to accept it as the indication of the very high estimation in which his scientific labours are held by the Royal Society of London.

One of the Royal Medals has been awarded to Arthur Cayley, Esq., F.R.S., for his Mathematical Papers published in the Philosophical Transactions, and in various English and Foreign Journals.

From the first institution of the Royal Society a large proportion of the papers communicated to them have related to Pure Mathematics, and none have contributed more than these to maintain the credit of the Philosophical Transactions. Among writers of the present time, no one has been a more earnest or more successful labourer in this department of science than Mr. Cayley. His numerous papers on these subjects bear testimony to his unwearied industry; and the undivided opinion as to their value and importance held by those who are best qualified to judge of them, sufficiently

establishes Mr. Cayley's claim to be regarded as one of the most eminent and profound mathematicians of the age in which we live.

Mr. Cayley is among the foremost of those who are successfully developing what may be called the *organic* part of algebra into a new branch of science, as much above ordinary algebra in generality as ordinary algebra is itself above arithmetic. The effect is a vast augmentation of our power over the comparison and transformation of algebraical forms, and greatly increased facility of geometrical interpretation.

To give any full account of Mr. Cayley's labours would be impossible, from mere want of space; and such account, were it given, would be intelligible to none but the highest order of mathematicians; moreover, you are well aware, it could not come from my own knowledge of the subject. I have, however, considered it my duty to lay something before you, in the most general terms of description, about these very remarkable papers, obtained from those who are competent to describe them.

Mr. Cayley's memoirs relate almost exclusively to pure mathematics, and a considerable proportion of them belong to the subject Quantics, defined by him to denote the entire subject of rational and integral functions, and of the equations and loci to which these give rise; in particular the memoirs upon linear transformations and covariants, and many of the memoirs upon geometrical subjects belong to this head. Among the memoirs upon other subjects may be mentioned Mr. Cayley's earliest memoir (1841) in the Cambridge Mathematical Journal, "On a Theorem in the Geometry of Position," which contains the solution in a compendious form, by means of a determinant, of Carnot's problem of the relation between the distances of five points in space; the memoir in the same Journal, "On the Properties of a certain Symbolical Expression," which is the first of a series of memoirs upon the attraction of ellipsoids, and the multiple integrals connected therewith; a memoir in Liouville's Journal, which contains the extension of the theory of Laplace's functions to any number of variables; and the memoirs in the same two Journals, on the inverse elliptic integrals or doubly periodic functions. The earliest of the memoirs upon linear transformations was published (1845 and 1846) in the Cambridge and the Cambridge and Dublin

Mathematical Journals, and under a different title in 'Crelle.' The antecedent state of the problem was as follows :—The theory of the linear transformations of binary and ternary quadratic functions had been established by Gauss, the same being in fact the foundation of his researches upon quadratic forms, as developed in the 'Recherches Arithmétiques,' and that of the linear transformations of quadratic functions of any number of variables, had been considered by Jacobi and others. A very important step was made by Mr. Boole, who showed that the fundamental property of the determinant (or, as it is now commonly called, discriminant) of a quadratic form applied to the resultant (discriminant) of a form of any degree and number of variables ; the property in question being, in fact, that of remaining unaltered to a factor près, when the coefficients are altered by a linear transformation of the variables, or as it may for shortness be called, the property of invariancy : the theorem just referred to, suggested to Mr. Cayley the researches which led him to the discovery of a class of functions (including as a particular case the discriminant), all of them possessed of the same characteristic property. These functions, called at first hyperdeterminants, are now called invariants ; they are included in the more general class of functions called covariants, the difference being that these contain as well the variables as the coefficients of the given form or forms. The theory has an extensive application to geometry, and in particular to the theory of the singularities of curves and surfaces. This theory for plane curves was first established (1834) by Plücker upon geometrical principles ; the analytical theory for plane curves is the subject of a memoir by Mr. Cayley in 'Crelle,' and of his recent memoir in the Philosophical Transactions, "On the Double Tangents of a Plane Curve," based upon a Note by Mr. Salmon. The corresponding geometrical theory for curves of double curvature and developable surfaces, was first established in Mr. Cayley's memoir on this subject, in 'Liouville' and the 'Cambridge and Dublin Mathematical Journal.' The theory for surfaces in general, is mainly due to Mr. Salmon. Among Mr. Cayley's other memoirs upon geometrical subjects, may be mentioned several papers on the Porism of the in-and-circumscribed polygon, and on the corresponding theory *in solido* ; a memoir on the twenty-seven right lines upon a surface of the third order, and the memoir

in the Philosophical Transactions, "On Curves of the Third Order." The memoirs on Quantics in the 'Philosophical Transactions' (forming a series not as yet completed), comprise a reproduction of the theory of covariants, and exhibit the author's views on the general subject. Mr. Cayley has written also a Report on the recent progress of theoretical Dynamics, published in the 'Reports of the British Association' for 1857.

Mr. Cayley,

In the name of the Royal Society of London, I request your acceptance of this Royal Medal, in testimony of the strong sense which they entertain of the value of your labours, and of the satisfaction which it affords them that so eminent a mathematician as yourself should be included in the list of their Fellows.

The other Royal Medal has been awarded to Mr. George Bentham, F.L.S., for his important contributions to the advancement of Systematic and Descriptive Botany.

The remarkable accuracy which distinguishes all Mr. Bentham's scientific researches, the logical precision that characterizes his writings, and the sound generalizations which his systematic works exhibit, may be in a great measure traced to the influence of his uncle, the late celebrated legal theorist Jeremy Bentham, who directed much of his early studies, and under whose auspices he published one of his earliest works, 'Outlines of a New System of Logic.' His mind was further imbued in youth with a love of Natural History, and especially Botany; and this taste was cultivated and nourished by a study of the works of the elder DeCandolle.

Fortunately for the cause of Botany in England, Mr. Bentham has devoted himself almost exclusively to that science; and to his excellent powers of observation, close reasoning, concise writing, and indefatigable perseverance, our country owes the distinction of ranking amongst its Naturalists one so preeminent for his valuable labours in Systematic Botany.

Amongst Mr. Bentham's numerous writings, those hold the first rank which are devoted to the three great natural orders, Leguminosæ, Labiatæ, and Scrophulariaceæ. These orders demanded a vast amount

of analytic study ; for they are amongst the largest and most widely distributed of the vegetable kingdom, and had been thrown into great confusion by earlier writers. They have been the subject of many treatises by Mr. Bentham, and especially of two extensive works, the contents of which have lately been embodied in the "Systema Vegetabilium" of the DeCandolles. On their first appearance these works secured for their author a European reputation, and will always rank high as models of skilful classification.

It would occupy too much time to specify the very numerous monographs and papers which Mr. Bentham has communicated to various scientific societies and periodicals in this country and on the Continent, and especially to the Linnean Transactions and Journal. That "On the Principles of Generic Nomenclature" may be noted as an example of his power of treating an apparently simple, but really abstract and difficult subject in a manner at once philosophical and practical. Mr. Bentham's most recent work, that on British Plants, is the first on the indigenous Flora of our Islands, in which every species has been carefully analysed and described from specimens procured from all parts of the globe ; it is distinguished for its scientific accuracy, advanced general views, and extreme simplicity, —a combination of qualities which can result only from an extensive series of exact observations, judiciously arranged and logically expressed.

MR. BENTHAM,

The early volumes of the 'Philosophical Transactions' contain numerous papers relating to Botany and the other sciences which are usually comprehended under the general designation of Natural History. As these sciences, but especially Botany, became more and more extended, it was thought desirable that another Institution should be called into existence, which might share with the Royal Society the privilege of promoting the cultivation of them, and of communicating to the world from time to time the progress which has been made in this department of knowledge : and such was the origin of the Linnean Society in the year 1788. The Royal Society, however, does not on that account feel the less interest in this class

of scientific investigations. It is accordingly with great satisfaction that the Council have awarded to you one of the Royal Medals, and that, in the name of the Society, I now place it in your hands, in testimony of their high appreciation of your researches, and of the respect which they have for you as a fellow-labourer in the field of science.